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Michael Filimowicz · Veronika Tzankova
Editors

New Directions in Third Wave Human-Computer Interaction: Volume 2 - Methodologies

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Chapter 1
Introduction: New Directions in Third Wave HCI

Michael Filimowicz and Veronika Tzankova

Abstract *New Directions in 3rd Wave Human-Computer Interaction* explores the diverse interdisciplinary inquiries comprising the forefront of developments in the field of HCI. This wide ranging collection aims at understanding the design, methods and applications of emerging forms of interaction with new technologies and the rich varieties of human knowledge and experiences. All chapters are structured around two major themes presented in two volumes: Volume 1– Technologies, and Volume 2 – Methodologies.

1.1 Waves, Paradigms, and Cultures

New Directions in 3rd Wave Human-Computer Interaction explores the diverse interdisciplinary inquiries comprising the forefront of developments in the field of HCI. This wide ranging collection aims at understanding the design, methods and applications of emerging forms of interaction with new technologies and the rich varieties of human knowledge and experiences. All chapters are structured around two major themes presented in two volumes: Volume 1– Technologies, and Volume 2 – Methodologies.

These two volumes address the widespread notion that the field of HCI can historically be divided into three 'waves' of approaches and application areas. Although there is a consensus on the presence of different 'waves', the definition and understanding of what constitutes these is far from set. Bødker (2015) following Bannon (1986), for example, has defined the sequence and conceptualization of the waves as follows:

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- 1st Wave – based on model-driven cognitive science and human factors methods and focusing on strict, formal guidelines grounded in systematic study and testing.
- 2nd Wave – initiated as an extension of the human-technology nexus to include collaborative, mediated, and distributed applications within work settings, involving a higher degree of participation from users of systems.
- 3rd Wave – triggered by the expanding context of HCI far beyond the workplace, an expansion resulting from the increasingly pervasive and ubiquitous essence of computation in everyday life. The 3rd wave places a stronger emphasis on human values, meaning-making, situated knowledge, and experiences.

Grudin (2005) considers the divergent foci on "computer operation, information systems management, and discretionary use" (46) to be the defining features of the three waves of HCI. Grudin emphasizes that these three strands of HCI have not converged and remain relatively autonomous today, and the three frames of inquiry are defined by two research cultures reinforced by differences in scholarly production and activity. A particularly interesting aspect of Grudin's account is that these three kinds of HCI research run in a parallel historical developments. The first wave, for Grudin, is grounded in engineering psychology and has been initiated with the human-machine interface. Although such machines were not necessarily in the first instance computational, the consideration of Human Factors can be traced back to its earliest origins in Taylor's scientific management of the early twentieth century. Grudin distinguishes compulsory (e.g. work and war) and discretionary (e.g. home and leisure) use as a critical difference that defines second- and third wave HCI research approaches. HCI oriented toward discretionary uses begins, in his account, with general purpose computers circa 1945, while information management-focused HCI begins in the mid 1970s with sociotechnical and participatory design approaches. Once founded, all three strands of HCI continue to progress in parallel through new developments discussed in journals, academic societies, and conferences which operate in relative cultural isolation from each other to the present day.

Harrison et al. (2007) formulate a third understanding of the three waves defined as a difference of 'paradigms' in the Kuhnian sense. For these authors, the first wave centered on engineering and human factors (i.e. human-machine "coupling") and was essentially atheoretic and entirely oriented toward pragmatic design enhancements and solutions, such as helping pilots effectively utilize cockpit instrument panels of increasing complexity. The second wave of HCI was grounded in cognitive science disciplines, where human-computer interaction is understood in terms of information transfer and efficiency of communication between a mind-as-information-processor, and an interface communication with that mind. The third wave is characterized by a growing interest in design that takes into account the full 'messy' context of socially situated and embodied action, which introduces humanistic and social science considerations into design research. These once marginal research agendas have moved toward more central positions in HCI discourse, prompting the notion of a third paradigm. "Participatory design, value-sensitive design, user experience design, ethnomethodology, embodied interaction, interaction design, and critical design" (2) as a grouping are brought together under the

heading of the "phenomenological matrix" due to the highlighting of the embodied and socially situated interactor where more than simply efficiency of operation or information transfer is at stake.

While the conceptualization of the historical waves of HCI differ significantly in the details, at a more global level there is a commonality in the sense of a gradual and considerable expansion of HCI's concerns, methodologies, and application areas. The earliest HCI work was strongly based on the concept of human-machine coupling, which expanded to workplace collaboration as computers came into mainstream professional use. Today, HCI can connect to increasingly more sides of human experience because now there is an app for every almost any aspect of daily life. Despite this clear sense of a commonly understood trajectory in the expansion of HCI's domains of research and application, there are some tensions to be noted as to how one understands this historical progression. Do the new waves replace the old, or update them? Can one combine waves through hybrid research agendas? Are they complementary to each other? Which wave is 'the right one' today? What is meant by a 'wave' in the first place? What fourth wave might be on the horizon? These two volumes allow us to explore such general disciplinary questions while also focusing in depth on particular aspects of methodologies and technologies to better understand the range of practices associated with third wave HCI today.

1.2 Are the Waves 'Paradigms?'

In one of the articles noted above that inspired this project, the three waves of HCI are understood as Kuhnian paradigms (Harrison et al. 2007). As compelling as this appears in terms of a general disciplinary taxonomy, careful consideration reveals some conceptual matters of potentially problematic nature. One of the most apparent issues to note is that the three paradigms of physics described by Kuhn (e.g. Aristotle, Newton, Einstein) unfold over thousands of years, whereas HCI paradigm formation seems to emerge and develop within a very short timeframe. Such fast speed of progression triggers new paradigmatic shifts in a matter of decades, producing a historical development several orders of magnitude faster than the sciences studied by Kuhn.

A key aspect of Kuhn's paradigm theory relates to the idea of incommensurability between paradigms, and the alterations between normal and extraordinary science. The way scientists in the Greek-, Enlightenment-, and contemporary periods understand phenomena (such as force, substance, motion, and acceleration for example) are incommensurate because of the difference in the conceptual and terminological frameworks that describe the underlying phenomena in question. Such frameworks seem to not be translatable into each other. Moreover, paradigm shifts are 'revolutions' in which normal science – which Kuhn conceptualizes as a form of mundane puzzle solving – is shaken up by extraordinary science, which takes up new research agendas in relation to anomalies that have turned up within normal science:

> In a given scientific field, long periods of conservative, tradition-bound normal science are punctured by an occasional crisis and, still less frequently, by a revolution. Normal science is highly regimented work under a paradigm. It aims to extend and articulate the paradigm, not to test it, for the paradigm *defines* the research tradition, the scientific life, of a particular discipline and its practitioners.

> During a crisis period the usual conservative strictures relax somewhat, and truly innovative ideas and practices may emerge as serious alternatives. The repeated failures of the normal scientists to handle the crisis situation, together with the emergence of a promising new approach, may trigger a revolution.

> [T]wo competing paradigms are "incommensurable," meaning, roughly, that they cannot be measured against the same standard….[I]n the more radical passages of Structure, he spoke of paradigm changes as akin to Gestalt perceptual switches, religious conversions, and political revolutions, comparisons he later dropped (Nickles 2002, loc 77, emphasis in original).

In order to more accurately appropriate the notion of paradigms into HCI discourses, we can distinguish between 'hard' and 'soft' understandings of paradigms. A 'hard' notion focuses on common dynamics of generational change and upheaval, revolution, accounting for anomalies, emergence of new exemplars and methods to take up unsolved puzzles. Such 'hard' essentialization of a paradigm creates discourses that are incommensurate with each other, where epochal and historical progressions in a discipline confine researchers to 'living in different worlds.' This scenario seems to be a poor fit with the three waves of HCI, not least because the waves conduct inquiry into very different phenomena, as opposed to studying the same or similar problems through differing and incompatible conceptual frameworks. As the contributions to these two volumes show, many practitioners develop hybrid approaches and technologies bridging across the discursive terrains of the various waves.

We believe that a 'softer' conception of paradigms is better situated to fit the domains of HCI discourse. A 'soft' understanding emphasizes communities of inquiry and shared exemplars, held together by a fuzzier logic of 'family resemblances.' The three waves under this paradigmatic model approximates families of related approaches, examples, puzzles, problems and solutions. Nersessian (2002) applies Eleanor Rosch's theories of concept formation to Kuhn's notion of paradigms to articulate the discourse and practices of research communities:

> Most of Kuhn's work after writing Structure centered on issues of what he called the scientific "lexicon," specifically, on how the language of a scientific community is acquired and how language changes relates to incommensurability.

> What one acquires in learning a conceptual structure are not sets of defining characteristics and specifiable rules for the concepts that participate in the problem exemplars comprised by the paradigm. Rather, one acquires sets of "family resemblances" that include both similarities and differences amongst instances.

> [R]esearch on categorization in cognitive psychology begun in the early 1970s by the psychologist Eleanor Rosch and her collaborators provides a cognitive underpinning for many of Kuhn's intuitive insights about concept representation and acquisition.

> [R]ather than representing concepts by sets of defining criteria, humans represent both natural and artificial concepts by a prototypical example. Category membership is determined by similarity and dissimilarity to the features of the prototype.
>
> Further, concepts show graded structures. That is, some instances of a given concept are better examples of the concept than other instances. (loc 2622).

Nersessian's approach seems to form a better match for the situation of paradigms in contemporary HCI fields. Understood in this 'softer' manner of graded category membership and family resemblance, the difference between HCI discourses and practices takes on a more recognizable outline. These two volumes can thus be understood as a way of organizing the family resemblances of third wave HCI across rich application and methodological domains – at once highly different from each other, yet recognizably belonging together in their distinctive differences from first and second wave approaches.

1.3 Theoretic Integration

> In preparing for a CHI 2015 panel on transdisciplinary design [...], I was asked if a fourth wave is coming. My best answer is that HCI is in the middle of a chaos of multiplicity in terms of technologies, use situations, methods, and concepts. Hopefully something lies beyond that horizon, but for now, I'll leave it to others to identify it (Bødker 2015).

While it is not the direct goal of these volumes to point the way to a fourth wave, it is possible to see some paths emerging for what this might look like – especially if we note the global commonalities in the distinctions between the waves, and take a softer or fuzzier family resemblance stance toward category membership of such vast research terrains. Niklas Luhmann's systems theory could serve as a basis for a more integrationist positioning amongst the divergent academic cultures and exemplary problem-types of contemporary HCI.

Luhmann's systems theory transcends Mind-Body dualisms (and by extension, traditional subjective/objective dichotomies) by introducing a third term – Communication – into the conceptual mix. Appropriating Varela and Maturana's concept of autopoiesis, Luhmann understood (1) Mind, (2) Body, and (3) Communication as separate and distinctive autopoietic systems in structural couplings to each other and to their environments. Two minds in close physical proximity, for instance, are operationally closed to each other – this is demonstrated by the absence of telepathic effects. A third autopoietic system – that of Communication – is needed in order to achieve information transfer between them. For Luhmann, minds don't communicate, only communication communicates (this is a function of its being an operationally closed, autopoietic system). He considered his theory to be a 'super theory' because it included itself in itself, as a theory of making distinctions generally, conceiving of communication, cognition, and bodies as systems that are always making self-other distinctions between their own operational closure and their environments.

Luhmann's systems conception aligns strongly with the three waves of human-computer interaction as he understands technologies to be in the environment of living systems. Within such conceptualization, the first wave of ergonomics-oriented approaches corresponds to structural couplings of technology to the Body, while second wave information processing models address the cognitive capacities of Mind. The third wave's central focus on meaning-making completes the mapping to Communication as its own autopoietic process. We will ground this somewhat abstract discussion in a concrete example by referring to Veronika Tzankova's current research in interactive sports technologies. Her research involves the development of new technical systems for horse riders to improve their overall performance in this contact sport. The successful operation of such systems involves considerations at several levels that closely correspond to the three waves associated with HCI. First, the system requires to be physically constructed which engages technical and ergonomic concerns – such as physical design of the equipment, posture of rider, and kinesiological characteristics of the horse. This level corresponds to problem conceptualization characteristic of first wave HCI. Second, the design of the system should take into account cognitivist considerations – e.g. not distracting the rider through misallocation of limited attentional resources – problematics essential to second wave HCI. Last, the system should effectively communicate to the rider by providing feedback that makes sense – facilitating interspecies communication between technology, horse, and rider through embodied interactions. This level of 'meaning making' is a distinct theme of third wave HCI. A system such as this – especially coming from a sports context where all three levels are vital to the safety and security of the sportsperson engaged – exemplifies the growing necessity of a research agenda that integrates all three HCI waves through discursive and practical variations based upon Luhmann's three autopoietic systems categories of Body, Mind, and Communication.

It is not just that Luhmann's theory logically maps to the typologies of the three HCI waves as explicated by others, but rather actually provides the only model available amongst the major theorists for imagining a possible convergence of all HCI discourses and practices. Instead of academic tribes of subspecialists narrowly concerned with their own local and preferred exemplars and problem-solution spaces, the Mind-Body-Communication matrix could point to a fourth wave of 'integrationist' agendas that at this point we can offer as a speculative gesture on our part. This goes somewhat further than Bødker's discussion "When second wave HCI meets third wave challenges" (2006) by suggesting that even first wave HCI might have potential for reintegration with the new domains and methods presented by the third wave.

While not usually grouped together as a set of related intellectual movements, systems theory shares a common origin with phenomenology and pragmatism in the development of new concepts in an attempt of transgressing Enlightenment binary positions. Just as thinkers like Husserl, Merleau-Ponty, James, and Dewey sought a way out of the traditional Empiricism vs. Idealism philosophical impasses, Bertalanffy's original formulation of general systems theory served as a way of moving beyond Determinism and Vitalism as explanatory frameworks for under-

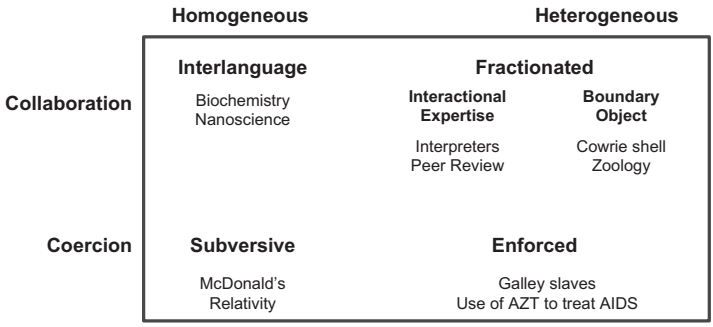

Fig. 1.1 Collins et al. general model of trading zones (as presented in Gorman 2010: Fig. 2.1)

standing organized wholes of self-interacting elements. Taken together, phenomenology, systems theory, and pragmatism can be understood broadly as 'third way' approaches that move beyond reductive-causal concepts on the one side, and ideal-spiritual explanations on the other, within an all-encompassing consideration of subjective, objective, and praxeological phenomena.

1.4 Trading Zones and Interactional Expertise

The third wave has generated perhaps the greatest expansion in the disciplinary interactions of HCI with other fields, and can be broadly understood as a trading zone with humanist and social science theories:

> Two groups can agree on rules of exchange even if they ascribe utterly different significance to the objects being exchanged; they may even disagree on the meaning of the exchange process itself. Nonetheless, the trading partners can hammer out a local coordination, despite vast global differences. In an even more sophisticated way, cultures in interaction frequently establish contact languages, systems of discourse that can vary from the most function-specific jargons, through semi-specific pidgins, to full-fledged creoles rich enough to support activities as complex as poetry and metalinguistic reflection (Galison 1997, 783)

> A trading zone can gradually become a new area of expertise, facilitated by interactional expertise and involving negotiations over boundary objects (objects represented in different ways by different participants). (Gorman 2010)

Third wave HCI has proposed in a sense a 'double condition' of negotiating trading zone inquiry with other areas of HCI research, together with scholarly domains far beyond HCI. Collins et al. (2010) have modelled trading zone inquiry into quadrants defined by the axes Homogeneity-Heterogeneity and Collaboration-Coercion as follows (Fig. 1.1):

> Interlanguage trading zones operate by developing new cultural tools, subversive trading zones operate by imposing one culture on another, while enforced trading zones operate with almost no cultural interchange. The final type of trading zone, which occupies the top

> right-hand area of the table, involves fractions of cultures as the medium of interchange. There are two kinds of fractionated trading zones: boundary object trading zones, which are mediated by material culture largely in the absence of linguistic interchange, and interactional expertise trading zones, which are mediated by language largely in the absence of the material (loc 169).

HCI clearly has both sides covered in the Fractionated quadrant, being a research practice typically organized around the development of new technical designs, while also being a subject of academic discourse. Where the material culture aspect is perhaps most foregrounded is in the appropriation of forms such as artworks, critique, or various communications media, where content and connotation considerations may take on as much interest as usability. Since third wave HCI has as an orienting feature a concern with meaning making, entertainment, aesthetic experiences, culture forming, style trends, or rhetorical arguments, for instance, can take on an increasing role in investigations and research output. Considering these volumes as a whole in relation to the general model of trading zones, third wave HCI seems 'squarely' (no pun intended!) in the Collaboration-Heterogeneous quadrant. Our framing of Luhmann's 'super theory' as a method for integrating all HCI waves could in trading zone terms be understood as a convergence toward the top left Interlanguage quadrant. This quadrant is also understood as the end-phase of trading zone development:

> Thus biochemistry, though it grew up as a trading zone, is now just a new homogenous cultural location in which trades happen. When they reach their end points, all the examples in the left-hand areas slip off the table in the westerly direction, as it were (loc 210).

It will remain to be seen of course whether HCI continues along its current path of increasing divergence and plurality of approaches, or whether new lines of convergence may start to draw the different strands together. Regardless of the course of development, the understanding of future trends necessarily depends on our thorough understanding of current affairs. Thus, the objective of *New Directions in 3rd Wave HCI* is to position present and emerging trends shaping the field of human-computer interaction both in terms of (1) technological dynamics (Volume I), and (2) systemic practices of study (Volume 2). As most individuals interact with technology routinely for extensive periods of time (File and Ryan 2014), it is important to understand the experiential dimension of HCI as a source of knowledge and design.

To address these issues, *Volume 1 – Technologies* focuses on the conceptualization and documentation of contemporary third wave HCI. It presents key developments at the leading edge of human computer interactions by providing reflective insights on the theoretic and practical conceptualization, valuation, and development of contemporary technologies. By doing so, this compilation of essays serves as a resource for understanding human-computer interaction through a multiplicity of interdisciplinary perspectives that can facilitate the systematic epistemological shaping (and reshaping) of technological design and production practices. The combination of perspectives from the humanities and social sciences emphasize the importance of human and experiential dimensions within HCI and contribute to the

better conceptualization of the challenges and opportunities that arise as a result of the rapid development and impact of technological progress. Transcending the task-orientedness characteristic of earlier HCI research, *Volume 1: Technologies* covers areas related to artificial intelligence, machine learning, metacreation, 3D printing, critical making, sensorial computing, physical computing, the internet of things, virtual reality, multimodal display, sonification and language technologies, within a frame of experiential inquiry. Drawing on the vast interdisciplinary expertise of the contributors, this volume investigates the experiential and expressive dimension essential to the positive progress of the field of HCI.

Designed to introduce the central themes of research design approaches, *Volume 2 – Methodologies* focuses on latest practices and conceptualizations of the systematic study of HCI. The volume introduces new methodological approaches – often situated in practical case-studies – that integrate human and experiential inquiry within the study of human-computer interactions. Its objective is to identify and address methodological challenges specific to third wave HCI and to propose research approaches embedded within phenomenological, experiential, and expressive modes of investigation. We also hope that the systematization of 'third wave' approaches to the study of HCI can serve further as a platform that invites ideas and 'ways of knowing' from different epistemological domains into ongoing design practices and applications. This volume integrates diverse research methods, ideas, and perspectives with the aim to highlight and integrate relevant – but often segregated – expertise from the arts, design, social sciences, and the humanities. The application of methodological approaches specific to the particularities of third wave HCI is essential to the development of new, effective, usable *and meaningful* technologies. *Volume 2: Methodologies* covers methodological approaches grounded in autoethnography, empathy-based design, crowdsourcing, psychometrics, user engagement, speculative design, peripheral practices, somatics, embodied cognition and transdisciplinarity. In addition to facilitating inquiry into the design of new technologies, this survey of approaches aims to encourage researchers and designers of technology to critically examine the gamut of processes involved in the production of contemporary technologies.

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Chapter 2
Steampunk, Survivalism and Sex Toys: An Exploration of How and Why HCI Studies Peripheral Practices

Theresa Jean Tanenbaum and Karen Tanenbaum

Abstract In this chapter we describe a trend we have observed in 3rd-wave HCI research, which we are calling "peripheral practices research". This form of research consists of primarily qualitative studies of niche, unusual, marginalized and/or highly specialized communities of practice that result in implications for HCI outside of that community. We describe how peripheral practices research serves three critical functions within HCI: (1) It introduces a diversity of perspectives into the field; (2) It identifies new approaches to existing problems and challenges; (3) It serves as a defamiliarizing lens on existing norms and assumptions within the field. We survey a broad and diverse selection of studies that engage with peripheral practices, and discuss four specific cases in more detail. By giving this mode of HCI research a name, we hope to see even more studies that look outside of the classical HCI domain for new ideas, new perspectives, and new values around technology.

2.1 Introduction

Most research in HCI is concerned with large socio-technical phenomena: social media practices, applications for ubiquitous computing, ethics and big data, information security and privacy, and other broad cross-cutting areas of inquiry are central to the efforts of the HCI community. However, in its "third wave", HCI has also benefited from devoting attention to communities of practice that operate at the margins of "mainstream" socio-technical activity. In this chapter we consider how and why some HCI research turns its attention to what we're calling "peripheral practices" to better understand the way in which these edge cases have informed more mainstream HCI research. We argue that attention to the periphery of technology use can inspire

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new designs, provide evidence for emerging paradigms, serve as a powerful defamiliarizing lens, and better engage with diverse stakeholder communities.

2.2 Making Waves in HCI

The first wave of HCI, which in many ways still forms the core of the field, was centered around engineering & human factors analysis. It was primarily concerned with "man-machine coupling" and understanding and optimizing the ergonomic fit between people and technology in the workplace (Harrison et al. 2007). The second wave of HCI moved from a focus on machinery and ergonomics into a more cognitive and information-processing paradigm. Researchers in this wave looked more at "mind-computer coupling" and aimed to optimize rationality and efficiency in information transfer (Harrison et al. 2007). The second wave also expanded beyond a single individual and machine pair, looking at groups working with applications, most often in a work setting within established communities of practice (Bødker 2006). In this context we start to see the rise of participatory design methods and contextual inquiry that brings the users into the design process and incorporates greater understanding of the use context. Finally, in the third and current wave the concerns of HCI expand out to consider issues of meaning construction, social situatedness, multiple interpretations, and context and value sensitive design (Harrison et al. 2007). Within this paradigm, use and context are broadened & intermixed with issues of culture, aesthetics, emotion, and experience complicating and enriching the field of study (Bødker 2006). There is a rise in looking at non-work, non-purposeful, and non-rational use of technology, i.e. in leisure, domestic and esoteric settings. This broadening of the scope of study brings a series of challenges on how to analyze, evaluate, and distill knowledge from these contexts. In this chapter we highlight one particular method for undertaking 3rd wave HCI work, which is increasingly common but not yet clearly called out as an established methodology.

2.3 What Do We Mean by "Peripheral Practices"?

In writing this chapter, one of our primary challenges has been deciding on the best terminology to describe the phenomenon we wanted to address. We have observed over the past decade a research trend that seems to be characteristic of the third wave of HCI: primarily qualitative studies of niche, unusual, marginalized and/or highly specialized communities of practice that result in implications for HCI outside of that community. The earliest examples of this were published in 2006 and 2007, concurrent with the first papers that theorized the notion of the third wave of HCI. But the range of subjects included in this research is almost impossibly diverse, including: body modification aficionados (Lingel 2012), the "Warez Scene"

(Chandra 2016), teens in foster care (Badillo-Urquiola et al. 2017), punk rockers (Lingel et al. 2012), Syrian refugees (Xu and Maitland 2016), craft beer makers (Foster et al. 2017), political activists (Kuznetsov et al. 2010; Vlachokyriakos et al. 2017), internet trolls (Kirman et al. 2012), veterans (Semaan et al. 2016), skateboarders (Hauser et al. 2013), queer communities (Van De Wiele and Tong 2014; Yeo and Ng 2016), "Makers" (Kuznetsov and Paulos 2010a; Wang and Kaye 2011; Tanenbaum et al. 2013b), BDSM practitioners (Bardzell 2006; Bardzell and Bardzell 2007), sex toy manufacturers (Bardzell and Bardzell 2011; Goodman and Vertesi 2012), sex workers (Sambasivan et al. 2011; Strohmayer et al. 2017), the homeless (Le Dantec and Edwards 2008; Kuznetsov and Paulos 2010b; Roberson and Nardi 2010; Woelfer and Hendry 2010; Koepfler and Fleischmann 2012; Massimi et al. 2012), antiquarian bookbinders (Rosner and Taylor 2011), IKEA hackers (Rosner and Bean 2009), Steampunks (Tanenbaum et al. 2012, 2013a), Tumblr fandoms (Hillman et al. 2014), furries (Liu 2017), and more. Taken individually, each of these subjects might be seen as a "curiosity" within HCI research, but when viewed in aggregate, we believe these kinds of studies paint a compelling picture of how paying attention to sociotechnical phenomena outside of the "mainstream" can enrich HCI as a field.

The challenge lies in finding a term to collectively refer to research of this kind without trivializing the variation among the communities being studied. Some of the communities are essentially niche hobbies or otherwise esoteric, voluntary activities: body modders, craft beer makers, antiquarian bookbinders, the warez scene, and IKEA hackers. Other groups, sometimes also based on niche activities, expand into more of a subculture or lived identity which can permeate everyday life, such as with the punk rockers, Steampunks, and Makers. Still other groups could be categorized as marginalized or vulnerable communities, and are frequently not identities that people "choose" the way they do their leisure activities, i.e. the homeless, Syrian refugees, or sex workers. But of course these categories are overlapping, as even within the category of "niche hobbies" there are groups that are more stigmatized (body modders) and those that are less (craft beer makers) and there is often no clear line between hobby, job, subculture, identity and community. The practices studied include aspects of daily lived identity as well as esoteric work conditions; weekend hobbies as well as circumstances of significant economic, personal and political strife. The only thing they have in common is, essentially, that they are not the "default" situation that is the premise of classical HCI studies: predominately male, white, middle class, straight and cisgender computer users in workplace and domestic settings.

We have considered and discarded many different terms for the phenomenon we are trying to describe in this chapter. Among the terms we considered were: "marginal", "niche", "other", "fringe", "alterior", and "subcultural". These terms, however, didn't apply to all cases, came with too much baggage for our comfort, or had negative connotations that we didn't want to invoke. The imperfect term we have finally settled upon is "peripheral practices". While we feel it captures the largest cross section of the work that we're interested in, it is not without its own issues.

Perhaps the biggest problem with the term is that it invokes a fraught relationship between the "center" and the "periphery", the problematic rhetoric of which is best articulated in Dourish and Mainwaring's postcolonial critique of the Ubicomp community (Dourish and Mainwaring 2012). They point out that a lot of rhetoric around technological progress "speaks in terms of centers of innovation from which new ideas, new technologies and new understandings flow out into the world". They challenge this notion of the "center" as the source of new ideas, but also note that the problem is not fixed by counter-claiming that "innovation arises at the margins". The paper asserts that "the very rhetorical distinction between center and periphery, never mind the elevation of the center to a privileged position, is a misstatement." In the conclusion of the paper, the authors advise HCI to "embrace polyvocality, diversity and multiple perspectives." Our goal with this chapter is to highlight the existing research that is taking up this call, by focusing on peripheral-appearing practices and taking them seriously as centralized practices for small groups of practitioners.

In her paper on *The Ethnography of Infrastructure,* Susan Leigh Star writes that "one person's infrastructure is another's topic, or difficulty" (Star 1999). This highlights the ways in which infrastructure is a "relational property" that changes depending on the perspective of a user. Infrastructures exist in the background unless you are in a situation where they are a central focus of attention. For example, most urban mobile phone users only engage with the infrastructure of cellular data when they find themselves outside of their carrier's coverage area, whereas a technician responsible for maintaining cellular towers experiences that same infrastructure foregrounded daily as a site for repair and maintenance. Similarly, one person's everyday practices with technology (for example, an urban 20-something) might represent a radical departure from the norms of another (a rural retiree). In the same way, the distinction between "center" and "periphery" is one that emerges from an individual's situatedness within a culture of practice. The notions of "center" and "periphery" in HCI research are continually being negotiated within the field, as subjects that had once been central to the "eclectic interdiscipline" (Rogers 2012) of HCI become new disciplinary centers unto themselves (Abowd 2012). Our interest within this chapter is not in those practices and communities which have matured into fully formed areas of concern within the field, but instead with those practices and communities that have not yet been (and indeed, may never be) centralized within HCI. We hope this approach can serve as a "decolonizing lens" for HCI research by viewing mainstream, monolithic-appearing HCI practices through the lens of more diverse and idiosyncratic communities. From this perspective, we use the term "peripheral practices" to signify those socio-technical practices that meaningfully diverge from what might be considered "mainstream" or "centralized" activity within HCI, which also acknowledging that the term is imperfect.

2.4 "Design for" vs "Learn from"

While we are generally interested in HCI research that is concerned with peripheral practices, we make a distinction between work that aims to "design for" these communities vs. work that seeks to "learn from" them as a source of insight and inspiration. In this chapter we focus on the latter category of research, although often this distinction is one of intent rather than of method. In fact, different papers within the same research project can fall into different categories. For example, Eaglin and Bardzell's paper on "Sex Toys and Designing for Sexual Wellness" (Eaglin and Bardzell 2011) engages with social taboos around sexual technology in order to develop design principles for sexual health. This work-in-progress paper undertakes interviews with experts in sex toy design and sexuality research in service of better design for a peripheral context, but does not make broader recommendations to the HCI community. In contrast, the paper from the same research group entitled "Pleasure is Your Birthright': Digitally Enabled Designer Sex Toys as a Case of Third-Wave HCI" employs similar interview methods within a community of sex toy designers to foreground modes of practice that can more broadly inform HCI research (Bardzell and Bardzell 2011). Both of these papers engage with sex toy use and design – a subject that has received relatively little attention from the HCI community – however only the latter of the two is engaged in the kind of epistemological work that we are concerned with here, which brings insights from peripheral practice into conversation with the broader field.

2.5 Case Studies of Peripheral Practices Research in HCI

In this section we select a few examples from the large list above and describe the motivations, methods, and contributions of the works involved in order to paint a clearer picture of how such research has been deployed within third wave HCI. The case studies contained herein should be viewed as the product of our own situated perspective, writing about HCI in early 2018 within a North American context.

2.5.1 Steampunks

In 2012, we published a paper on the Steampunk subculture as a case study for new ways of thinking about relationships to design and technology (Tanenbaum et al. 2012). Steampunk began as subgenre of science fiction literature that traces its roots back to the early science fiction of Jules Verne and H.G. Wells. Most works in a Steampunk setting take place in a world in which steam power rather than the internal combustion engine became the dominant form of energy, creating an alternate history where aspects of the modern day, such as computation, combine with

elements of Victorian aesthetics, materials and culture. One of the key defining characteristics of Steampunk, however, is that it is built around physical artifacts (props, costumes, etc) that evoke this imagined alternate past, present and future. Steampunks not only spend time & money creating these artifacts, they attend conventions and other gatherings where they wear their costumes, often take on a persona or character, and engage in a kind of lived identity drawn from this fictional world. Looking at the online evidence of how the Steampunk community undertakes and disseminates design practices related to the creation of props and costumes, we identified themes related to material practice, technical skill dissemination and the development of a more agentic relationship to technology.

2.5.2 Bookbinding & Restoration

Daniela Rosner and Alex Taylor (2011) describe antiquarian book restoration practices for the CHI community. This research is not concerned with making book binding better or more technologically augmented. Rather, it seeks to take knowledge from these practices and apply them to our understanding of software and technology design. The research questions motiving the work include: "What might it mean to restore old operating systems and software to their original condition, instead of, for example, simply upgrading them? Might there be value in how technologies wear, rather than how effectively they perform? How might HCI foster more longstanding relationships with digital technologies as they have developed with some traditional media – such as manuscripts, photographs or books?" (Rosner and Taylor 2011) The researchers visited seven bookbinding/restoration workshops and interviewed amateur and professional restorers, as well as their customers. From these interviewers, the researchers extracted insight into issues of authenticity and longevity that can also inform software and hardware design. Similarly, Rosner later undertook a three-month long apprenticeship in bookbinding and used this experience to extract lessons on materiality and collaboration (Rosner 2012). These insights were applied to how the field of computer-supported cooperative work (CSCW) approaches digital materiality and temporality.

2.5.3 Sex Toy Design

Bardzell & Bardzell spoke with designers of high-end sex toys to get insight into a very specific and often stigmatized design space (Bardzell and Bardzell 2011). By studying this highly personal and embodied design practice, the Bardzells highlight the ways in which 3rd wave HCI could incorporate this experience-first approach to design, asking "what might it look like when designers start with the objective of designing to support pleasurable, embodied, affective experiences? We have seen that in the case of designer sex toys, designers operate in a critical, rather than

empirical, space. They interrogate key vocabulary, from sex to attraction to feeling sexy to love itself, dialogically, by engaging in design criticism, reasoning from their own experiences, and having intimate conversations with friends, family, colleagues, customers, and even strangers" (Bardzell and Bardzell 2011). This approach to design requires a high level of intimacy and vulnerability on the part of the designers as well as the users who are contributing their opinions and insight.

2.5.4 Survivalists and Preppers

Within our own research group, we have been looking at the technology practices of survivalists and "preppers". These are communities of practice that invest substantial time, energy, money, and thought into how to live in a world of impoverished infrastructures. Frequently (but not always) these practitioners adhere to a constellation of often extreme political and ideological commitments that position them outside of normative culture in ways that make it hard to study their activities without also engaging with their motivations and personal narratives of the future. Historically, survivalism has been a difficult phenomenon to study closely, due to the often secretive nature of survivalist communities (Mitchell 2002). However, in recent years, much survivalist discourse and activity has moved online, allowing insight into a set of material practices that were previously inaccessible. We study survivalists and preppers from the perspective of Sustainable HCI (DiSalvo et al. 2010; Silberman et al. 2014) and Computing within Limits (Tomlinson et al. 2012; Pargman and Raghavan 2014). The fields represent two sides of the same set of underlying concerns. SHCI asks how technology designers and researchers can support more sustainable relationships to the natural resources of the planet, while LIMITS asks "what do we do?" in the face of diminishing access to resources, infrastructures, and materials that are frequently treated as limitless when conceptualizing technological futures. If we consider that we live on a planet with limited capacity to generate food, energy, minerals, and clean water over the long term, then it becomes prudent to seek out expertise from communities that are already designing resilient infrastructures and practices that anticipate a context of scarcity. As with other research into peripheral practices, our ongoing work in this area adopts an "outsider" perspective in order to better understand existing orthodoxies in the field.

2.6 Why We Study Peripheral Practices

Across these case studies, as well as in the broader body of peripheral practices research, we have observed some recurring epistemological commitments. This kind of research does not produce generalizable empirical truths about technology, nor should it. Peripheral practices research instead serves to introduce

diversity and uncertainty into HCI discourses, by highlighting the ways in which sociotechnical phenomena in the world do not fit into any "one-size-fits-all" theory or framework. We identified three primary contributions peripheral practice research makes to HCI: (1) it documents and explores a diversity of relationships with technology, (2) it functions as a testbed for unusual design strategies, (3) it acts as a defamiliarizing lens.

2.6.1 Diversity of Relationships with Technology

Attention to peripheral practices foregrounds the diversity of potential practices and relationships with technology. In some cases, this research is explicitly interested in what happens to our relationship with technology when "normal life" is disrupted. Such is the case with Massimi et al.'s work on technology use during life disruptions such as situations of domestic abuse, the death of a family member, or the loss of a stable home (Massimi et al. 2012). They write "by examining the extremes, we can shed new light on areas of technology use and design", arguing that studies of extreme situations "broaden how domestic technologies are considered within HCI and open discussion about a wider range of concerns when conceptualizing technology use in our personal lives" (Massimi et al. 2012). Our work on Steampunk makers similarly looked at how the subcultural practices of this particular hobby group highlighted a diverse constellation of political and ethical commitments about the relationship between consumers and producers of technology (Tanenbaum et al. 2012). Our work on survivalists treats these communities as templates for new modes of thinking about our relationship to the material resources and (often fragile) infrastructures that are taken as a given within the world of technology design. Studies of peripheral practices do important work to remind us that humans are diverse in their interests, backgrounds, lifestyles, needs, and values. By calling attention to highly specialized and unexpected human practices, this kind of work helps us avoid the impulse to overgeneralize about people and technology. Citing Sarah Thornton's seminal work on subcultural capital (Thornton 1996), Jessica Lingel describes how studying non-normative, subversive, and risky practices within the extreme body modification community benefits from ethnography's particular suitability at looking at "the diverse and the particular" instead of the more general and mainstream (Lingel 2012).

2.6.2 Testbed for Unusual Design Strategies

In other cases, the kinds of insight produced by studying peripheral practices give us insight into alternative ways to do design work that deviates from classical HCI approaches. In the case study presented above on high-end sex toy designers, the Bardzells describe an approach to technology design that foregrounds vulnerability,

intimacy and embodiment on the part of the designers and users (Bardzell and Bardzell 2011). This is also seen in Chandra's study of the supply side of the illegal software trading scene (Chandra 2016). Chandra draws a line between the robust long-term practices of the warez scene and the design of other virtual communities, writing "the longevity of the warez scene provides important pointers on the specific mechanisms that can sustain robust virtual communities" (Chandra 2016). In this example, the peripheral community represents an exceptional context that has developed particular solutions and strategies that address problems that plague other similar contexts. Similarly, our studies of survivalists and preppers have been looking at how new solution spaces emerge when different values and ethos are applied to an existing problem in SHCI: how do we design for scarcity. These are examples of peripheral practices research seeking "in-the-wild" cognates for current challenges in the field, or for envisioned future challenges.

2.6.3 Defamiliarization

Studying peripheral practices can work as a form of "defamiliarization" (Bell et al. 2005), allowing researchers to adopt a new "outside" perspective that allows them to understand the mainstream of HCI in a new way. But it can also serve as a method for interrogating specific domains and solution spaces by focusing on exceptional practices and learning from them. Studying survivalists helps us to think critically about facets of HCI practice that are often invisible, such as the assumption that the massive manufacture and distribution of consumer technologies such as smartphones will continue indefinitely into the future, or assumptions around the long-term survivability of cloud computing infrastructures, internet server farms, and distributed sensor networks. Similarly, Rosner & Taylor's work on bookbinding provides a lens from which to view modern day software practices in a new light, with the repair and restoration focus of antiquarian practices throwing the cycle of planned obsolescence into sharp relief (Rosner and Taylor 2011).

2.7 Ethical Considerations and Challenges

The research we've discussed here is primarily qualitative in nature and frequently deploys ethnographic methods, which should not be surprising. Because so many of the specific practices and communities under study here are stigmatized or vulnerable there are particular challenges to ethnographic work in this context. Although we will not tackle the broad issue of conducting ethnographic research within sensitive or vulnerable populations, we will consider a few specific examples from the HCI work that we have reviewed. In some cases, researchers of these spaces find themselves negotiating delicate lines between participant observer and researcher, as with Lingel's research in the body mod community (Lingel 2012). Both Lingel's

research and Chandra's work on the "Warez Scene" were additionally complicated by questions of what was and was not illegal activity, a distinction that sometimes varied from state to state (Lingel 2012; Chandra 2016).

In his ethnography of the Orange County Furry community, Calvin Liu had to negotiate a similarly delicate situation. Furries are united by their shared interest in anthropomorphic and zoomorphic art, costume, and media (Liu 2017). The furry subculture is a highly stigmatized fan group, which makes them a vulnerable and closed community to study from the outside. Privacy is a major concern for furries, and researchers seeking access to events within the community must demonstrate that they are not there to "out" anyone, or mock the community, or otherwise pathologize members of the group. Although not all furry groups engage in sexualized activity, there is a common public perception of furries as sexual deviants, both within and outside of furry culture (Liu 2017). To engage with this community in a manner that was not exploitative or pathologizing, Liu needed to demonstrate that he was sympathetic to the norms of the community without misappropriating or stigmatizing them. He did this by performing his researcher persona through a hand-worn plush cat puppet that he introduced as "cat" when out at events and other community functions. In another context, such a move might have invited ridicule, however, Liu discovered that this performance of shared interest was sufficient to "break the ice" within the furry community, allowing him to build relationships and recruit interview subjects that might have otherwise been wary of him (Liu 2017). This approach could easily have backfired: had he been perceived as insincere or mocking of the community then his "gimmick" could have isolated him from the population he sought to better understand.

Liu's experience in the furry community reveals a bit of a chicken-and-egg problem that occurs when approaching vulnerable, non-normative, or socially stigmatized groups. Often, acceptance into these spaces requires one to understand and perform a set of emic norms that are understood within the community, but are not necessarily clear to an outsider. However, these can be difficult to learn without some sort of "insider" support. Liu was able to learn many of the community norms by "lurking" in the spaces where furries gather online, spending months observing online behaviors before reaching out to people in the physical world (Liu 2017). Similarly, in our studies of survivalists and preppers, we have spent significant time reading the forums, blogs, and websites that this community maintains in order to to better understand how to engage with them in a respectful manner. When doing this kind of research, it is important to avoid treating subcultural communities solely as a source of insight to be exploited, reframed, and integrated back into the mainstream of HCI. We must engage with them sincerely, on their own terms, and in a way that respects the practices and knowledges present within the group, even if those practices are well outside our own comfort zones. This does not mean we suspend our critical faculties as researchers. Instead it means that we learn how to shift between multiple critical stances by performing both insider and outsider perspectives.

2.8 Conclusion

In this chapter we have focused on research within the HCI community that seeks inspiration from practices, groups, and communities that fall outside of HCI's "mainstream". We propose the term "peripheral practices research" to describe this emergent trend within the field, despite the imperfect nature of that phrase. We have described how peripheral practices research serves three critical functions within HCI: (1) It introduces a diversity of perspectives into the field; (2) It identifies new approaches to existing problems and challenges; (3) It serves as a defamiliarizing lens on existing norms and assumptions within the field.

While this chapter surveys a broad and diverse selection of studies that engage with peripheral practices, these initial projects represent a tiny subset of the sociotechnical phenomena that could be conceivably studied within the field. The emergence of this new possibility space for research is at least in part a consequence of how technology has proliferated over the lifespan of HCI as a discipline. In the third wave., HCI has had to become concerned with issues of culture, aesthetics, emotions, values, diversity, and many other subjective, elusive, humanistic phenomena because computing technology is no longer "safely" contained within the contexts of home and work that birthed the field. While many HCI scholars continue to do their work within laboratory contexts, new relationships to computation and technology are proliferating "in-the-wild" at a rate that we will be hard-pressed to keep up with as a field.

By giving this mode of HCI research a name, we hope to see even more studies that look outside of our communal norms for new ideas, new perspectives, and new values around technology. This will require the field to develop new strategies for evaluating contributions, especially of early work on peripheral practices. It is easy to look at a study of Steampunks, or furries, or preppers and ask, "What does this have to do with HCI?" We must instead learn how to ask, "How can HCI learn from this?" We hope that this chapter will help those interested in studying peripheral practices to better position and clarify how these kinds of studies benefit the field.

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Chapter 3
Autoethnography in Human-Computer Interaction: Theory and Practice

Amon Rapp

Abstract Autoethnography is an ethnographic method in which a fieldworker's experience is investigated together with the experience of other observed social actors. Over the years, Human-Computer Interaction (HCI) research almost exclusively produced "objective ethnographies", attempting to generate accurate descriptions of the "world" and the individuals inhabiting it. However, recently HCI community started exploring different forms of observing and describing reality, making the ethnographer regain visibility, and produce reflexive first-person recounts of her work. Autoethnography might be precisely inscribed in this movement, whereby it explicitly attempts to recount the fieldwork from the fieldworker's point of view, situating the ethnographer as the protagonist of the ethnographic narration. In this chapter, I will outline the anthropological roots of the autoethnographic method, and describe its potential implications for HCI research.

3.1 Introduction

Ethnography was originally incorporated into Human-Computer Interaction (HCI) methods to understand how people utilize technology in real contexts of use, moving away from laboratory settings. The laboratory, at a certain moment, started appearing somehow artificial and insufficient to account for designs addressed to satisfy people's situated needs. Dourish (2006) retraces the use of ethnography, on the one hand, to the emergence of Computer-Supported Cooperative Work, which aimed at gaining knowledge about the social forms of organization of work activities; on the other hand, to the rise of the Participatory Design movement, which valued methodological approaches capable of making people's voices heard. Since then, HCI ethnography almost exclusively yields "objective ethnographies", attempting to produce accurate descriptions of the "world" and the individuals who inhabit it, where the figure of the ethnographer is presented in an impartial, distant,

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and impersonal voice. In this chapter, I will outline the distinctive features of the autoethnographic method, contrasting it with the more common – at least in HCI – paradigm of the objective ethnographies. Sect. 3.2 provides a historical account of autoethnography highlighting its utilization in anthropology and social sciences. Sect. 3.3 underlines some relevant theoretical and methodological aspects that differentiate autoethnography from the "objective" ethnography, connecting it with reflexivity. Sect. 3.4 outlines the practice of autoethnography in Human-Computer Interaction. Sect. 3.5 describes an example of autoethnography based on my personal experience, emphasizing some methodological and practical issues. Finally, Sect. 3.6 concludes the chapter. Conceptually and theoretically, third wave HCI expands the cognitive to the emotional and focuses on experience (Bødker 2006). Exploring ways of doing ethnography that value the emotional and experiential role of the fieldworker becomes essential.

In recent years HCI started exploring different forms of ethnography, in which the objective stance might make way for more subjective takes, and where the ethnographer regains visibility, producing reflexive and first-person recounts of her work (Rode 2011). In this vein, autoethnography found a place even in HCI. Autoethnography is an ethnographic method in which the fieldworker's experience is investigated together with the experience of other observed social actors. The researcher's personal account is considered valuable on its own and worthy of reporting in the ethnographic recounting (Tedlock 1991). This makes autoethnography similar to the autobiographical genres of narration: the fieldworker exposes her intimate experiences to the reader and produces a version of reality painted from a first-person perspective. However, such an ethnographer's personal "story" is not disconnected from the social and cultural contexts in which the autoethnographer is immersed: instead, the individual, social and cultural levels of description are tied together to produce a complex and multilayered recount of reality (Ellis and Bochner 2000). The autoethnographer uses self-observation as a starting point of reflection on the social and the cultural, and then returns to the self and to the interpretations of what has been observed: "Autoethnography requires that we observe ourselves observing, that we interrogate what we think and believe, and that we challenge our own assumptions, asking over and over if we have penetrated as many layers of our own defenses, fears, and insecurities as our project requires" (Jones et al. 2013: 10). Goodall (1998: 2) emphasizes how autoethnography "completely dissolves any idea of distance, doesn't produce 'findings,' isn't generalizable, and only has credibility when self-reflexive, and authority when richly vulnerable… When it is done well, we can learn previously unspoken, unknown things about culture and communication from it".

3.2 Autoethnography in Anthropology

The first autoethnographic work can be traced to Jomo Kenyatta's study (1938), an anthropological account of Kikuyu people of central Kenya made by the first President of that country (Hayano 1979). Over the years, this term has been used to

point to the key informants' own understanding of their world: as in the Dani people autoethnography, where 50 Dani children gave responses to the question "what do people do?" (Heider, 1975). It has also been referred to the process of studying a fieldworker's own people, where an indigenous insider collects and analyzes the data concerning a particular group (Hayano 1979). This position ascribes autoethnography to marginalized subjects (Sundén 2012), as a response to the "dominant" European tradition, where ethnographic works represent to researchers their (usually subjugated) others, whereas autoethnographic works are those the others construct in response to or in dialogue with those representations (Pratt 1986).

Ellis, Adams and Bochner, in turn, prefer to define autoethnography as "an approach to research and writing that seeks to describe and systematically analyze (graphy) personal experience (auto) in order to understand cultural experience (ethno)" (2011: 273). This emphasis on "personal experience" and "writing" reflects the important transformations that ethnography has seen in its theoretical accounts during the 1980s. The postmodernist position in anthropology, which can be rooted in the Clifford's and Marcus' book Writing Culture (1986), highlights "the constructed, artificial nature of cultural accounts" (p. 2), provoking a "crisis" in the confidence on the fieldworker's objectivity. Such accounts claim that ethnographies are no more than fictional texts which should be judged only in terms of honesty and aesthetics as per literary practice. This somewhat extreme position reflects a deep transformation in the epistemology of science at that moment: in those years scholars begun to question the objective ontology of science, showing how facts and truths are conditioned by the overarching paradigms in which they are discovered (Kuhn 1962), and are inevitably tied to the words used to represent them (Rorty 1982).

On the one hand, this epistemological shift provoked a realist reaction in anthropology, with the Evidence Based research movement (Goldthorpe 2000; Runciman 1983) claiming that ethnographies should be assessed by using the same criteria adopted by the hard sciences. On the other hand it opened the way for methods that value the ethnographer's subjective position. Researchers started considering what social sciences would be if they were closer to literature than to quantitative sciences, and if they were self-aware of the values and beliefs affecting their research, rather than pretending to be free of any conditioning (Ellis et al. 2011; Bochner 1994). Many fieldworkers turned to autoethnography because they "wanted to concentrate on ways of producing meaningful, accessible, and evocative research grounded in personal experience, research that would sensitize readers to issues of identity politics, to experiences shrouded in silence, and to forms of representation that deepen our capacity to empathize with people who are different from us" (Ellis et al. 2011: 2).

Autoethnographers value personal experiences, recognizing that every attempt to describe the world is framed in the subjectivity of the observer. When this is not accounted for, ethnography will commonly encompass a series of assumptions about the identity of the ethnographer, taking them for granted:

> For the most part, those who advocate and insist on canonical forms of doing and writing research are advocating a White, masculine, heterosexual, middle/upper-classed, Christian, able-bodied perspective. Following these conventions, a researcher not only disregards other ways of knowing but also implies that other ways necessarily are unsatisfactory and invalid (Ellis et al. 2011: 3).

Race (Boylorn 2006), gender (Keller 1995), age (Paulson and Willig 2008), education (Delpit 1996), or religion (Droogsma 2007) entail different assumptions about the world (Ellis et al. 2011). Similarly, writing styles are by no means neutral. The way ethnographies are recounted inevitably implies a stance on the world that has been observed. This textwork involves "choices, innumerable ones concerned with such things as voice, authorial presence (or absence), analogies and metaphors, allusions, professional dialect and jargon, imagery, interpretative moves, tone, empirical or theoretical emphasis, truth claims (or lack thereof), figures of speech, and so on" (Van Maanen 2011: 159). Van Maanen identifies three main styles of writing ethnography in anthropology: (1) realistic, (2) impressionistic, and (3) confessional. Whereas the first one actually encompasses a positivist position that contrasts with the autoethnographic account, the others get close to the autoethnographer's aim of revealing the individuality lying behind the fieldwork, emphasizing the personal experiences of the "I".

3.2.1 The Realistic Style

The realistic teller commonly removes any subjective cues from the text in order to give to the ethnographic recounting the appearance of an objective narration of the world, completely transparent and exempt from biases emerging from the author of the writing: "the most striking characteristic of ethnographic realism is the almost complete absence of the author from most segments of finished text" (Van Maanen 2011: 46). The vanishing of the "I" is usually paired with a documentary style focused on minute details about the daily life of the investigated people, and a univocal interpretation of the collected data, offering one reading and culling its facts to support that reading. This

> …permits readers to hold the attitude that whatever the fieldworker saw and heard during a stay in the studied culture is more-or-less what any similarly well-placed and well-trained participant-observer would see and hear. Ironically, by taking the "I" (the observer) out of the ethnographic report, the narrator's authority is apparently enhanced and audience worries of personal subjectivity becomes moot. (Van Maanen 2011: 46)

For Van Maanen these rhetorical devices not only hide the ways in which the research and the text have been constructed, but also leave out any event that may disconfirm "the" provided interpretation, without allowing alternative perspectives to creep into view.

3.2.2 The Impressionistic Style

Impressionistic accounts, in contrast, show different features:

The form of an impressionist tale is dramatic recall. Events are recounted roughly in the order in which they are said to have occurred and carry with them all the odds

and ends that are associated with the remembered events. The idea is to draw an audience into an unfamiliar story world and allow it, as far as possible, to see, hear, and feel, as the fieldworker saw, heard, and felt. Such tales seek to imaginatively place the audience in the fieldwork situation. (Van Maanen 2011: 103).

This kind of recount seeks "transparency", using evocative language that tries to project the reader into the fieldwork, making her "relive" it. More than disciplinary, in impressionistic tales the standards are literary, and the impressionist tellers aim at engaging their audience, keeping it alert and interested. Unlike the realist tales, the ethnographer's subjective point of view is important, since, as with impressionist paintings, reality is captured from a unique and individual perspective.

3.2.3 The Confessional Style

Finally, confessional tales "attempt to explicitly demystify fieldwork of participant-observation by showing how the technique is practiced in the field. Stories of infiltration, fables of fieldwork rapport, mini-melodramas of hardships endured (and overcome), and accounts of what fieldwork did to the fieldworker are prominent features of confessions" (Van Maanen 2011: 73). The author is close at hand, since her writing is intended to show how the fieldwork came into being. Typically, the evolution of a confessional tale starts from the way in the fieldworker sees the observed reality, to end with the ethnographer seeing the world in an entirely different manner: this sort of new perception is normally claimed to be close to the native's point of view. Narration is then enriched with the fieldworker's autobiographical details, as well as those that constitute the field experience of the author.

3.2.4 The Autoethnographic Style

Confessional style closely resembles autoethnographies. However, autoethnography goes beyond such "confessions" since it puts the ethnographer's subjective experience and self-observation at the center of the fieldwork. What is interesting here, nonetheless, is that the methodological observations made by Van Maanen with reference to confessional tales are even more valid when looking at the autoethnographic method. Van Maanen notes that the major difficulty in confessional recounts is to convince the audience that the work is authentic and reliable, despite the touch of the fieldworker.

Autoethnography has been criticized for its autobiographical component as well, which risks to transform scientific work into "art" (Ellis et al. 2011). For example, it has been claimed that autoethnography is too aesthetic and emotional (Hooks 1994; Ellis 2009), or that it does not spend a sufficient amount of time with "others" (Delamont 2009; Fine 2003). Delamont (2009) summarizes the main concerns that researchers have in recognizing autoethnography, arguing that research is supposed

to be analytic and not merely experiential, and introspection is not a sufficient substitute for data collection.

Critiques of autoethnographic writing 'of being too literary' without respecting the 'canon' of social science research points to the debate between postmodernism and positivism we highlighted at the beginning of this Section. Autoethnography needs a theoretical and methodological background capable of accounting for its results and responding to the critics discussed above. The notion of "reflexivity", which has been extensively discussed in social sciences and recently introduced to HCI, can provide solid grounding of the autoethnographic genre. When autoethnography becomes reflexive – not only in the sense of a gaze that looks back to the observer, but also with reference to a procedural strategy aimed at exposing all the methodological and theoretical tools used in the fieldwork – it can recover that "objectivity" traditional ethnographies pursue in different ways.

3.3 Autoethnography and Reflexivity

The awareness of considering the ethnographer's "gaze" crucial in ethnographic research has been spreading for a long time in anthropology, whereas it has been adapted only recently within the HCI community (Johnson et al. 2012; Rode 2011). HCI practitioners and researchers framed ethnographers mainly as "realist tellers" whose subjectivity is completely hidden in the text, "preventing discussion of how the researcher's presence in the field, their interactions with participants and their own background and experiences, have shaped the ethnography" (Johnson et al. 2012: 1136). As a consequence, confessional or impressionistic styles of writing revealing the subjective stance of the ethnography have been rarely used in HCI research (Rode 2011). From this perspective, autoethnography could hardly find a place in HCI, because one of its main characteristics is to make the "author" of the ethnographic work visible, consequently revealing that the "realist teller" is only one way to recount the fieldwork.

In recent years, however, HCI researchers have started rethinking most of their methodological tools. This methodological and theoretical shift – marked as the "third wave" in HCI – has also led to questioning the assumptions behind the HCI ethnographic work. Rode (2011) introduced the term "reflexivity" to the HCI ethnography debate. She emphasized that hiding the ethnographic voice under a cover of objectivity narrows our perspective on the data and our possibility to use it for design purposes. Following Burawoy (1998), she defines reflexivity resting on four criteria: (i) reflexivity, unlike positivism, embraces intervention as a data gathering opportunity; (ii) reflective texts aim to understand how data gathering impacts the quality of the data itself, commanding "the observer to unpack those situational experiences by moving with the participants through their time and space" (Burawoy 1998: 14); (iii) reflexive practitioners attempt to find structural patterns in what they observed; (iv) in doing so they extend theory (Rode 2011). Rode, therefore, emphasizes the experiential nature of ethnography, noting how the relationship with

informants is always two-way, where fieldwork is inherently subjective, contextual, and incomplete.

If Rode opens the way to using impressionistic and confessional ethnographic styles in HCI, de facto legitimizing the use of autoethnography, the notion of reflexivity she introduces entails further theoretical considerations that might better ground the autoethnographic method. Cardano (2009) emphasizes that reflexivity – distancing both from the constructivism of the postmodernist position and the positivism of the natural sciences – may represent a third way to found the ethnographic approach. Cardano stresses that the content of ethnography is both theory-laden and procedure-laden. On the one hand, it is shaped by the theories that guide the observation, as it is not possible to describe the world from a "God's eye view" (Putnam 1981). Such theories are both scientific theories which may help the ethnographer explain the observed phenomena, and more widely–shared common sense theory, namely "notions which are established, with images of the world which the totality of rational individuals adheres to" (Cardano 2009: 9). On the other hand, ethnographic research is procedure-laden, which means that "the observational role taken up, the research techniques used, the implicit or explicit forms of sampling adopted, and more in general the line taken up during ethnography – all these, as well as theoretical preconceptions, go towards determining the representation of the culture being studied" (Cardano 2009: 8).

If ethnography is not neutral in representing the world, then the realistic recount can no longer represent a valid way to found the ethnographic narration: the epistemic authority of the "realist teller" reveals itself as a fiction, a rhetoric procedure that misleads about how the fieldwork has been conducted. From this perspective, reflexivity becomes a means to make the ethnographic work accountable: "Reflexive accounts enable readers to assess the plausibility of each statement (or at least of the most salient one) by scrutinizing the empirical condition which led to their formulation" (Cardano 1999: 11). Altheide and Johnson (1994) claim that the ethnographic ethic imposes on ethnographers the responsibility to evidence the foundations of their interpretations and results, by using an accurate reflexive narration:

While no one is suggesting a "literal" accounting, our work and that of many others suggests that the more a reader (audience member) can engage in a symbolic dialogue with the author about a host of routinely encountered problems that compromise ethnographic work, the more our confidence increases. Good ethnographies increase our confidence in the findings, interpretations, and accounts offered. (p. 591).

Reflexivity, by describing the rapport between the observer and what is observed, provides the reader with the tools for understanding how the fieldwork has been conducted and how the data have been collected, analyzed and interpreted.

Satisfying such criteria "enables the ethnographic reader to approach the ethnography interactively and critically, and to ask what was done, and how it was done, and what are the likely and foreseen consequences of the particular research issue, and how was it handled by the researcher" (Altheide and Johnson 1994: 591–592). Reflexivity imposes to accurately account for the theories used to explain the observed reality, the procedures employed to sample the data, and the interpretative strategies used to "make sense" of the observation. In this way, the ethnographer

grounds the ethnographic description, assuring more validity, reliability and credibility, not by withdrawing subjectivity, but actually highlighting it.

Within the reflexive perspective, autoethnography becomes a paradigmatic technique to account for the ethnographic work: the fieldworker not only explains her methodological and theoretical choices, but exposes herself in her interpretative doubts, in her failed attempts, in her temporary hypotheses and precarious experiences to describe how the observed reality has been constructed. In other words, autoethnography becomes a means to completely enact the reflexive recount.

3.4 Autoethnography in Human-Computer Interaction

Within HCI, autoethnography has been gaining an increasing popularity in recent years, where it has been employed to understand the impact of location-based services on a bus drivers' work conditions (Pritcherd et al. 2014), to explore how individuals learn music through listening, embodied understanding, and creative imagination (Xiao and Ishii 2016), to examine the practices of people that do not use smartphones and social media to interact with others (Diaz et al. 2017), and to investigate how prototype wearable devices aimed at increasing the awareness of time might be integrated in daily living (Harrison and Cecchinato 2015). Under the name of autobiographical design, it has been employed as a form of design research that draws on extensive use of a system by its own creators (Neustaedter and Sengers 2012). Boehner et al. (2008), for example, designed a system for reflection and awareness of emotional presence, claiming that their objective was to "critically reflect on our experiences with the system, to plumb their nature and how they relate to design choices, and use them to continually push the system design in new, perhaps unexpected directions" (Boehner et al. 2008: 6–7).

3.4.1 Autoethnography as a "Quick" Method

A reason for moving to the autoethnographic method can be retraced in the need of finding less-demanding techniques than those employed in traditional ethnographies for studying technology in real contexts of use. Ethnographies typically require a period of several months of observation and analysis (Bentley et al. 1992), face barriers in gaining access to the field, and spend excessive periods of time finding, observing and interviewing key informants, as well as acquiring a deep knowledge of the field. While HCI research has always attempted to "understand" the user, namely to empathize with her (Segal and Suri 1997) and obtain knowledge about what she feels, thinks and perceives when using technology: "spending 24 h over several weeks with the participants is just not feasible" (Cunningham and Jones 2005: 2), or better, is very hard to achieve with the often limited resources available to HCI researchers.

Wright and McCarthy (2008) proposed to fill the gap between the researcher's understanding and the users' knowledge through the "imagined other", personally involving researchers in the use of technology through a variety of self-studies (O'Kane et al. 2014). If such self-studies in HCI can be brought back to Hawkin's auto-observation,[1] autoethnography seems to precisely satisfy the need of gaining empathy with the user without engaging in ethnography-heavy techniques. Ljungblad (2009) stressed that autoethnography-like techniques may lead to a deeper empathic understanding of the participants' experiences. Ljungblad required people to use the passive camera device SenseCam for a week, in order to explore how it might involve a different type of photographic experience. In doing so, she personally used the camera for 1 month (before and after the study), where the experiences of using the camera were reflected upon and written down as a diary, mainly focusing on the questions raised by the participants.

Autoethnography appears to promise a quicker access to the "ethnographic data" as the main "object" of research becomes the ethnographer herself who may already know the "field" of study due to past experiences and expertise. From this perspective, autoethnography can be inscribed in those approaches that refer to the umbrella-term "rapid ethnography", aimed at understanding users and their environments in a shortened timeframe and particularly valued in industry contexts due to the evident savings of time and resources (Millen 2000).

Marcengo et al. (2016), for example, accounted precisely for the use of autoethnography in exploring the reliability of self-tracking devices by claiming that self-observation may provide "easier" access to data impossible to collect otherwise, overcoming the difficulties of observing users in private settings, such as during sleep. Similarly, O'Kane et al. (2014) used autoethnography for evaluating a wrist blood pressure monitor used by individuals with hypertension, claiming that this method enables researchers "to understand and empathize with the experiences mobile device users can face in difficult to access contexts", allowing them "to better understand user experiences with mobile devices, including mobile medical technology, especially during non-routine times that can be difficult to study in-situ with traditional user studies" (O'Kane et al. 2014: 990). Cecchinato et al. (2017) combined autoethnography and semi-structured interviews with early adopters to uncover perceived benefits, issues and unmet needs when using a smartwatch. Here, autoethnography allowed researchers to gain first-hand situated user experience of a device not yet widespread, relieving them from the task of conducting long sessions of observation of users in private settings: autoethnographic data were also used to inform the questions for the interviews, a role that in traditional ethnography is usually covered by participant observation in the field.

[1] Hawkin carried a block of wood within his pocket simulating how would fill like to carry a Palm Pilot always with oneself (Bergman and Haitani, 2000),

3.4.2 Autoethnography as a "Reflexive" Method

Grounding the autoethnographic method in practical convenience and cost saving leaves autoethnography open to a variety of critiques: for example, that the autoethnographer does not spend a sufficient amount of time with "others", and that her take on reality is too subjective and unreliable. Saving resources, in fact, cannot be a sufficient motivation to account for an inspection technique that can be blamed for not complying with the standards of social science research. Situating autoethnography in the reflexive frame, instead, can give support to the subjective position of the ethnographer, emphasizing the importance of her own experience in the fieldwork's recounting.

Williams (2015), for example, conducted a multi-year autoethnography on the use of self-tracking technologies for weight-loss in order to explicitly counter the realistic position of traditional ethnography largely predominant in situated studies of human-technology interaction. She emphasized that designing technologies entailed personal interests and experiences that should be embraced rather than put aside: bringing her approach back to postmodern ethnography and autobiography, she called into question the objective observer position and the conventions of the realist teller, with the explicit aim to disturb the concept of the coherent and individual self as well as the classical opposition between self and society, subjective and objective (Reed-Danahay 1997). Using weight trackers generated from a personal interest, being not initially intended as research, but as part of an effort to address a personal need. However, it turned into an opportunity to develop an experiential understanding and a professional account of fitness self-tracking devices. What she explicitly stressed in her work was the highly idiosyncratic nature of her research as a point of strength rather than of weakness: exposing personal experiences has the potential to generate a connection with what can be the life paths of other individuals in similar situations, producing "a rich understanding of the role of personal devices in our lives" (Williams 2015: 122). Such a perspective, therefore, emphasizes the vulnerability, motivations, personality traits, and contradictions of the ethnographer as a source of value. Williams claims for the subjectivity of ethnographic research, and in doing so, exposes the methodological and theoretical foundations that underpin the position: this reflexive recount allows the reader to fully account for the fieldworker's choice, making her work transparent.

Sundén (2012) further deepened the methodological reasons for using autoethnography in design by explicitly arguing for its peculiar ways of producing knowledge, different from the objectivism of traditional ethnographies, but nonetheless equally valuable. She made use of personal experiences and emotions, by recounting an in-game as well as out-of-the-game love affair, emphasizing the importance of a fairly intimate disclosure of the researching "I" to investigate queer potentials in mainstream World of Warcraft cultures. Instead of the "self-confidence" of the realist ethnographer she made visible the "epistemological uncertainty" of the autoethnographer, strictly tying the autoethnographic experience to the reflexive narration:

> Uncertainty, here, is meant to evoke a manner of not being sure of whether one's methodological strategies will work productively in an academic setting. Uncertainty points at how

> ways of knowing are shaky, partial, and always in the process of being proved otherwise. Uncertainty may also work as a theoretical code word in new media ethnographies in relation to which the limits, of this body and that, and of the field itself, are everything but clear (Sundén 2012: 173).

Rather than hiding the doubts and the risks of the fieldwork, Sundén emphasized them as a means to expose how the research took form, its dynamics and assumptions.

The Participatory Design researchers Malinverni and Pares (2017) stress that self-investigating their role and subjective experience does not only allow them to empathize with users but can also guide ethical practice, helping designers become more aware of their unconscious values and assumptions. The use of the autoethnographic method, then, becomes a means to guide ethnographer's "reflection on her standpoint in PD, the way in which she conceptualizes participants, and the way in which she perceives her authorship in the design process" (Malinverni and Pares 2017: 411). Moreover, it allows for the revealing of assumptions and values that surround PD practice, unveiling "how even simple decisions and behaviors have specific meanings that are grounded on a vast array of antecedents, which may lead to different kinds of consequences" (Malinverni and Pares 2017: 411). Here again, the use of autoethnography is motivated by the unique perspective on reality that it introduces, as well as the reflexive recount that it produces, providing a de facto theoretical and methodological legitimacy rather than a practical one.

3.5 Autoethnography and Design in Practice

Over the last 4 years, I conducted a multi-phase ethnography in World of Warcraft, trying to dig into the methodological consequences of the autoethnographic stance when paired with the reflexive recounting. I looked at autoethnography as a means for "phenomenologically" experiencing the reality as it is seen through eyes of the others, attempting to understand how "natives" live their world. Massively Multi Player Online Role-Playing Games (MMORPGs) are a game genre that involves millions of players around the world. These games project individuals in a fantasy world where social relations are developed and different identities are explored. MMORPGs are an interesting phenomenon for design practices: they intensely involve their players, being played for longer periods of time than other videogames (Ng and Wiemer-Hastings 2005); their players carry out a variety of burdensome activities – such as farming and managing resources – transcending the common concept of play (Calleja 2007); finally, MMORPGs support the creation of a large variety of social relationships (Drennan 2007).

All these characteristics suggest that MMORPGs embed design features highly capable of engaging and gluing players to the screen, making them an ideal object of study for searching design patterns that can be utilized outside the game domain. The use of game elements in non-game contexts has been called gamification: gamification techniques have been used, for instance, to promote healthy food habits (Orji et al. 2013) and lifestyles (Thompson et al. 2010), support physical activity

(Macvean and Robertson 2013), increase control on patients' diseases (Bassilious et al. 2012), raise awareness about sustainability (Antle et al. 2011) energy consumptions (Bang et al. 2007), and evaluations of prototype applications (Rapp et al. 2016a). However, the design elements used by gamification designers are still scarce: points, badges, and leaderboards are the most commonly employed game elements (Rapp 2014b), where designers rarely look at the world of games to find new insights (Rapp et al. 2016b; Meder et al. 2017).

3.5.1 Setting

My research aims to draw inspiration from MMORPGs to discover new design elements to be employed for gamification purposes (Rapp 2013, 2014b, 2017a, 2017b, 2017c). Among MMORPGs, World of Warcraft (WoW), is still the most popular MMORPG available on the market. Players proceed through 110 levels of play, exploring the world of Azeroth, killing creatures, acquiring new powers and learning new professions. Game activities are designed in the form of quests, i.e. missions that should be faced to gain experience points and gear. Players create characters choosing their "race" (e.g. Human, Night Elf) and class (e.g. Death Knight, Warrior) – choices which impact play styles. Players also collaborate to accomplish the hardest missions of the game, i.e. the raids. Raids are ten-to-thirty players dungeons that can be faced by being part of a guild (i.e. a permanent structured group of players). Over the years, WoW has entered "the offline culture's everyday speech to a greater extent than have most other computer games" (Corneliussen and Rettberg 2011: 5) attracting players also outside the strict circle of hardcore gamers. For designers, it set the MMORPGs' "genre standards" (Debeauvais et al. 2011: 181), while researchers found in WoW the "typical" game able to deeply engage its players, hitting "on all cylinders motivationally" (Rigby and Ryan 2011). All these elements make WoW an "ideal type" (Weber 1949) of a MMORPG.

Given these characteristics, I decided to do an ethnography in WoW, which lasted more than 4 years. The autoethnographic stance gave me the opportunity to answer my research questions. I was seeking design elements able to highly engage players that can be utilized as building blocks for gamification design in other, non-ludic, contexts. This goal required a deep personal involvement in the game, in order to experiment the game mechanics' effects personally. As a matter of fact, only the ethnographer's lived experience can really explain why and how a certain game element works and its consequences on the players' behavior.

3.5.2 Notes from the Field

Autoethnography, then, represents an ideal tool to gain knowledge about specific designs. By analyzing my reactions, and how certain game design elements impacted my game experience, I was able to formulate more precise research questions to be

explored in the field. Conversely, data collected during the fieldwork was constantly compared with my personal histories.

This passage presents my notes dated January 6th, 2014:

> It was Monday when I became officer of The Emperors. That day I found myself wondering about my whole social experience in WoW up to that moment. My first attempts at socializing, as I was recalling them, were meant to fail. I was not used to online gaming and it sounded strange to me to request help from others in accomplishing in-game missions. So, until I reached the level cap, I played almost alone. [...] Suddenly, by chance, when I was with a casual group in the Vale of the Eternal Sorrow, I met Derkes and Axial. After chatting for a while they invited me to join their guild. I left my previous guild with no regrets, it had no meaning for me. I was lucky enough to discover a new world, in the subsequent months. While Derkes and Axial helped me optimizing my character suggesting me which skills to develop, I started chatting with three other members of the group, Kairos, Neon and Elin. I felt free to talk with them even of my private life, and progressively so, I began to think those could be friendships beyond the game world. Slowly, I began to "feel" the values and the goals of the guild as mine, thinking that I would never have left it. In the meanwhile, hours of play accumulated also because I wanted to meet my friends in there, sharing with them the efforts and the responsibilities of guild activities, but also the experiences that was happening in our 'real lives (Rapp 2017a: 460).

The episode emphasizes that one of the essential elements that sticks players to the game is the "social environment" that they encounter while playing. The autoethnographic work allowed me to understand how WoW favors, through its designs, the creation of specific kinds of relations, and how such relations have a variety of effects. In other words, experiencing friendship, camaraderie, casual encounters, and short-term collaborations in first person gave me the opportunity of obtaining fine-grained information about the impacts of specific design elements, such private chats and raids. From this perspective, autoethnography is not a cost-saving method, but the unique technique that has the potential to reveal how designs are turned into meanings by players.

It happened, more or less, when I began to raise my character's level and to collect more powerful items. Each piece of gear, each new experience level, and each new unlocked dungeon opened new possibilities for action. This progression was somehow exponential. The more I advanced in the game, the more I felt free of choosing my own direction. The interesting thing was that I was connecting all those rewards with my character's abilities, and through them with my sense of agency in the game. For me, gaining a new weapon meant to become more powerful; acquiring a new spell meant to become more skillful. The game somehow drove me along a path where each reward was only the nth trigger for pursuing the next one. I clearly remember when I finally conquered the "Unerring Vision of Lei Shen", which considerably raised the item level of my mage. I was so happy not for the object per se, but because, with that trinket, I could face more difficult challenges. Now, things are subtly changed. Having outstanding gear is still crucial for facing the most difficult raids, but such items have also other meanings for me. (Rapp 2017c: 389).

As this episode shows, autoethnography also offers a recount of how the research has been conducted, exposing the initial hypotheses, the interpretative doubts, and the theoretical choices that the (auto)ethnographer has made during the fieldwork, and how all these evolved over time.

3.6 Conclusion

In this chapter I have outlined how the autoethnographic method may be employed in Human-Computer Interaction. Starting from reflections in anthropology, I described how the autoethnographer can argue for her subjective position by relying on a reflexive approach. In doing so, I suggested that HCI ethnography might leverage the autoethnographic method, not only for saving costs and resources of the fieldwork, but also, and more importantly, to offer an alternative perspective on the observed reality, going beyond the presumed objectivity of the realist teller.

I personally conducted an autoethnography in WoW to take away ideas from a game world and porting these into non ludic environments. During the 4 years of fieldwork, I identified a variety of game elements to be employed in the design of online communities, behavior change technologies and personal informatics systems. For example, I found that WoW gives life to a plethora of different stories in which players can project themselves, becoming the protagonists of the deeds told in the game. WoW employs "quests" to frame activities and goals, inserting game missions in narratives, usually told by Non-Player Characters. Through such stories players are pushed to perform laborious and repetitive tasks, such as collecting items and slaying monsters, since the burden of their accomplishment is lightened by the narrative frame in which they are inserted: I personally experimented the "power" of WoW's stories in affecting behavior and habits, as well as committing to game assignments. The variety of the provided narratives, nonetheless, allows players to choose the tales that are closer to their desires, leading to experiencing a sense of freedom (Rapp 2017b).

Building on these findings, I identified ways to exploit a narrative framework to present objectives and tasks, encouraging the user's projection into a different universe of meanings, which could lighten the activities to be carried out during behavior change interventions (Rapp 2017b). Moreover, by providing diverse and overabundant stories, which can differently dress the same type of assignments, behavior change systems would make users feel free of determining their own experience of change (Rapp 2017b). Similar techniques based on narrative elements could be employed to make sense of personal data, for example in fitness applications (Rapp 2014a). Narration, in fact, has been highlighted as an important component of data visualizations aimed at providing self-awareness (Rapp and Cena 2016; Rapp and Tirassa 2017; Hilviu and Rapp 2015).

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Chapter 4
Empathy-Based Design Approaches

Tizneem Jiancaro

Abstract In roughly 20 years, the concept of empathy has grown from virtual obscurity in design circles into a valuable new approach. Empathy in design is being promoted within new and existing methodologies, for the purposes of fostering understanding and spurring innovation. This has occurred as HCI shifts toward more creative, playful, and meaningful applications that cross boundaries between work and home.

For the designer, empathy represents an open, experiential way of *knowing the user*. As an interplay of feelings between people, it is deeply subjective; not a replacement for objective inquiry but a complement to it.

This chapter begins with a theoretical discussion of empathy, including the definition of high-level empathy; then shifts to a practical survey of design approaches. These include the following: a four-stage empathy framework; user-sensitive inclusive design; empathy-based participatory design; empathy-oriented co-design; and empathic product design. The chapter ends with a discussion of related challenges and recommendations. For designers of technological and business solutions, empathy remains one of the few ways to answer the crucial question: *what is an experience like for you?*

4.1 Introduction

Empathy is defined as "the ability to understand and share the feelings of another" (Oxford Dictionary of English 2015). Initially, it was the subject of studies in philosophy and aesthetics; and later, psychology, where it has since become a burgeoning research topic of its own. Today, discussions on empathy are pervasive, from business management (Somogyi et al. 2013) to medicine (Pollak et al. 2011) to public discourse (e.g. Jauhar 2017). Why all this interest? The ability to empathize

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relates to emotional intelligence and creative problem solving, both key to addressing complex issues (Goleman 2006; Krznaric 2008).

In design, empathy is linked to HCI's *third wave* (Bødker 2006). *Third wave* HCI is associated with shared creativity, meaning, and emotion; with settings that cross boundaries between work and home; applications that range from videography to virtual worlds; and platforms that include wearable, mobile, and pervasive systems (Bødker 2006, 2015). This phase of HCI builds on its predecessors: the first emphasizing productivity and human factors; the second emphasizing collaboration and participatory methods (Bødker 2006).

In its current form, HCI is associated with lived experience. It takes a holistic perspective that encompasses human cognition and emotion, rich personal histories, and complex networks and environments. However, one of the main challenges facing *third wave* HCI concerns accessing and interpreting "intangibles" (Mcdonagh and Thomas 2010: 183), including emotional and experiential content (Wright and McCarthy 2008). It is this challenge that has designers turning toward empathy.

More than two decades ago, design researchers recognized that empathic approaches can be leveraged for the purposes of *understanding* (Dandavate et al. 1996) and *inspiration* (Leonard and Rayport 1997). Empathic *understanding* has since been adopted to bridge significant differences between designers and users. These include cultural (Battarbee et al. 2014), cognitive (Lindsay et al. 2012), physical (Mcdonagh and Thomas 2010; Strickfaden and Devlieger 2011), and demographic (Newell et al. 2011) differences.

Meanwhile, empathic *inspiration* has been adopted to trigger design insights. Projects have employed innovative tools ranging from creative visual metaphors to help urban dwellers re-imagine their sense of home (Gaver et al. 2004) to a walk-through "tunnel of paperwork" to help telecom executives understand their customers' frustrations (Battarbee et al. 2014: 13). Accordingly, design empathy has been applied to solve both technological and business problems (Battarbee et al. 2014).

This chapter offers theoretical and practical perspectives on empathy in design. Section I presents a historical and theoretical review of empathy. Section II presents related design approaches. The chapter ends with a discussion of the challenges and considerations associated with this paradigm.

4.2 Empathy in Theory

4.2.1 Historical Overview

From the outset, empathy has been conceptualized in different ways. It was introduced into German philosophical circles of the nineteenth century as *einfühlung* or *feeling into* (Jahoda 2005; Vischer 1873). In this context, *einfühlung* first referred to the visceral sensation evoked in response to natural phenomena like sunsets. In aesthetics, it was then described as the process of an observer engaging with an artefact to the point of permeability (Warszawa and Nowak 2011). The concept was

further developed by philosopher, Theodor Lipps, who explored why art gives us pleasure, describing deep art appreciation as a non-conscious process in which we kinaesthetically resonate with an object (Coplan and Goldie 2011). Lipps' aesthetics classes on *feeling into* objects attracted artists from across Europe, ranging from the painter Kandinsky to the poet Rilke (Corbett 2016).

In his psychological research, Lipps categorized *einfühlung* by valence, describing *positive einfühlung* as an inner life-affirming resonance with another; that is, a "harmony" (Jahoda 2005; Lipps 1906: 21); and *negative einfühlung* as inner "discord" (Depew 2005; Jahoda 2005: 158; Lipps 1906). For instance, "I see … a person looking, not proudly but arrogantly. I experience within myself the arrogance contained in that look. It is not just that I imagine this inner conduct or inner condition; it is not just that I know about it; rather, it obtrudes, forces itself into my experience. But within myself I work against it" (Jahoda 2005: 158; Lipps 1903: 139–140).

Einfühlung as a guiding concept spread widely amongst psychologists including Freud. It was translated into English by the British psychologist, E.B. Titchener (1909), who coined the term, *empathy*. Accordingly, empathy involved an inner experience to an outer phenomenon. Prior to this, the description for this experience was the term "sympathy" or *feeling with* another, rather than *feeling into* another (Agosta 2011). Interest in empathy continued to grow through the succeeding decades. In the 1950s the humanistic psychologist Carl Rogers called empathy "the centrepiece" of person-centered therapy (Coplan and Goldie 2011: xiii). More recently, it has been described as the "grand theme of our time" (de Waal 2010: 4).

4.2.2 Current Models, Definitions and Pitfalls

Empathy research remains an important topic for philosophers and psychologists. Recently, it has also been taken up by neuroscientists, who first discovered *mirror neurons* while studying primates, later extending their findings to humans (Rizzolatti et al. 1996). Mirror neurons are a type of brain cell that respond when we execute an action ourselves, *and* when we perceive someone else execute that action (Winerman 2007). In other words, it is a kind of internal simulation that we perform in response to an external event. The mirror neuron system explains why spectators shift their posture while watching a rock climber stretch out for a handhold (Smith 2010). The spectator's experience is sensed in the body, but it develops with mirror neurons in the brain. Notably, mirror neurons process sensory stimuli as well as emotional stimuli (Bernhardt and Singer 2012; Gallese 2003). Accordingly, the affective mirror neuron system reacts to external cues such as facial expression, body language, and tone of voice (Bernhardt and Singer 2012; Jiang et al. 2012).

While considerable research on empathy is underway, as a burgeoning field, there are still substantial issues to resolve. One issue is the lack of a standard definition. Researchers across domains have acknowledged the problem. In a recent review, for instance, Cuff et al. (2016) counted 43 definitions and concepts associated with empathy. In a similar vein, Batson (2009) lists the following eight variants (p. 4):

Table 4.1 Features and pitfalls of high-level empathy (Coplan 2011a)

	Features	Requirements	Pitfalls
I	Affective matching	Mirroring another person's feeling or emotion	Emotional contagion
II	Perspective-taking	Taking the other person's perspective	Pseudo-empathy False consensus Personal distress
III	Self-other differentiation	Maintaining one's own identity	Enmeshment

1. "Knowing another person's internal state, including thoughts and feelings
2. Adopting the posture or matching the neural responses of an observed other
3. Coming to feel as another person feels
4. Intuiting or projecting oneself into another's situation
5. Imagining how another is thinking and feeling
6. Imagining how one would think and feel in the other's place
7. Feeling distress at witnessing another person's suffering
8. Feeling for another person who is suffering".

Furthermore, terms such as empathy, sympathy, and compassion are routinely conflated. Such confusion leads to various difficulties, not only in understanding and evaluating research studies, but also in applying their findings. Generally speaking though, models of empathy can be situated along a continuum, with a *broad* definition at one end and a *narrow* definition at the other end.

The model, offered by primatologist Frans de Waal (2010), adopts a broad definition. Empathy according to this model is "the capacity to (a) be affected by and share (i.e. simulate) the emotional state of another, (b) assess the reasons for the other's state, and (c) identify with the other, adopting his or her perspective. This definition … applies even if only criterion (a) is met" (p. 279). The model acknowledges various empathy-related features, though it regards the felt sensation of another's emotional state as sufficient for an empathic experience. Some consider broadly defined models such as this to be *low-level* forms[1] of empathy (AI Goldman 2006), in part, because simulation is its sole requirement (Coplan and Goldie 2011).

Coplan's (2011a) model belongs to the second category, adopting a narrow definition. In this model, three features are required for an empathic experience: *affective matching*,[2] *perspective-taking*, and *self-other differentiation* (Coplan 2011a). Unlike broadly defined models, this is a narrow view because all three features are necessary. Like other *high-level* models,[3] it regards full empathy as involving the affective mirror neuron system as well as higher cognitive processes (e.g. Decety and Meltzoff 2011). Notably, this model specifies and defines the features that comprise empathy as well as the pitfalls associated with each feature (see Table 4.1).

[1] See also *basic empathy* (Stueber 2012) and *mirroring* (Al Goldman 2011).

[2] Affect involves 'any experience of feeling or emotion' (VandenBos 2007).

[3] See also *perspective-shifting* (Goldie 2011), *re-enactive empathy* (Stueber 2012), and *reconstructive empathy* (Al Goldman 2011).

The first feature, *affective matching*, "occurs only if an observer's affective states are qualitatively identical to a target's, though they may vary in degree" (Coplan 2011a: 6). Key to affective matching is the identity requirement (that is, *empathic accuracy* (Ickes and Mast 2007). Accordingly, if a person experiences trepidation (i.e. fear) associated with a technology, while a design researcher experiences frustration (i.e. anger) with the existing device, that fails to qualify as empathy. Furthermore, affective matching is not to be confused with *emotional contagion*. This pitfall refers to unconsciously "catching" (Singer and Lamm 2009: 83) or being "infected" (Cuff et al. 2016: 145) by someone else's emotion. Because emotional contagion operates unconsciously, the observer does not realize the emotion emanates from the other person; he thinks it is his.

With the second feature, *perspective-taking*, "I imagine that I am you in your situation, which is to say I attempt to simulate *your* experiences from *your* point of view" (Coplan 2011a: 10, italics added). Key here is the *other* orientation. In other-oriented perspective-taking, we must also account for a target's particular situation—their character, mood, background, and life experience (Coplan 2011b; Goldie 2011). Conversely, with s*elf-oriented* perspective-taking, "I imagine what it's like for *me* to be in *your* situation" (Coplan 2011a: 9). So, if I am a designing a phone for people with dementia, my empathic task is to understand their situation from *their* perspective, not my own. Although this is challenging, there are design methodologies to address such situations, as we will see later in the chapter. Unfortunately though, we typically take only our own perspective. While a self-centered view can be a precursor to an *other* orientation, on its own, it is a pitfall. Self-orientation is what Coplan calls, *pseudo-empathy* (2011a: 12). The implications of pseudo-empathy are twofold: *false consensus*, that is, assuming what we feel is what the other person feels (i.e. egocentric bias); and *personal distress*, sensing the distress of another person, but getting caught up in our own suffering (i.e. over-arousal) (Coplan 2011a).

With the third feature, *self-other differentiation*, one "remains aware of the fact that the other is a separate person…This enables deep engagement with the other while preventing one from losing sight of where the self ends and the other begins" (Coplan 2011a: 16). Key to this feature is a clear personal boundary. The pitfall is e*nmeshment*. *Enmeshment* is the opposite of egocentric bias. It involves being "too caught up in the life of the other, too involved and overly concerned with that person" (Stocker and Hegeman 1996: 116). In design, it is the problem of over-identification, designing too closely for a single issue or user.

One's capacity to empathize can also be altered by various factors, "amplified by similarity, familiarity, social closeness, and positive experience with the other" (de Waal 2008: 291); and diminished by difference, distance, and negative experience. One's mood and motivation play important roles also (Engen and Singer 2013). Some of these findings can be considered cautionary, alerting us to those situations when our state of mind is negative; or when interpersonal differences appear significant. In each situation, the tendency is avoidance. In the first situation, meeting someone in distress can be emotionally taxing for oneself; in the second situation, meeting someone of different race, demographic or other characteristic can lead to bias (Zaki 2014).

Countermeasures to these threats are accomplished by exerting cognitive control. One way is to re-frame one's approach by recalling the value of empathy and the cost of misunderstanding; another is to fine-tune one's attention by zeroing in on the emotional cues presented by the other person and noticing the contextual details (see Zaki 2014). Adhering to the principles of empathic dialogue, as described in the next section, can also support this process.

4.3 Empathy in Dialogue

Dialogue is a fundamental way of understanding others empathically (Jiang et al. 2012). However, it is also deceptively complex. Between listening, interpreting, turn-taking, and so on, many processes are recruited, both cognitively and emotionally. This section outlines the role of empathic dialogue in humanistic psychology and describes some of the key ways that designers can listen deeply.

4.3.1 Humanistic Psychology

Empathy in humanistic psychology has two functions: "information gathering [and] emotional bond[ing]" (Kohut 1982: 894). To be "empathic is to perceive the internal frame of reference of another with accuracy, and with the emotional components and meanings which pertain thereto, *as if* one were the other person, but without ever losing the 'as if' condition" (Rogers 1959: 210).

Accordingly, this is a high-level form of empathy, requiring affective matching, other-oriented perspective-taking, and a clear self-other boundary. Of particular concern are the "sensations, perceptions, meanings, and memories" of another person (Rogers 1959: 210). More specifically, it is the "felt meaning" that is emphasized (Rogers 1975: 3). Furthermore, empathy in this tradition is "value-neutral" (Kahn 1985: 396). Consequently, to be empathic, a listener must defer judgment. More than that, however, the listener must care: you must "value that person and his world" (Rogers 1975: 6). Other recommendations for empathic dialogue include, periodically summarizing what the other person says to be sure the speaker is understood correctly; and repeating specific words the person uses that are rich or meaningful to give her a chance to expand on those comments.

4.3.2 Listening with Care

We typically value speaking over listening. Consequently, listening requires some effort. Cognitively, it is a re-directing of the spotlight of attention, so it falls squarely on the speaker. More than that, listening deeply requires a quiet mind; a willingness

to be fully present; and a relinquishment, at least for the moment, of one's prior knowledge (Lipari 2010). A mindful listener is focused on what is said, rather than how to respond, so she is alert to the understated and hidden meanings in a conversation.

In parsing the meaning of a message, there is the literal definition, called the denotation, and the emotional colouring, called the connotation (Edwards 2011). Typically, it is not the literal definition that is disputed, but the emotional colouring. Even a simple remark such as, 'that was interesting', can be construed in various ways. Much depends on tone, body language, facial expression, and context. Interpreting these cues is a complex process.

Accordingly, empathic listening and conversing seem simple, but are often difficult to apply. When there are doubts concerning meaning, a listener has options: ask for clarification, at the risk of interrupting the flow of conversation; defer the follow up, at the risk of forgetting to enquire later (Edwards 2011), or accept that the speaker may be uncertain. For a person who listens deeply, there can be a comfort level with uncertainty (Lipari 2010: 360). Uncertainty, akin to open-endedness, plays an important role in the *fuzzy front end* of design too, where the focus is on exploration (Sanders 2005).

Before turning to the discussion of design approaches, it is important to note what empathy is not. It is not a cause-and-effect explanation. While the process of empathy can reveal a personal insight, it is subjective and non-replicable. Accordingly, it is non-scientific, "one source of data among many. Admittedly, it may not be a very reliable source. But it may provide what no third-person form of scientific understanding can: understanding of another person from the 'inside'" (Coplan 2011a: 18).

4.4 Empathy in Design Research

Empathy as a fundamental design commitment is being channeled in various ways. Some approaches stress empathic *understanding*, while others stress design *inspiration*. One distinguishing factor is the degree to which designers and users differ. Typically, *understanding* is the primary aim when differences, such as age or ability, are seen as significant. In other cases, such as when designers wish to encourage a flash of design insight, inspiration is the primary aim.

However, across approaches, some features are shared. Wright and McCarthy (2008) highlight three common characteristics of empathy-based design: a disposition on the part of the designer to be helpful; care in fostering an environment and mindset that supports attunement; and a focus on the emotional life of the other person. A description of various approaches follows. Table 4.2 presents a summary.

Table 4.2 A summary of empathy-based design approaches

Approaches, features and tools	
A framework for empathy: *Designing for users who differ significantly from developers* (Kouprie and Visser 2009)	
Defining features: Adopting a four-stage framework: Discovery, immersion, connection, detachment	*Related methods/tools:* Empathic listening; pre-and post-reflection; original data (e.g. photos; quotes); interpretation (e.g. personas; storyboards); analysis (e.g. patterns; themes); additional methods as req'd
User-sensitive inclusive design: *Designing for diverse sets of users (e.g. older adults)* (Newell and Gregor 2000)	
Defining features: Studying extraordinary users; building relationships with users	*Related methods/tools:* First-person contact (e.g. informal social events; unstructured activities); theatre-based techniques for requirements gathering; additional methods as req'd
Empathy-based participatory design: *Designing for marginalized groups (e.g. w cognitive impairment)* (Lindsay et al. 2012)	
Defining features: Incorporating a person-centered care approach	*Related methods/tools:* Empathic listening; focus groups; additional methods as req'd
Empathy-based co-design: *Designing to trigger creative inspiration* (Mattelmäki et al. 2014; Sanders and Dandavate 1999)	
Defining features: Accessing the *intangibles*, including users' values, meanings, and experiences using play and visual communication	*Related methods/tools:* Emotional and cognitive toolkits; games; cultural probes; interview; observation; additional methods as req'd
Empathic product design: *Designing for creative understanding in product development* (Postma and Zwartkruis-Pelgrim 2012)	
Defining features: Integrating reason and emotion; making empathic inferences; partnering with users; and collaborating within the design team	*Related methods/tools:* Observation, video, photos, design probes, context mapping, role play, experience prototyping; additional methods as req'd

4.4.1 A Framework for Empathy in Design

Kouprie and Visser (2009) turn to empathy to help address the challenge of designing for users who differ in some significant way from the designers. Under their framework, the aim is "to get closer to the lives and experiences of (putative, potential or future) users, in order to increase the likelihood that the product or service designed meets the user's needs" (Kouprie and Visser 2009: 437).

This framework offers a structured four-stage approach, employing a narrow definition of empathy. It consists of *discovery*, *immersion*, *connection,* and *detachment*. Briefly, the first stage, *discovery* involves first-person contact with users and relies on the willingness and empathic abilities of the researcher. The second stage, *immersion,* involves adopting the user's perspective, remaining open-minded and free of judgment. Of the four stages, this is the most important. *Immersion* is

unfocused, encouraging the user to 'wander around' her own environment and, consequently, enabling the researcher to gain a sense of the person and her context. As an unstructured activity, it requires a flexible schedule. During the third stage, *connection*, there is an opportunity for the researcher and user to emotionally bond via dialogue. This includes sharing experiences with the user to help forge a personal connection. In this stage, both "cognitive" and "affective empathy" are important "to understand feelings…and meanings" (Kouprie and Visser 2009: 445). Finally, during *detachment*, the researcher resumes her professional role, proceeding with analysis. In all, the process incorporates the three features of Coplan's high-level empathy model (2011a), that is, affective matching, other-oriented perspective taking, and self-other differentiation.

Various design tools and techniques can aid the empathic process. Pre- and post-reflection help design researchers identify their own beliefs and perspectives at the outset and distinguish them from those of the users (as in deep listening approaches). Exhibiting original data, such as photos and quotes, helps researchers remain immersed in the experience. Interpreting the results via personas and storyboards deepen the connection. Finally, presenting the analytical results, including emerging patterns and themes, can spur design insights. Since this is intended as a conceptual framework, it can accommodate other techniques, as required. (Kouprie and Visser 2009).

In all, the empathic process described here shifts between the processes of experiencing and reflecting. Accordingly, it requires an open mindset and a flexible timeframe. Finally, personal motivation on the part of the designer is a key factor for the success of this approach (Kouprie and Visser 2009).

4.4.2 User-Sensitive Inclusive Design (USID)

User-Sensitive Inclusive Design (Newell and Gregor 2000) emerged in response to the challenge of designing for diverse sets of users, such as older adults and those with impairments. Besides age and ability, diversity may also include differences in culture; in comfort with technology; in experiences; and in performance. In the case of conditions such as dementia, performance variation can be considerable, shifting over a day, from day-to-day, and over time (Jiancaro et al. 2017).

The emphasis on sensitivity in USID "suggests that the users are firstly people and that the designer should develop an empathic relationship with them, rather than treat them as 'subjects' for usability purposes" (Newell et al. 2011: 237). Accordingly, USID requires a mindset that is open and available, consistent with empathic dialogue and listening. With this approach, the design team not only develops relationships with users during formal design workshops, but also during informal social events.

A unique feature of USID is its early focus on *extraordinary users.* These are users who are outriders in some way. Accordingly, extraordinary users differ substantially from representative users associated with user-centered design. Because

there is more diversity amongst those who are older or who have cognitive or physical impairments, this technique can effectively capture a broad range of characteristics associated with these user groups (Newell and Cairns 1993).

In addition, the USID approach may include the use of theatre (Newell and Carmichael 2006). Performances can range from brief scenes to longer open-ended pieces involving trained actors and script writers. Theatrical pieces are intended help design teams reflect on and discuss sensitive issues, such as those around aging and disability. In some instances, actors may stay in character during facilitated Q&A sessions. The use of theatre requires advance planning and funding, and may be well suited to large or particularly challenging projects.

USID methods stress informal approaches, akin to some of the activities of the Kouprie and Visser framework (2009) described above, such as first-person contact, unstructured activities, and a willingness for the researcher to connect. Also encouraged are theatre-based techniques "for requirements gathering and for improving designers' empathy for marginalised groups of users" (Newell et al. 2011: 236). Additional methods can be adopted, as required.

Empathic dialogue and listening are implicit to USID. Since formal guidance to enhance empathy is not specified, one can surmise that a broad definition of empathy is intended with this methodology. It has been applied to projects involving older adults (e.g. Eisma et al. 2004) and people with cognitive impairments (e.g. Brown et al. 2011).

4.4.3 Empathy-Oriented Participatory Design

Besides USID, other approaches have also been proposed to design for marginalized groups. In work by Lindsay et al. (2012), empathy was incorporated into a participatory design process to develop a 'safe walking' device for people with dementia. To work with this population, the team followed recommendations associated with the person-centered approach to patient care (Kitwood 1997), which involves direct engagement with patients through empathic dialogue.

Notably, the communication protocol for this project was to "uncritically accept and engage with the accounts [a user] put forward…[assuming] the factual accuracy of a person's narrative is secondary to what it reveals of their own experiences" (Lindsay et al. 2012: 522). Accordingly, participants were accepted unconditionally, with no "need to justify or defend" their comments (Lindsay et al. 2012: 523). In this way, the team forged close contacts with the participants.

A similar communication protocol was adopted in another technology study involving people with dementia (Jiancaro and Mihailidis, in review). In that study, participants demonstrated and discussed various home technologies, such as phones. Participants often expressed satisfaction with the devices, despite experiencing difficulties operating them (Jiancaro and Mihailidis, in review). In attempting to understand the users from their perspective, the researchers adopted an open, nonjudgmental approach, learning that successful performance was not a primary

concern for some users. With mobiles phones, for instance, simply having the device at hand offered reassurance and satisfaction. Consequently, by taking users' comments at face value, the researchers were able to re-frame their understanding of a complex topic.

Open, accepting dialogue is a key method for empathy-based participatory design. However, one of the challenges in the participatory design study concerned users who developed such a bond with their facilitator, that they were reluctant to criticize the initial prototypes (Lindsay et al. 2012). Once the situation was recognized, however, it was managed and resolved. Overall, the design team found the commitment to empathy valuable. In this methodology, as with the others described previously, the key to its success depends on the openness of design researchers to learn from participants.

4.4.4 Empathy-Oriented Co-Design

Co-design has been employed by various design firms, including IDEO (Battarbee et al. 2014) and Sonic Rim (Venkataramani 2016). This approach uses collaborative techniques involving users, researchers, and designers. Empathy in the co-design framework is employed as a route to design inspiration, using visual communication as a gateway to gleaning people's values, meanings, and experiences.

With the Say-Do-Make approach (Sanders and Dandavate 1999), researchers explore both past experiences and optimal experiences using various methods. Established HCI methods, such as interview and observation, tap into people's words and actions (*say, do*), while creative methods tap into people's feelings and dreams (*make*). More specifically, *Make Tools* function as "a 'design language' for users" (Sanders and Dandavate 1999: 4). These include items that comprise "emotional toolkits", such as collages and diaries, intended to depict "dreams, fears and aspirations"; and "cognitive toolkits", such as maps and models, intended to depict ideas (Sanders and Dandavate 1999: 4). Together, the toolkits access users' implicit thoughts and feelings that designers then interpret and re-imagine.

With the Helsinki approach (Mattelmäki et al. 2014), design as interpretation is emphasized. The approach is based on four core beliefs: "people give meanings to things and act on these meanings"; "design research must be done in real life"; "research methods should…be visual and tactile, inspiration-enhancing, deliberately cheap and low tech, playful, tested in reality, and targeted at the fuzzy front end"; and, since "analysis of research seeks to explicate meanings for design,… researchers need to explore these meanings — and by implication also possible futures" (Mattelmäki et al. 2014: 68). Like the Say-Do-Make approach, tools associated with this program emphasize visual components and include games and cultural probes (Gaver et al. 1999).

Both the Say-Do-Make and the Helsinki approaches employ generative tools to access people's implicit knowledge in the hope of finding values and meanings that inspire novel design concepts.

4.4.5 Empathic Product Design

Principles and challenges of empathic product design were discussed by design researchers at Phillips Research, investigating care for infants (Postma and Zwartkruis-Pelgrim 2012). In the Baby Care project, the researchers describe empathic design as an "approach that is directed towards building creative understanding of users and their everyday lives for new product development" (Postma and Zwartkruis-Pelgrim 2012: 59).

The researchers express four empathy-based design principles (Postma and Zwartkruis-Pelgrim 2012: 60):

1. "balancing rationality and emotions in building understanding of users' experiences";
2. "the need to make empathic inferences about users and their possible futures";
3. "involving users as partners"; and
4. employing "design team members as multi-disciplinary experts in performing user research".

The first principle involves a holistic approach that addresses people's actions as well as their aspirations; the second refers to an empathic kind of understanding to interpret people's underlying thoughts, feelings, and dreams, often requiring a significant time commitment; the third refers to a mindset that recognizes people as the "experts of their experiences" (Postma and Zwartkruis-Pelgrim 2012: 60); and the fourth, refers to the cooperation between researchers who generate understanding and designers who generate creative ideas (Postma and Zwartkruis-Pelgrim 2012).

The methods include observation, video, photos, design probes, context mapping, role play, and experience prototyping. As the project progressed, the researchers encountered several challenges. First, some industry stakeholders expected "specific market directions" and "validated end-user insights" (Postma and Zwartkruis-Pelgrim 2012: 66). However, the authors explained that "Stories about users and their experiences…cannot be easily up-scaled, quantified or generalized" (Postma and Zwartkruis-Pelgrim 2012: 66). Consequently, some of the expectations held by stakeholders were at odds with the process, itself. Meanwhile, other stakeholders were "focusing on innovative technical solutions, rather than design for experience" (Postma and Zwartkruis-Pelgrim 2012: 67). While technical solutions are important, perhaps making a process more efficient or effective, they can result in incremental improvements to an experience, rather than significant changes. Other challenges involved specifying team member responsibilities; integrating new members into the team; scheduling; and, analyzing raw data. With data analysis, difficulties arose when analysts either focused too narrowly on individual participants (akin to enmeshment) or too broadly on generalities.

4.4.6 An Overview of Methods

A variety of methods are associated with empathy-based design. Dialogue, which was discussed previously, is central to empathy (Wright and McCarthy 2008). Because dialogue "dissolves alienation" (Rogers 1975: 6), it is well-suited to projects involving populations who may feel stigmatized, such as those with cognitive or physical impairments. Other methods[4] include narrative literary fiction (see Mar et al. 2011), role play, cultural probes (Gaver et al. 1999), and empathy maps.

Designers may be less familiar with empathy maps, which are relatively new, compared to other methods. This tool, which leverages visual communication, is a template to better understand users and to generate personas (Ferreira et al. 2015). First proposed by the design firm, XPLANE, they were adopted in business literature to develop "really simple customer profiles" that extend beyond basic customer demographics (Osterwalder and Pigneur 2010: 131). The business model template is divided into six sections to describe what a customer sees; hears; "really" thinks and feels; says and does; and experiences in terms of pains (frustrations) and gains (needs) (Osterwalder and Pigneur 2010: 131). The template includes specific questions to help analysts understand the customer's perspective. It can be completed using post-it notes on a whiteboard.

In summary, designers have adopted a variety of approaches and methods to empathize with users. The next section considers some of the challenges associated with this paradigm.

4.5 Challenges and Considerations for Empathic Design

Designers applying an empathic approach to their work face a diverse set of challenges. Among them is *theoretical coherence*, that is, ensuring the methods and analyses undertaken in a project align with the theory it is based on (Wright and McCarthy 2008); *practical management*, ensuring that a project advances in well-organized manner; and *empathic sustainability*, ensuring that a commitment to empathy is maintained through a project and developed throughout an organization (Battarbee et al. 2014).

Theoretically, "The challenge for HCI practitioners is to know the methodological context of the methods and techniques they use" (Wright and McCarthy 2008: 644). This challenge is crucial. Empathy, as we have seen, involves insights into the thoughts and feelings of another individual. It has been described as "experiential understanding" (Coplan 2011a: 7); and "aesthetic seeing, not scientific knowing" (Wright and McCarthy 2008: 644). Accordingly, this kind of understanding comes from a particular point of view.

[4] For an insightful commentary on empathy-based methods, see Wright and McCarthy (2008)

Since empathic understanding is not objective, the process cannot coherently be tied to scientific criteria such as reliability and generalizability. The reasons are varied. There is "no guarantee of… an empathic response" in the first place (Wright and McCarthy 2008: 641); a person's thoughts and feelings can change over time, so the results cannot necessarily be repeated; and, given the uncertainties of the process, the inferences or models that comprise a generalization cannot necessarily be trusted. Furthermore, because the data are subjective, the urge to validate or triangulate may need to be checked. "From a qualitative perspective, triangulation can be seen as producing not different dimensions of the same thing, but *different things*" (Eakin and Mykhalovskiy 2003: 190). Accordingly, stakeholder expectations of validated insights, as in the Baby Care project (Postma and Zwartkruis-Pelgrim 2012), work counter to the empathic process. Comfort with uncertainty, in keeping with the fuzzy front end of design work, may be more to the point.

Notably, design researchers can take steps to avoid these theoretical pitfalls. In an industry context, researchers can begin by setting appropriate expectations with stakeholders early in a project, including outlining the expected outcomes of the research. Concerning criteria, rather than adopting generalizability, they may consider *transferability*, particularly case-to-case transfer (Polit and Beck 2010), which is a qualitative research standard that involves the degree to which research findings may transfer to other people, places, or scenarios. This requires rich, detailed descriptions of both the source and target scenarios to ascertain whether a transfer is appropriate. Whether this standard suits inspirational insights gleaned from methods, such as cultural probes, however, which were not originally intended for broad applicability, is questionable.[5]

Concerning methods, there are additional considerations. Dialogue and direct engagement, including literary fiction, are supported by neuroscientific studies; however, parallel research regarding film and other visual media remains unexplored. Neuroscientist, Marco Iacoboni, believes that compared to face-to-face dialogue, "Virtual reality and video are shadowy substitutes" (Blakeslee 2006). However, this position is not universally accepted (Cuff et al. 2016). Consequently, the degree to which an empathic understanding can be developed with methods beyond dialogue is an open question. Design researchers will need to keep abreast of scientific studies on this topic.

On a practical level, empathy-based design research also requires an investment of time and training. Training includes learning about the empathic process, implementing empathic techniques, and analyzing raw data. In addition, if the team is large, then a breakdown of the team members' roles and responsibilities may be helpful, distinguishing between those actively involved in a project from those only informed of its progress. Undertaking a project management approach that is tailored toward research-industry partnerships may be a useful investment (Ernø-Kjølhede 2000).

Finally, the challenge of sustaining empathy involves maintaining one's empathic understanding over the course of a project and, more broadly, building this capacity

[5] For more on this topic, see 'Cultural probes and the value of uncertainty' (Gaver et al. 2004)

within an organization (Battarbee et al. 2014). At the project level, keeping design data and artifacts visible is one way to encourage a team to remember their experiences. However, without a culture of empathy, the risk is that one-off empathy-based projects get lost or overtaken by other organizational priorities.

Building empathic capacity requires an ongoing commitment. On a small scale, this commitment can include encouraging colleagues to connect (Suri 2001); on a large scale, it can include developing storytelling media to share a design team's empathic experiences with the broader organization (Battarbee et al. 2014). Given the demands of such a commitment though, it can be helpful to recall why empathy is important in the first place. It is important because in its absence, "we're not really solving problems; we're just working on puzzles" (Gates and Gates 2014).

4.6 Conclusion

In roughly 20 years, the concept of empathy has grown from virtual obscurity in design circles into a valuable new approach. Empathy in design is being fostered within new and existing methodologies, using a diverse set of HCI methods, for the purposes of understanding and innovation. All this has occurred as HCI has shifted toward more creative, playful, and meaningful applications that straddle boundaries between work and home.

Accordingly, with emotions and experiences at the technological fore have come new sets of design research skills. These include the ability to listen closely, openly, and nonjudgmentally; to adopt another perspective; to creatively explore ambiguity; and to interpret new experiential understandings. At heart, however, remains the original notion of empathy as *feeling into*. This experiential capacity means we might understand someone "from the 'inside'" (Coplan 2011b: 58), and from that new understanding, meaningfully address the challenges we face.

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Chapter 5
Measuring Experiences

Paul Cairns and Christopher Power

Abstract The science of HCI in the third wave is intended to understand user experiences through the filter of the values and contexts of individuals using systems and moreover as filtered through the values and contexts of individual researchers. This is not to neglect the importance of measurement to science and the challenges of measuring user experience (UX). This chapter will discuss how HCI can draw on the methods of modern psychometrics to provide tools for measuring user experiences. In particular, we will introduce bifactor analysis as a way to examine both the conceptual coherence of a questionnaire for measuring UX and also the distinct influences of different facets of the core concept. Further, through looking at modern methods of analysis, in particular treatment of outliers, we also consider how modern statistics are not to be treated as black boxes but require researchers to think more deeply about the people behind the data. Drawing on our work in player experiences, we make the case that psychometrics used well as a tool in UX has an important role to play in HCI as a successor science.

5.1 Introduction

In its early days and its first wave (Harrison et al. 2007), HCI was concerned with engineering systems to make people working with machines more effective (Long and Dowell 1989). Typically, more effective meant people (not machines) were faster and made fewer mistakes. This engineering conceptualisation of HCI relied on measurement as key: to engineer a good system it was necessary to measure the performance outcome of interest and then refine the system to improve the measure (Dowell and Long 1998). However, as HCI, and indeed the world, progressed from computers as limited workplace tools to widespread, everyday devices, so the emphasis in HCI moved from engineering systems to developing richer

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understandings of people's relationship with digital technology and the interventions that might lead to new possibilities. This has been characterised as the third paradigm (Harrison et al. 2011) or the third wave (Bødker 2006).

In the third wave, the emphasis has moved away from a focus on the individual interacting with a system to a more holistic view of interactions. People interact with technology within a context of the physical space, their social situation, their goals and more importantly the values and meaning of the interactions. Technology is no longer just about getting things done but it is a tool to enable people to have meaningful experiences to the point where the focus on technology may be secondary (Baumer and Silberman 2011). The difference in emphasis is the difference between the best way for people to input a text message (Cox et al. 2008) to the way in which texts bring people together and enables social and political outcomes (Vieweg et al. 2010).

For HCI as a discipline to make progress in this third wave, it can be envisioned as a successor science (Harrison et al. 2011). Successor science is a term growing from feminist philosophy which has identified that scientific practice and hence the resulting science embodies gender, class and racial biases. A significant example of this is well discussed and analysed in Stephen Jay Gould's classic book The Mismeasure of Man (Gould 1996) on the way in which measures of intelligence, in particular IQ, have promoted the intellectual superiority of white men on the back of weak, misleading or wrong scientific evidence. Successor science instead sees science as epistemologically situated in society, culture and history. This does not invalidate the scientific knowledge produced but it requires that researchers are not blind to the inherent bias in their methods and that a fruitful line of research is to seek out how the knowledge found might differ from taking a different epistemological stance.

Even while it is acknowledged that it is not possible to engineer experiences (Wright et al. 2003: 52), the experiences that people have still form a valuable focus for science. In digital games, for example, game developers look to bring about both short and long-term engagement with games (Cairns 2016) and do so through designing for a range of intended experiences such as challenge (Denisova et al. 2017), fun (Lazzaro 2009), flow (Chen 2007), social presence (Hudson and Cairns 2014) and so on. But what exactly are these experiences? How does the design of games influence them? What else in the context of players and their playing influences these experiences? And how do these different experiences influence each other? Being able to define and measure experiences allows us to begin to answer such questions. Or rather, measuring player experiences at least allows research to isolate the potential phenomena of player experiences (Hacking 1983) in ideal conditions ("in the lab") before looking for the richer experiences found "in the wild."

It should also be noted that the third wave is not intended to supplant the focus on individual interactions. There is still a specific focus on Interaction within HCI, such as gestural, wearable and tangible interactions (Reeves 2015; Kuutti and Bannon 2014) and therefore a need to quantify aspects of these interactions, including the experiences they offer. However, at the heart of measuring experience there

seems to be contradiction in terms. Wright and McCarthy (2004) see experiences with technology, amongst other things, to be:

- Holistic: experiences can only be understood as happening to the whole person
- Situated: experiences arise pre-linguistically out of engagement with a specific situation
- Singular: highly specific to the person having the experience
- Becoming: experiences make new the world from which they arise and so are a process of redefining themselves.

By contrast, measurement is inherently intended to be:

- Reductionist: dividing a whole into parts which can be separately understood
- Abstract: a measurement means the same thing separate from both the context of measurement and the instrument used
- Averaged: individual measurements of experience are not as important as the aggregation of several measurements
- Definite: a measurement is fixed in both value and meaning at the time of measurement

How then is it possible to claim to measure experiences? Here we do not claim to remove or ignore this contradiction. Instead, we aim to show that by being explicit about the limitations of any measurement it is still possible to do science but it very much has to be a successor science where the epistemological stance of any findings are always open to negotiation. This does not prevent HCI from making progress in at least some aspects of knowledge but moreover forces us to acknowledge and even seek out the limitations of what we learn.

The most common approach to measuring experiences used in HCI is questionnaires. As a discipline, HCI has recognised the implicit and subjective nature of user experiences and drawn on the work in psychometrics, particularly the methods of questionnaire development, to produce instruments specific to measuring experiences of interactions. Such questionnaires cover a wide range of general facets of user experiences including engagement (O'Brien and Toms 2010), aesthetics (Hassenzahl 2004) and spatial presence (Witmer and Singer 1998) as well as ones specific to particular contexts such as digital games (Jennett et al. 2008) or mobile interfaces (Ryu and Smith-Jackson 2006).

Any sort of measurement, including with questionnaires, necessarily operationalises the concepts to be measured with the risk that they become identified as the concepts themselves. That is, there is a risk of false positivism that the only meaningful experience of, for example, spatial presence is that defined by Witmer and Singer (1998) in their questionnaire. This flies in the face of the situated, personal and emergent nature of experiences proposed by third wave HCI. If HCI is to function as a successor science then it must acknowledge the epistemological biases inherent in any form of data gathering and therefore the inherent limitations to any questionnaire. A questionnaire used to measure experience is epistemologically situated in both the context of use of the questionnaire and the processes which generated the questionnaire in the first place.

Another risk of quantifying user experiences, particularly in experiments, is that there is then the move to consider only average behaviour as captured in statistical averages of the measurements. This neglects the variations that constitute the experiences of individuals.

In this chapter, we describe how psychometric methods can be employed in HCI yet still maintain a view on the contingent and situated knowledge these methods generate. We also discuss new methods of statistical analysis that bring a richer interpretation of questionnaires. Specifically, bifactor analysis (Reise 2012) considers both the unifying concept of a questionnaire and where there are nuances and deviations from the unified concept. These methods and the challenges of third wave HCI to these methods are discussed with reference to our own work in the development of questionnaires for measuring player experiences and in particular with reference to our recent development of a questionnaire to measure the feelings of uncertainty people have when playing digital games.

Furthermore, when it comes to analysing data from questionnaires, modern statistical methods force explicit consideration of the assumptions underpinning tests and how concern for the underlying distributions leads to examination of possible features in the data such as bimodality and outliers. Whereas traditional statistical methods might consider these features as problems to be avoided (or worse, ignored), modern methods view them as requiring further investigation and understanding. As such, we make the case that modern statistical methods for psychometrics are appropriate to a vision of a successor science suitable for the third wave of HCI.

5.2 Questionnaires for User Experience

The goal of using psychometric methods in user experience is to develop a questionnaire that participants complete and can be used to assign a value, a number, to the level of the experience had by participants. Each item of the questionnaire is typically a Likert item (Likert 1932), that is, a statement to which respondents are required to rate their level of agreement from Strongly Disagree to Strongly Agree. Such Likert items typically have 5 response options, (though sometimes 7) and these are simply scored from 1 to 5. Where necessary these scores are sometimes reversed to take account of the direction of the statement, for example, “I did not understand the game mechanics” is scored in reverse from “I understood the game mechanics.” These item scores are then summed or more often averaged either across the whole questionnaire or across subscales from the questionnaire depending on the questionnaire structure. For example, the Game Engagement Questionnaire (GEQ) (Brockmyer et al. 2009) is a single scale and a measure of engagement is obtained by averaging across all of the items in the questionnaire. By contrast, the social presence in gaming questionnaire, the CCPIG (sea-pig) (Hudson and Cairns 2014), has two separate subscales, one for measuring social presence between players on opposing teams and another for measuring social presence between players

on the same team. It would not make sense to have a single notion of social presence across these two contexts and so the subscales are scored separately.

In order to develop a questionnaire, the first stage is to generate items for the potential questionnaire and to iteratively refine the items. The second stage is to statistically validate the proposed set of items to see if they have coherence and also to identify their structure in terms of subscales.

The basic steps are therefore:

1. Define the concept to be measured
2. Generate and refine an item pool
3. Trial the items with target participants
4. Administer the questionnaire to a large number of participants
5. Conduct factor analysis to identify weak items and the factor structure (subscales) of the questionnaire.

The following sections will consider the basic activities of these steps and the challenges of producing a meaningful measure of user experience using them.

5.2.1 Uncertainty in Games

To make the discussion in this chapter concrete, we will use as a running example our development of a questionnaire to measure uncertainty in games. This is, in part, because this the most recent work on questionnaire development that we have been involved in. It is also because in our development we set out to use the factor analysis methods described here rather than re-analyse a questionnaire that had been produced using different methods.

Our interest in uncertainty in games arose from two sources. First, it was clear that uncertainty is a common experience for people involved in information seeking, for example finding historical documents in an archive (Pugh and Power 2015). However, the feeling of uncertainty comes both from the challenge of finding documents that may or may not exist and from interactions with the search tools where the failure to find documents may be more about the idiosyncrasies of the search tools. Secondly, uncertainty is already recognised as an important constituent in the experience of playing digital games (Salen and Zimmerman 2004; Costikyan 2013). Games are a good context in which to study user experiences because the purpose of games is to generate experiences for players and those experiences are an end in themselves (Cairns 2016: 90) unlike information seeking where a user must have a task for which the interaction with a search tools is not the primary goal.

Perhaps the most interesting aspect of these two really different domains is that when working with users, we often encountered the same descriptions regarding the experience. Users in information seeking would describe not knowing where to look next, using phrases like “being overwhelmed” and “going in circles” when they were awash with information spread across multiple archives. In digital games, players would use similar phrases when trying to solve problems, or deciding which

actions would lead them to the best outcomes. This is particularly important, as it means that this experience is one that users can not only identify in different contexts, but also one they can describe with clarity that they are feeling. This means it is a good candidate for measuring with a psychometric scale.

For these reasons, we set about investigating players' experiences of uncertainty in digital games. Our first analysis was lightweight and represented an initial report on this area using traditional statistical techniques (Power et al. 2017). Our subsequent analysis however aimed to apply the most modern techniques in order to get a more situated account of our data, as will be discussed (Power et al. to appear).

5.3 Grounding the Concept

In order to generate items, there must first be some notion of what the experience to be measured actually is. Where this notion comes from can be quite vaguely defined but then it probably needs to be investigated further to provide a more concrete concept.

In looking at uncertainty in games (Power et al. 2017), the motivation came from a confluence of the concept in the two different domains of information seeking and player experience. In the domain of information seeking, uncertainty had not just arisen from our own work but was also well reflected in the literature and models of information seeking (Kuhlthau et al. 2008). In digital games, uncertainty was recognised and discussed in the literature but had more recently been more deeply analysed by Costikyan (2013), where uncertainty was mapped to different sources both in and around a game. Beyond these very domain specific views of uncertainty, we also found discussions of uncertainty being a contributing factor in cognition (Kahneman and Tversky 1982) and specifically related to decision making processes (Fox and Ülkümen 2011; Ülkümen et al. 2016), all of which helped inform what this experience may be comprised of in its constituent parts.

Where the literature does not already articulate a useful or appropriate concept of experience, an alternative is to generate an account of the concept based on qualitative research. Grounded theory is well suited to this task (Charmaz 2014) as it aims to develop a theoretical account of phenomena that faithfully represents the experiences and accounts of people. Thus, starting from a recognition of some phenomenon of interest, a grounded theory study sets out to get people's account of that phenomenon and to try to discuss what brings it about. We have used this approach successfully to try to bring clarity to notions of immersion (Brown and Cairns 2004), user experience (Calvillo-Gamez et al. 2015) and time perception (Nordin 2014) in games. Similarly, others have gone from a very general notion that players have experiences when they play games and used focus groups to distinguish and refine the general concept into specific aspects of player experience (Poels et al. 2007).

Regardless of the theoretical basis for the concept to be measured, such theories are always prey to the processes that generated them. Despite the desire of grounded

theory to theoretically sample across people and experiences in order to test the scope and range of an emerging theory (Charmaz 2014), there are both practical constraints on how far the boundaries of a theory can be developed and implicit constraints from the researcher's own interests and biases. It is considered good practice for the researcher to be reflective of how they have influenced the theoretical development but this cannot remove such influences from any resulting theory. Indeed, some biases may be beyond the ability of a researcher to either identify or articulate.

Similarly, with theories based on existing literature, all such knowledge is situated in the studies conducted and the researchers who conducted them. Costikyan (2013) is drawing on his own experiences as a game developer and player of games to identify the sources of uncertainty. No matter how extensive his experience, it will only be with a fraction of all the possible digital games that have been developed and only one perspective on those games. Of course, that his views resonate and are meaningful to other players and researchers of games gives support to his ideas. But it is always hard to see what has been omitted.

In some sense, as long as there is some grounding of the concepts in the actual experiences of people, then there is some legitimacy to the development of those concepts. If we are unable to draw a line under collecting descriptions and data regarding experiences, researchers could wait forever for an exhaustive account of a concept like uncertainty. If you wish to start going deeper then you have to start somewhere. This is not just true of user experience but even physical concepts such as temperature. Emerging theoretical concepts start from a basic understanding of our own senses (Chang 2004). For example, temperature emerges from the basic touch sensation that some things feel warm and some things feel cold. With time, research, false avenues and new theories, it becomes possible to extend the reach of such concepts beyond what could ever be sensed by us directly. So now it makes sense for physicists to make meaningful statements about absolute zero or the surface of the sun. Similarly in HCI, we are setting out to understand the concepts of user experience but we are long way from the rich theoretical accounts like the kinetic theory of gases. However, we are trying to move beyond the basic intuitive sensations to more general accounts of user experience, no matter how constrained by context and individual differences. In time, we will refine, challenge and even discard some ideas about those experiences and their composition, avoiding the temptation to supplant what has come before, and instead building a broad, nuanced and ultimately more useful understanding of a concept.

5.4 Generating Items

Once there is a concrete articulation of the concept to be measured, the next step is to begin to generate items that relate to that concept. The principle of using multiple items in a questionnaire is that the concept itself is subjective and so cannot accurately be directly expressed by people. Instead, each item is intended to tap into one

specific and distinct part of the subjective experience so that, cumulatively, the items together build up the specific and, more importantly, quantifiable account of the experience.

Each item must therefore provide a statement that captures some aspect of the experience against which participants are able to rate their agreement. For instance, with uncertainty in digital games, it was clear that a sense of being lost in a game was an important source and experience of uncertainty. However, this was not necessarily lost in the sense of navigation but in the sense of not knowing what to do. Thus, in developing the uncertainty questionnaire, it made sense to consider items related to lostness. Of course, lostness is only one facet of uncertainty but that players could talk about this gives something concrete to ask about the internal and hidden experience of what it is to feel uncertainty in a game.

In generating initial items for the pool, the items can explore the range of possible wordings and consider both positive and negative phrasings. For example:

- I often felt lost
- I always knew where I was going
- I always had a plan
- I was going round in circles
- I didn't know what to do next

All of these are potential items though more than one is probably not needed as it is only one facet amongst many of what people describe as uncertainty. Selecting which item to use may be done based on the closeness of fit to how people express their experiences or even down to the preferences of the researcher. To guard against choosing too early, it is a good idea to maintain two or three likely candidate phrasings and these can be trialled with participants.

Wording is also important to avoid common, known traps and problems, For example, bipartite questions like "I found this website interesting and enjoyable" make it ambiguous whether people found the website interesting or enjoyable or both. Though often associated, enjoyment and interest are not the same thing. Also, care needs to be taken to avoid questions that do not make sense in some contexts. For example, "The first person perspective drew me in to the game" only applies if the game does in fact have a first person perspective on a virtual world. Extensive resources exist to guide researchers such as Oppenheim (2000) and Müller et al. (2014).

No matter how much care researchers might take, the wording of items can show strong cultural biases. One personality questionnaire that we have used previously in our research had the item "I am a spendthrift." Whilst it is a perfectly reasonable statement, "spendthrift" is not a commonly used word and many non-native English speakers had real trouble with this item as they simply did not know the word. In fact, many native English speakers also had trouble as they had never seen or used the word enough to be sure of its meaning. It may be the case here that the questionnaire had aged badly from a time when spending and how you spent your money was thought about and talked about more. Just as questionnaires may be of their time, they can also be of their place with colloquialisms like "my cup of tea" or

"curve ball." These may be very clear expressions to the researcher and any reviewer that the researcher knows, but they place the questionnaire firmly in a cultural context.

Another form of cultural contextualisation seems to arise from what researchers think people will be responding to. To be specific, in player experience research, there is often in the mind of the researchers a prototypical or even stereotypical idea of what it is to play a game. Such an idea might be that playing a game is sitting down at a gaming console and spending two hours exploring alien worlds in Mass Effect, or it might be stopping for 10 minutes during the day for a quick burst of Candy Crush on an smartphone. The researcher will try to be broad in imagining such prototypes and evaluating items against relevance in these contexts. But all imaginings are necessarily limited. It is not possible to envisage all the possible games, current and future, that players might play and so mentally check each item against them. Even defining game genre is a challenge (Clarke et al. 2015). Thus, to some extent all researchers are guided by their mental prototypes of the technologies that people use. This limits the reach of the questionnaire but without specific ways to articulate the prototypes considered, it is impossible to really acknowledge what those limits are.

As the generation of items progresses and items need refining, sometimes experts are used to review the items for relevance to the intended underlying concept. Though this will help to broaden and challenge the cultural and prototype biases of the researcher, it cannot overcome them, particularly when the experts are chosen from the researcher's colleagues (as they typically are).

5.5 Participants

One way to validate items early on is to ask potential questionnaire respondents to try out the items. This can be done with the large, relatively unrefined item pool where there might be items with overlapping content or where different wordings are used for the same ideas. This allows the participants to give their view of what it is like to do the questionnaire: it is a form of usability test on the items and is sometimes done with only a few participants. This can lead to removing items, rephrasing others or even suggest new items which the researcher did not think of. Later, once items have been selected and refined down to a plausible questionnaire with the right balance of length and conceptual content, the questionnaire is administered usually in a survey with a large, representative group of participants.

Regardless of at what stage participants are involved in the process and how many times participants are involved, as with any quantitative study, there is always the issue of who a sample of participants are. Though statisticians often talk about the distinction between sample and population, there is typically no meaningful population that can be identified. The sample is typically drawn from a pool: students at a university; people who subscribe to a particular forum; passers-by on the day of the field trial. With good demographics, it is possible to characterise to some

extent the diversity of participants but there is no way to know in what sense any particular set of participants are either typical (and if so, typical of what) or idiosyncratic.

Information from participants is often used in questionnaire development to remove items that do not function well, whether this is a result of specific feedback from participants or through statistical analysis. In statistical analysis, the reasons for considering the item weak might be:

- It is often omitted by participants
- It shows little variation, for example, everyone strongly agrees with it so it adds little insight into the concept
- It shows no coherence with the other items

In many discussions of questionnaire development, these reasons are considered good indications that the item is weak. For example, in developing the uncertainty questionnaire we had an item "I found myself going round in circles." We felt that this was a very good characterisation of the experience of uncertainty. There is a sense of doing something but ending, unintentionally, back at the same point. This suggested to us a lack of progress, not knowing what to do or not knowing why something happened when the player did do something. This item however did not load well in our factor analysis suggesting it lacked coherence with the other items or at least less coherence than others. Thus, we eliminated it.

However, it is worth examining this assumption a little further. If a researcher, along with expert reviewers and early trial participants have proposed an item, on what basis is it then considered weak as a result of running with a group of participants? It could be that for these participants, they simply did see themselves as going in circles. Or maybe not enough of them played games where going in circles was a possibility.

This also relates to the notion of prototypes in developing the questionnaire. When a group of participants respond to a user experience questionnaire, they are either bringing to mind or have just engaged in a particular experience. Naturally, this set of experiences goes beyond the prototypical experiences imagined by the researcher. However, these experiences are still specific and concrete to given contexts and the range of contexts is necessarily limited. This is in part influenced by the ways in which participants are recruited. If participants are found through a particular discussion forum about games, they are likely either to be engaged with a particular sort of game or to have particular attitudes to playing games that make them want to engage in that forum.

As with all statistical methods, it is not possible to know for sure whether it is the participants that are somehow not typical or whether the items are indeed not suitable. However, unlike other contexts, such as experiments, where the variation of participants is accounted for by statistical methods, it is not possible to use statistical methods to decide whether it is the participants or the items to blame. Until a sound operationalisation of a concept has been established, for instance through a questionnaire, it is not possible to know how relevant items are to the concept and therefore to account for their variation with statistical methods. And given the

subtleties and nuances of language, though there is not an infinite set of plausible items to include in a questionnaire, it is effectively unbounded within the scope of the questionnaire development process. Just as with participants, the pool of potentially relevant items is only represented by the sample of particular items that we happen to gather together.

5.6 Factor Analysis

The core step in validation of a questionnaire is to do factor analysis. For this, a version of the questionnaire, let's call this Version 1.0, is administered to a large number of people. Version 1.0 is not necessarily expected to be the final version of the questionnaire. It may well include too many items but the previous processes are not able to decide between them. For instance, the Version 1.0 of the uncertainty questionnaire contained 65 items, which we knew was too long for a practical instrument for use in player experience research. The hope is that factor analysis will both highlight items that are not useful to respondents as well as give an indication of which items, in a statistical sense, work better than others.

The purpose of factor analysis is, in essence, to reverse the process of item generation, where a complex concept is broken down into items that each partially reflect the concept, and try to find the commonality between different items that might reflect the hidden concept that underpins them. There are many good books and resources on how to do factor analysis, for example Kline (1994, 1998) and Hair et al. (1998), that go into both the mathematics and the practicalities of doing factor analysis on questionnaires. The purpose here is to give some insight into how meaning arises from these processes. Such books will also give guidance as to what actually is a "large" number of participants.

Typically, when a concept is being captured for the first time by a new questionnaire, exploratory factor analysis is undertaken. This is usually Principal Component Analysis but it may also be a factor analysis approach like Principal Axis Factoring. In my experience, these only give slightly different results. What these methods do give is a way of grouping items in such a way that items from the same group strongly correlate with each other but only weakly with items from the other group. Each group then forms a factor.

However, this is usually not as easy or clear a step as one might hope. While some items will clearly group, some items cross-load, that is, they correlate well with items from two or more distinct factors. Also, though there may be a set of distinct factors, it can be hard to collectively interpret the items in the factors as a unified, meaningful concept. Additionally, some factors naturally correlate with each other because they are all, after all, meant to relate to the same underlying concept.

The role of the researcher is to navigate the challenges of deciding on useful factors with the statistical tools of factor analysis, in particular choosing the number of

factors in a solution and judging what constitutes an item belonging to a factor. The result is a set of factors that underpin the concept in hand.

In our first attempt to analysed the uncertainty questionnaire data using Principal Component Analysis, we found four distinct factors.

- Disorientation
- Exploration
- Prospect
- Randomness

Though the factor analysis was done using the recommended best practice, there is a puzzle at the heart of this. How could a questionnaire intended to measure the single concept of uncertainty result in four distinct factors? These factors correlate together but not strongly so is there one concept of uncertainty that players experience or four? Interestingly, the factors did not divide along the same lines as Costikyan (2013)'s analysis of sources of uncertainty suggesting that different sources may not lead to distinct experiences of uncertainty.

Bifactor analysis was developed in the early days of questionnaire design but was neglected until relatively recently (Reise 2012). Whereas traditional factor analysis posits that data can be represented by distinct factors that may correlate, bifactor analysis assumes a single underlying factor, often called g, that accounts for all common correlation between the factors and then specific distinct variation due to each distinct factor.

The second and more careful analysis of the uncertainty questionnaire was conducted with this model in mind. Our first application of this method deliberately looked only for a single factor solution. Almost all of the 65 items in Version 1.0, loaded well on a single factor. The argument is that this single factor is capturing the underlying notion of uncertainty. Further analysis suggested five distinct factors (Power et al. to appear):

- Uncertainty in Decision Making
- Uncertainty in Action
- Uncertainty in Problem Solving
- External uncertainty
- Exploration

Not all items loaded well on these five distinct factors suggesting that while some items are relevant to uncertainty they are not central enough to form into factors. As there were still a lot of items, we selected items that loaded strongly in each factor and therefore might be understood to be core to the concept represented by the factor. We then applied a bifactor analysis to this 24-item Version 2.0 of the questionnaire.

What we found was that all of the items of Version 2.0 loaded to some extent on the single underlying factor, g, but that External Uncertainty and Exploration both showed strong distinct loadings. Our interpretation is that the first three items are core to the internal sense of uncertainty of what players feel uncertain about but which relies on them to resolve. External uncertainty is due to things outside of their

control: behaviour of other players, hidden information, chance, randomness, or even just perceived randomness. It of course relates to internal uncertainty but as it is perceived to arise from outside the player's control, it is also clearly distinct. Finally Exploration is a strategy to resolve uncertainty. Feeling uncertain leads to the need for exploration but is otherwise unrelated to the other factors, but might relate to how External Uncertainty can become internal uncertainty within the game space.

Even within this model, though internal uncertainty emerges strongly, there is still room for some people to feel that uncertainty in different ways, say from not being able to solve problems or from not knowing what action to take. What bifactor analysis suggests is a broadly unified concept that is nuanced more or less strongly by the different factors according to the players, their contexts and what the games mean to them. It may be this nuancing that led to four factors in our preliminary analysis because internal uncertainty there factored only into disorientation and prospect rather than the three factors we later found.

What should also be noted here is the role of the researcher in developing this model. We arrived at this description of uncertainty in games iteratively and only stopped when we felt we had a good description. The numbers of factors, the choice of what constituted a high factor loading and our choice of items for Version 2.0 were in no way determined algorithmically. The hope, of course, is that though this solution may be idiosyncratic it is nonetheless a meaningful representation of uncertainty and one that would agree with other such measures developed by other researchers. The problem is that once such a measure is in place, the inclination of others to develop similar measures is greatly reduced.

5.7 Analysing Data

Once a suitable instrument for an experience has been developed, it can then be deployed in studies, experiments, surveys and so on. In this way, it is possible to begin to both quantify and manipulate the experiences that people have in different contexts. Experiments will explicitly manipulate the context of interaction and use statistical testing to see the effect on experience, for example, altering the degree of what is visible to see the effect on players' feelings of uncertainty (Kumari et al. 2017). Surveys or other in-the-wild studies enable researchers to build a picture of how people experience a particular concept. Through exploratory statistical analysis, such studies reveal correlations and associations between different aspects of the players and their experiences, for example whether winning or losing in a game influences their sense of social presence (Hudson and Cairns 2016).

Statistical tests are used to do these analyses and typically with questionnaire data, the default is to use the classic parametric statistics like a t-test and ANOVA. Historically, these tests are believed to be robust to deviations from their assumptions and likely to lead to sound analysis. For instance, one such belief is that a t-test still gives sound results even when underlying distributions are not at all

normal provided the sample sizes being compared are equal (Sawilowsky and Blair 1992). However, more recently, such beliefs have both been challenged and also rendered unnecessary thanks to new tests that are genuinely more robust and rely less on inappropriate assumptions (Wilcox 2017). These more modern tests however do require the researcher to be more careful in looking at data.

It is a much larger topic to explore the full range of the implications of modern robust statistics for measuring user experiences (Cairns 2018). However, here it is worth considering something very relevant to a third wave approach which is consideration of the individual and their experiences. Typically statistical tests work with averages, that is, some measure of a sample of participants that aggregates across all of the participants such as the mean or median. However, this not only downplays the importance of the individual participant but also considers individuals as a relatively uniform group whose experiences are in some sense the same.

There are of course good reasons not to put too much weight on individual data points about user experience. Measures of experience are likely to be quite inaccurate partly because a questionnaire is at best measuring facets of a hidden experience and partly because of people's interpretation of the questionnaire. It is only on aggregate over a series of measures that quantification of experience becomes meaningful.

However, where individual participants' data do meaningfully stand out and with implications for analysis are when a measurement outlying. It is possible that any outlying measure is just highly inaccurate but at the same time, the reasons for such inaccuracy must be considered.

Modern statistics has robust tools for identifying outliers of individuals from a sample. One of the most effective is in a boxplot. The box of the boxplot represents the interquartile range of a sample of data, the middle 50% of data points. A point is declared an outlier if it is a fixed proportion of the box's size away from the box. This slightly complicated decision procedure arises so that the outliers themselves are unlikely to influence the decision of what constitutes an outlier. This robust decision procedure is built into most statistical packages that can draw boxplots with the result that it is easy to identify outliers as points singled out on the boxplot. Traditionally, outliers were nuisances. Theses single points can strongly influence the results of parametric tests and so mislead the interpretation of the "average" behaviour. Thus, outliers are often omitted from the analysis (Bakker and Wicherts 2014). However, it is not clear that that is justified. If a person has an unusual or outlying experience, that may still be an important aspect of the technology or interaction under consideration. Yes, it could also unduly influence the statistical analysis but it is also worthy of consideration in its own right.

Thus, the detection of outliers should be a reason to pause and think about the possible causes of outlying values. There are typically four possible reasons why they might occur (Osborne 2010):

1. Data entry error
2. Mischievous participants
3. Bad study design

4. True representation of a participant

Of these, only the first is easily solved. An outlying value may occur because of a miskeying or slip when entering data ready for analysis. In which case, the outlying value has no relevance to any analysis. However, if an outlying value can be tracked back to a participant who had not engaged in a study properly then there is a more serious problem. It is not enough to discount that one outlying participant's data because the same behaviour that led to an outlying value may also be influencing other participants and their measurements as well. This can particularly be a problem when a study has been run online and the researcher has not been on hand to observe participants' behaviours during a study. Checks would need to be made to see if other participants also behaved the same way and then all of the affected data removed from any analysis. More serious still is that the study design itself led to outlying values, for instance, by a failure in the questionnaire software (or even the wetware) to deliver all the questions correctly to all participants.

In these last two cases, outliers, far from being nuisance values, are important indicators of potential problems in the research. They require investigation and the causes of the problems need to be tracked down and if possible eliminated.

When all possible mishaps have been discounted, then the only conclusion can be that some people simply produce outlying values. Some people have different experiences than others and in some cases, sufficiently different to be considered extreme or outlying. But that does not make them illegitimate values to be discounted. Indeed, taking seriously the challenge of third wave thinking, such values may arise from a different type of person in a different situation and could signal important variations in people's experiences. In almost all cases, then, outliers are food for thought either about the nature of the research or the nature of the experiences being researched.

In research where questionnaires are used to measure user experience, it is not at all clear that there has ever been any systematic consideration of outlying measurements. In more traditional usability contexts, we have noticed that there can be persistent outliers in any particular usability task (Schiller and Cairns 2008). For example, we have seen that the time it takes people to navigate an online website always seems to produce one outlying person who takes an unusually long time. However, it would be mistaken to attribute that unusual time as atypical. It seems to be a persistent feature of either that sort of study or of people generally. We have a new project underway to explore this more systematically but up until now it has remained unexplored by others despite the prevalence of usability tests in both the research and practice of UX.

It would be useful to try to look systematically across large bodies of data to see if, similarly, outlying measurements are a feature of studies into experience. Are there individuals or even sets of people for whom experiences simply do not lie in the typical range of given questionnaire? Or more challengingly, perhaps we should be trying to seek out outliers and so highlight the limitations and situatedness of our measures.

5.8 Limitations and Opportunities

From the above account of questionnaire development, there are two immediate implications. First, the epistemologically situated nature of any questionnaire has to be acknowledged and accordingly, any numbers produced that measure user experience are not absolute but represent a particular understanding of what that experience could be. Perhaps this is not news to many HCI researchers but it brings to the fore what is often overlooked or ignored: just because we have hard quantities we do not necessarily have hard concepts. Secondly, it may seem that given the bias and context of any questionnaire, it is pointless to pretend that any questionnaire captures anything meaningful about the general nature of human experience. Our questionnaires cannot capture anything that reflects wider and useful truths about humans and our relationships to technology. In which case, we would be entitled to have an existential crisis about our research careers!

Stepping back though, having a scientific theory which is known to be false is not a problem. History is on our side because almost every scientific theory to this point has been proven to be wrong both in the specifics of its predictions and indeed the underlying "reality" that it represents. Phlogiston, Newton's theory of gravity, Faraday's lines of magnetic flux and so on have all fallen by the wayside as essentially wrong theories. Even now, the two most precise theories in modern physics, general relativity and quantum field theory are known to be wrong because they are fundamentally incompatible. Based on this, we have no right to expect our theories, based on questionnaires or not, to be correct. This is the principle of pessimistic induction.

It is pessimistic but it is also liberating. The judge of the value of a scientific theory is not some reference to an elusive underlying truth but rather whether it is useful: can we make testable predictions? does it help answer questions? does it drive inquiry? None of these criteria assert the truth or correctness of a theory but they suggest that in some sense we are making progress in developing new knowledge.

With this regard, we argue that limited and situated though questionnaires may be for measuring user experience, they help us to make progress. We have not had much opportunity to use the uncertainty questionnaire to see how progressive it is (though our early forays with student projects are encouraging). Considering instead the older immersion questionnaire, the IEQ (Jennett et al. 2008), there has been a lot of work using this questionnaire. Understandably, and as you might hope, it has helped to validate some expected results: more interesting games are more immersive (Jennett et al. 2008); playing under time pressure increases engagement (Cairns et al. 2014). Rather than informing user experience, this adds weight that the IEQ is measuring something relevant to how immersed a person feels in a game. We have also learned less expected things: players are more immersed if they think they are playing against humans (Cairns et al. 2013); players are more immersed if they believe the game is adapting to them (Denisova and Cairns 2015).

The fact the IEQ and other questionnaires do help us to make progress is encouraging. Despite all the limitations and narrowness of the epistemological grounding of the questionnaire, it seems to capture something that starts to reveal new things, things we did not previously realise and things that might be useful and important. Our feeling is that perhaps this is because in some way, people are not so different. Yes, we value different things. Different contexts, different relationships, different times of our life, all give different meanings to the experiences we have with technology and with each other. However, those experiences seem to have some commonality despite all this variety. We cannot know for sure if your experience of uncertainty in games is the same as ours but it is perhaps an act of faith in human nature that in some sense, while not the same, it is very like ours.

This is not to say we can neglect that for some their experience are very different. Many will agree on the experience that is called "red" but we know there are colour-blind people for whom the experience of red is fundamentally different and blind people for whom it is not even meaningful. Modern statistics suggest that we should take seriously both the difference in nuance of experiences between individuals and the differences that lead to radically different experiences.

With these considerations, measuring experiences is not the inherent contradiction in terms that it might at first seem. A successor science view of measuring experiences, or indeed anything, must require us to question the situated nature of the knowledge we produce. Measuring uncertainty allows us to make progress in certain ways but we should not stop at this particular measure but constantly reach and extend both our concept and our measurements to investigate new people, new games and new situations of play, and beyond into other interactive systems. In this sense, a successor science view of measurement accords well with Wright and McCarthy (2004)'s view of experiences as becoming: our measures must be in a process of becoming as well.

The uncertainty questionnaire is in its early days but we are already thinking about how it is relevant to different sorts of people from our mainstream players who helped us to develop it. In particular, it seems that disabled players may experience uncertainty when playing games that is both intrinsic to the game but also driven by the technology that enables them to play. We are therefore looking to validate the questionnaire specifically with gamers with disabilities. We believe that at some level they will experience the same pleasures and frustrations that other players feel, even if they come from different sources, and that this uncertainty questionnaire will allow us to make progress for their experiences as well. However, if it does not, then we will need a new way to understand and measure their experiences.

In the third wave of HCI, we must recognise that there is not just one experience or one way to measure it.

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Chapter 6
A Holistic Approach to Measuring User Engagement

Heather L. O'Brien

Abstract This chapter provides an overview of methodological approaches and current work in the evaluation of user engagement (UE). Using a series of propositions about the nature of engagement, I review a selection of recent research that utilizes varied methodological approaches to study UE in various human-computer interaction settings. The propositions and the reviewed literature are used to propose a methodological framework to guide decision making and reflection regarding how UE will be evaluated in a given context. The chapter concludes with reflections on broader issues related to how researchers' methodological stances influence the evaluation of UE. Overall, the chapter argues that UE should be measured using a thoughtful mix of qualitative and quantitative methods, considering the particulars of the use context, and balancing established and emerging subjective and objective metrics.

6.1 Introduction

Today's digital technologies, including web search engines, e-book readers, mobile apps, library databases, social networking sites (SNS), and Massive Open Online Courses (MOOCs), log vast quantities of data. Users leave behavioral traces whenever they download, click, scroll, like, query, etc., where these actions are often equated with user engagement. While indicators of user activity and "stickiness" (i.e. repeated use), these behaviors may not reveal the whole story about how people engage with technology in the moment or over time. Over the past decade, I have focused on user engagement (UE) as a quality of user experience, arguing for the need to understand the cognitive, emotional, behavioral, and, increasingly, social, dimensions of people's digital interactions. Beyond what people do when they use these applications, why do they shop, learn, search, connect or play in the first

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place? What affordances of technologies foster, deter, or sustain meaningful engagement? Furthermore, what is the benefit of UE: Does it help people think critically, feel connected to others, learn, relieve stress, or manage their health?

A holistic view of user engagement acknowledges the myriad motivational, individual, technological, and contextual factors that shape experience, and recognizes that meaningful outcomes, such as learning how to program or changing an unhealthy behavior, are more nuanced than outputs, such as pages viewed during a web search or products purchased while shopping online. A truly holistic view, however, is not always pragmatic for designers, product developers or content strategists who operate in competitive and fast paced environments, or those with limited resources to evaluate user experience. Sets of metrics (e.g., daily active users, number of comments or likes) that can be tracked over time and that generate interpretable outputs (e.g., retention rates, amount of downloaded content) may be preferable and more feasible than trying to account for the many factors that precipitate engagement, or to map less tangible effects of technology interactions, such as well-being and learning gains.

Yet, design is not prescriptive and neither is measurement. It is problematic to apply a single set of engagement metrics to all digital experiences, given that applications vary in terms of targeted user group, purpose, media type, and content. Consider online communities, for example, and how engagement might differ in citizen science versus micro-worker crowdsourcing communities; users' motivations for participating, the nature of the activities carried out, and the degree of subject knowledge required for completing crowdsourcing tasks mean that we cannot conclude that engagement is the same even within the same digital domain. This is not to say that there is no room for quantifiable, easy-to-apply metrics in the evaluation of UE, but we need to ensure they are effective proxies within the contexts in which we are applying them.

Thus, in the study of user engagement, we need not abandon the methods of "second wave" HCI completely in favour of the third wave. This is not to say we should continue to view HCI interactions as purely cognitive (e.g., humans as "information processors") rather than as situated in particular contexts (Harrison et al. 2007). Rather than dividing methods as second or third wave, it may be more productive to examine the overlap between the modes of inquiry used in each paradigm (Bødker 2015). Taking a more pragmatist stance, we might first ask what it is we want to know about a phenomenon, and the constraints operating within the context that will shape our inquiry and design processes. We can then employ a variety of relevant methods (objective, subjective) and explore the interface between the findings to achieve "rich, detailed descriptions of specific situations" (Harrison et al. 2007: 11) that characterized third wave ways of knowing.

This chapter seeks to provide an overview of methodological approaches and current work in the evaluation of user engagement, by exploring the definition and measurement of UE. Using a series of propositions about the nature of engagement, I will review a selection of recent research that utilizes varied approaches to study engagement. The chapter will conclude with reflections on broader issues related to how researchers' methodological stances influence the evaluation of UE.

6.2 An Overview of User Engagement Methodological Approaches

A number of methods have been employed to investigate user engagement (UE) across a range of digital applications[1]:

- Self-reporting via questionnaires, think aloud/think after protocols, interviews;
- Log analysis, or usage patterns derived from behavioral observations, such as number of mouse clicks, scrolling behavior, number of unique or returning users, time spent using an application, etc.;
- Neurophysiology, which uses measures such as heart rate, electrodermal activity (EDA), electroencephalography (EEG), electromyography (EMG), functional magnetic resonance imaging (fMRI), and eye tracking to infer, for example, users' attention, cognitive load and level of arousal based on electrical activity, blood flow, pupil dilation changes, etc. in the brain and body;
- Ecological momentary assessments (EMAs), which prompt people to record their current behaviors or experiences in the moment; and
- Mobile or environmental sensors that record geographical location or behaviors (e.g., step counts, route information) as people move through time and space.

Each of these methods has its benefits and drawbacks. For example, as Yardley et al. (2016) point out, EMAs are interruptive; they purposefully disengage people from their activities and may negatively impact engagement; O'Brien and Lebow (2013) suggest that analytic metrics effectively capture large-scale user behavior patterns but do not account for people's motivations, goals, or emotional responses to their activities.

The purpose of this chapter is not to advocate for/against a particular method, but to make a case that the study of UE must be approached with a well-equipped toolbox, the expertise to utilize its contents effectively, the ability to consider the impact of contextual nuances on evaluation, and ultimately, an openness to the different ways that meaningful engagement is constructed through digital technologies. All methodological approaches have their place and time, and all contexts come with a set of constraints to be negotiated, such as access to users or their data, time and resources to collect and make sense of data, etc. There are also differences in the nature of individual measures in terms of whether they have been substantiated in a particular setting and generalized to others, or are emerging and therefore more exploratory and limited in their validity.

Furthermore, the abstract nature of UE makes the act of measuring it problematic. In many instances, we are inferring engagement rather than truly measuring the phenomenon itself. For example, let us consider e-commerce settings where potential shoppers spend varying amounts of time, have different goals ("I know what I am looking for" vs. "I want to browse and see if something catches my eye"), and

[1] For more in-depth discussion on different UE evaluation approaches, please see Lalmas et al. (2014) and Yardley et al. (2016).

may or may not make a purchase. How do we understand shoppers' levels of engagement? We can't be inside other people's minds (and sometimes people have great difficulty explaining their own motivations and actions), but patterns of interactions (e.g., dwell time on product information pages, adding products to the shopping cart, purchasing behavior, activities of new versus returning customers) can be used as proxies of engagement. Yet different e-businesses may use the same metrics to tell different stories. One business might view returning customers as a positive sign of loyalty or brand reputation, while another business might want to look a little more deeply at the returning customers in terms of their purchasing behavior, or the time between return visits: some returning customers may make periodic visits over a long period of time, while others may make frequent visits within a small window of time. The former return visitors may be the loyal customers, whereas the latter might be making a decision about a single purchase. It is for this reason that we need to look beyond the metrics, and why our definition of UE is fundamental to our methodological choices.

6.3 Defining User Engagement

When I began research in the area of UE in 2005, I drew upon the foundational work of Richard Jacques (Jacques 1996; Jacques et al. 1995), Jane Webster (Webster and Ho 1997), and Brenda Laurel (1993) among others, published in the mid- to late-1990s. I attempted to unite scholarship across different fields of inquiry (human-computer interaction (HCI), information systems, learning sciences, etc.) to define user engagement (UE) and to distinguish it from related concepts, such as flow, immersion and presence (O'Brien 2008; O'Brien and Toms 2008). Early on, I envisaged a single definition of user engagement that could be applied consistently to aid in evaluation and facilitate communication amongst multidisciplinary stakeholders. I followed in the path of other researchers who focused on identifying attributes of and influences on UE (Jacques 1996; Webster and Ho 1997). Based on a systematic review of the literature and an exploratory interview study with online gamers, searchers, shoppers, and learners, I proposed that:

> Engagement is a quality of user experiences with technology that is characterized by challenge, aesthetic and sensory appeal, feedback, novelty, interactivity, perceived control and time, awareness, motivation, interest, and affect (O'Brien and Toms 2008: 949).

The benefit of this definition (and others like it) is that it operationalizes dimensions of user engagement that can be isolated and measured. For example, psychological tests, such as the Stroop task (Stroop 1935), can reliably measure selective attention, which has been demonstrated to be a component of engagement. In my own work, I operationalized engagement through the User Engagement Scale (UES). I compiled a bank of questions derived from the literature and my initial interview study that corresponded to each of the attributes in my original definition. I then tested a portion of these items that were shown to have face validity in two

online surveys with hundreds of online shoppers to further reduce the number of questions to a parsimonious and reliable set, and to examine the factor structure, or how items grouped together. The latter analysis demonstrated distinct dimensions of UE as measured by the UES: focused attention, involvement, novelty, usability, aesthetic appeal and endurability, or overall feelings of success and willingness to engage in the future (O'Brien 2008; O'Brien and Toms 2010). Thus the attribute-based definition of engagement led to the construction of questions that together captured user engagement as a multidimensional construct through self-reporting.

Attribute-based definitions, however, can be problematic. We might ask how stable these attributes are over time and across different user groups and types of technologies (O'Brien 2016a), which leads to the question of the universality of any definition. Further, it may not be so much about the presence or absence of attributes, such as motivation, novelty, challenge, etc. but rather their intensity. I put forward a stage-based Process Model of User Engagement where I envisaged that technology users move through a point of engagement, a period of sustained engagement, disengagement and (potentially) re-engagement, and that some attributes may be more salient at particular stages of the process (O'Brien 2008; O'Brien and Toms 2008). I have also noted that different attributes are more compelling than others for people placed in the same situation. In a study I conducted of online news browsing, some participants' engagement was embodied in the physical interactions they had with the news site, while others were cognitive or affectively engaged with the news content (O'Brien 2011). This definition is less rigid than the previous one, yet more conceptual in nature and therefore more challenging to operationalize. However, it creates space to select, adapt and experiment with methodological approaches that reflect a broad perspective of UE and the anticipated outcomes of engagement in a given scenario.

6.4 An Interpretive Framework for Studying User Engagement

There are multiple perspectives on user engagement, and these are guided by our epistemological practices as researchers and designers, as well as the outcomes we are trying to facilitate for people through technologies. Despite different approaches to the study of UE, there are commonalities. Recently I documented "unifying propositions" within the literature, with the idea that these could be used to develop a theory of user engagement (O'Brien 2016a). This was not intended to be "Theory with a capital T," which is constructed over many years and can seem overly abstract for day-to-day application. Rather, the propositions were intended to provide a flexible, interpretive framework for considering the scope and meaning of engagement in a given setting, and, consequently, its evaluation. The propositions are summarized as follows:

- User engagement is a process and product of digital interactions.

- User engagement has affective, behavioral, and cognitive aspects.
- User engagement is a quality of UX that is characterized by the depth of the actor's temporal, emotional and cognitive investment in the interaction; users' level of engagement may range from shallow to deep; this depth continuum occurs within individuals and communities. Shallow participation may be adaptive to human wellbeing and contribute positively to "the digital ecosystem" made up of "touchpoints" that "are 'woven together' by social practice" (Bagnara and Pozzi 2016: 64). Thus, engagement is not an all-or-nothing phenomenon characterized by constant, high arousal or concentration, or lengthy interactions; rather, the intensity of experienced engagement can ebb and flow depending on the user or community's need for (inter)action.
- In addition to the nature of the interaction itself, external factors, such as situational constraints, and users' goals, motivations, and personal qualities (e.g., computer self-efficacy, topic interest or expertise) affect UE. Therefore, UE is context dependent, and context may be discerned at different levels (personal, social, task or situation related) (O'Brien 2016a: 22).

These propositions represent a synthesis of the conceptual understandings of engagement over the past two decades, yet they can also be used to consider the expression, as well as the merits and drawbacks of different methodological approaches. By focusing on theoretical propositions rather than types of measures, my intention is to place user engagement in a more intersectional space where methods are not rigid but adaptable to the kinds of complex research questions posed in HCI. In the following sections, I use recent examples to illustrate each of these propositions; these examples are not exhaustive, but are intended to show contemporary work in the area. It is important to note that no single study encapsulates all aspects of any one proposition; for instance, not all researchers view UE as behavioral, cognitive and affective, and therefore measures related to all of these facets are not included in their work. However, we can examine these studies with respect to the conceptualization of UE and approach to measurement, and the role of contextual constraints and outcomes of interest on the research design.

6.4.1 User Engagement As Process and Product of Interaction

User engagement is a process and product of people's interactions with digital environments. In other words, UE can be analyzed during and after human-computer interactions. It has been more common to measure engagement as an outcome of interaction. Self-report measures administered after a user has completed a computer-mediated task are common practice. It has been more challenging to evaluate engagement as a process. While neurophysiological equipment has been becoming more accessible to HCI researchers, the dilemma of syncing and making sense of the large amounts of data generated (Lebow and O'Brien 2012) remains. Further, commercially available neurophysiological equipment, while less invasive

and more affordable than before, may affect data quality. Andujar et al. (2017), for example, critiqued wearable Brain-Computer Interface (BCI) devices:

> [The BCI headset] requires the user to stand still, restrict muscle movement as much as they can, have shorter or no hair, and be at a room at a decent cold temperature to avoid sweat. These requirements do not allow the user to perform a real-world task in a natural manner and may affect how they feel about BCIs negatively. An ergonomic issue is that these BCIs are not adjustable for all the different types of head shapes and sizes (p. 104).

However, recent work also highlights strides made to collect, analyze, and interpret process-based data using neurophysiological methods, increasing their potential to be used outside of controlled laboratory settings. The following studies show the complexities of collecting and interpreting process data, and also the role of the human body in the measurement of UE, where engagement is the result of "doing things in world" (Bagnara and Pozzi 2016; Harrison et al. 2007: 7)

Anzalone et al. (2015) performed two studies to explore robots' ability to foster social intelligence in young adults and children. In the first study with young adults, the researchers were interested in the robots' ability to elicit non-verbal communication behaviors through a task where participants attempted to teach a robot the colours of objects. In study two, the aim was to induce joint attention between children and the robot on an object; the purpose was to compare children with autism spectrum disorder and those experiencing typical development. The authors used sensors to detect and log participants' gestures, eye gaze, and body and head positions in the interaction space, and inferred UE with the robots based on nonverbal behaviors. Anzalone et al. discussed the potential of their findings to monitor humans' non-verbal behaviors for the purposes of increasing attention focus and responsiveness in human-robot interactions to "strengthen the engagement, regulate the rhythm of interaction, and arouse in people the perception of social intelligence" (p. 474).

Li et al. (2016) were also interested in engagement and the "rhythms" of interaction between humans and robotic systems. They developed and tested a cyber-physical stroke rehabilitation system (CP-SRS) to enhance stroke survivors' motor abilities when performing rehabilitation exercises. The CP-SRS combined an assistive robotic system and gamification, and monitored engagement using data collected from on-screen content changes, eye movements, facial expressions, electromyography (EMG), and electroencephalography (EEG). Some of the measures were more successful than others in capturing engagement. For example, although the exercises were created to require different levels of cognitive load, this did not result in differences in cognitive engagement. In addition, there was a lack of correspondence between the facial recognition data and self-reports used to measure emotional engagement; they did, however, find that including an accuracy requirement in the exercises increased the amount of attention and effort needed to complete the tasks.

Li et al. (2016), Anzalone et al. (2015) and other researchers are confronting the difficult measurement challenge of capturing and making sense of data gathered through numerous channels to identify (non) engaged states. As in Li et al.'s (2016)

study, part of this sense-making may involve combining process and product measures, and looking for correspondence between these. Another recent example is the work of Jensen et al. (2016). They used a strategy/simulation game and a training video to teach students about the impact of cognitive biases on decision-making, comparing engagement and responses to failure by mode of interaction. They performed a study at two different sites with over 150 students using eye tracking, self-report and physiological methods; heart rate and EDA (specifically skin conductance levels) were measured only at one site. The self-report measures included established questionnaires for cognitive absorption (CA) (Agarwal and Karahanna 2000), positive and negative affect (PANAS) (Watson et al. 1988), and personality (ten-item personality inventory or TIPI) (Gosling et al. 2003). Results corroborating the various measures were mixed. Although there were no physiological differences between the game and training video conditions, the researchers observed that skin conductance levels decreased for those in the video condition and remained stable for those playing the game compared to participants' own baselines. Only one dimension of cognitive absorption (temporal disassociation) differed between the video and game conditions, but PANAS scores showed that positive affect declined from pre- to post-task for the game group, which would be expected since these participants experienced failing to win the game, while those in the video condition watched failure occur but did not experience it personally.

Martey et al. (2014) also explored UE in a gaming environment using multiple measures: self-reported presence, EDA, and mouse clicks, mouse rests, and attention (time spent looking at the screen based on screen captures). The same two-dimensional (2D) puzzle-based gaming environment was used in two studies but with different manipulations: in study one, people were/were not able to customize an avatar, and in study two the art (simple versus detailed) and narrative (rich versus light) detail varied. Across both studies, they found consistency in and correspondence across the various self-report measures. However, the relationships between physiological, behavioral and self-report data were not as significant. This is similar to the findings of O'Brien and Lebow (2013), who found strong correlations between self-reported engagement, cognitive absorption and usability, but not between self-reported UE and search behaviors (browsing time, reading time, links and pages visited), or heart rate, EDA and EMG.

6.4.2 User Engagement As Affective, Behavioral and Cognitive

My perspective is that user engagement has affective, behavioral, and cognitive aspects. However, examining the multifaceted nature of UE effectively in a single research study may not be feasible or desirable. In these cases it is prudent to be clear about how UE is being defined and why in a given scenario.

Nguyen (2015) chose to examine only behavioral engagement in the context of crowd-based open collaborations, justifying this decision by reasoning that "to the crowdsourcers, online users' engagement is significant only when they actually

contribute something to the crowdsourcing events" (p. 4). In doing so, Nguyen articulated that engagement is voluntary, "on-task," and observable in the context of online collaborative initiatives. In addition, the author speaks of engagement as process-based and associates it with active, effortful participation but not the quality of the contributions: "[engagement] represents an effort, not a work outcome. That is, it does not matter whether users' contributions are outstanding or mediocre. The emphasis is on the fact that they actually make an attempt to do something" (p. 28). Nguyen's framing of user engagement allowed it to be operationalized as the "intensity, sustainability, and variety of tangible effort online users voluntarily devote to what is requested in an open collaboration initiative" (p. 4) and to develop measures accordingly. Intensity referred to the effort required to make various contributions, where contributions were weighted according to effort required to complete specific tasks; sustainability examined participants' contribution patterns over the duration of the initiative, and variety accounted for the diversity of participants' activities.

While Nguyen (2015) focused solely on behavioral engagement, Andujar et al. (2017) sought to measure affective engagement in their study with high school students. They used a wearable brain computer interface (BCI) to collect EEG data as students performed a simple task with one of two different programming environments over a 10-min period of time, with changes in engagement averaged every 2 min. The engagement patterns captured with the EEG data were not statistically different between the two programming environments. However, they noted differences in terms of whether engagement was demonstrably different or similar amongst participants using the same programming tool.

Andujar et al.'s (2017) emphasis on affect and changes within individual learners relates to related work by O'Brien et al. (2016) where students' comprehension of materials in a digital reading environment was evaluated. Students' engagement was categorized as high, medium, or low based on their scores related to UES questions about involvement, novelty and endurability. The researchers tested comprehension using true and false items to assess recall and the sentence verification technique (SVT) to explore participants' understanding of main ideas presented in the texts. The low and high engagement groups performed significantly better on the tests than the medium group; their average scores were similar for the true and false questions, but the least engaged participants had the highest mean SVT scores. In other words, participants who experienced low and high engagement achieved the same learning outcomes, but the high engagement group had a more positive experience, and the researchers concluded that, while not necessary for learning to occur, the ability to engage with the readings helped this group do "the hard work of learning" (p. 73). Thus in learning and other applications – where it is not the destination but the journey – it may be crucial to attend to the affective qualities of the interaction, such as motivation and interest, and affective measures may help the researcher make sense of non-significant behavioral or performance differences between experimental conditions or study outcomes.

Lohse et al. (2016) looked specifically at the role of engagement in enhancing motor learning in a game-based environment, but were also interested in affective

aspects of the experience. Forty university students were assigned to a rich game condition, where they practiced a novel motor skill, or a sterile condition, where they engaged in the same game stripped of its aesthetic features. Findings were compared across conditions and participants who engaged in low (200 trials in one day) or high (400 trials over two days) doses of practice; retention was tested one week after the practice session. Modified versions of the User Engagement Scale (O'Brien and Toms 2010) and the Intrinsic Motivation Inventory (McAuley et al. 1989) were used to measure engagement and intrinsic motivation, respectively, and behavioral metrics (e.g., catching an object, trial time) assessed game performance. The researchers concluded that the more engaging game environment improved motor learning. Although the game and sterile groups performed similarly during the practice phase of the study, the game group's motor skill retention was higher when they played the game a week later. This was not due to differences in participants' intrinsic motivation, but in overall engagement with the more aesthetic version. This study's emphasis on retention and the time lapse between gaming sessions also calls attention to long-term engagement.

In another study, Leiker et al. (2016) used the same game conditions to test motor skill retention and transfer, but added cognitive components to the study design. Audio probes were presented randomly during game play to tax participants' attention and EEG was used to monitor brain activity during the first session only. The researchers failed to detect learning or engagement effects across the sterile and game groups, with both groups achieving similar performance outcomes in the second session. However, they did observe an association between EEG and self-reported engagement, where engagement was related to how much attention participants were required to expend in both game environments, i.e., the auditory probes increased cognitive complexity. The authors suggested that this was strong evidence that engagement is related to cognitive changes and is more than just an affective experience.

Some research has attempted to examine multiple aspects of UE in the same study. Returning to Li et al.'s (2016) work to design and test the CP-SRS, different types of engagement were defined, and distinct measures were developed to reflect these types. Since the system was designed to assist people to complete physical exercises, motor engagement was important, and operationalized as "active and effortful motion" (p. 3). However, they were also interested in perceptive engagement or "sensory concentration," as measured by eye gaze and cursor and content change positions, since patients were supposed to focus on and interact with a video game to complete the exercises. The researchers also measured cognitive engagement and emotional engagement using neurophysiological methods –EEG and facial expressions – to derive patients' degree of concentration and positive/negative emotions during their interactions. They then performed a series of experiments to test and validate their chosen measures for each of four types of engagement. What is noteworthy here is the operationalization of engagement in this particular study as it related to the broader goal of developing an effective rehabilitative system.

6.4.3 User Engagement As Depth of User Investment

User engagement is not an all-or-nothing phenomenon: people can experience different degrees of investment as they engage, disengage and re-engage with technology. In fact, the ebb and flow of engagement is essential, as fatigue would be eminent with constant high engagement or could lead to problematic behaviors. In addition to being personally beneficial to disengage periodically, it is not necessarily harmful to have different levels of engagement operating within user communities.

In their study of two, two-year citizen science crowdsourcing projects, Ponciano and Brasileiro (2015) found five distinct engagement profiles of the sites' thousands of volunteers based on their performance of over one billion tasks; volunteers were defined as those who made an "ongoing contribution" to the projects, contributing on more than one day (p. 253). The profiles – hardworking, spasmodic, persistent, lasting, and moderate – were created by clustering participants' data according to number of activities performed, duration of involvement in the project, and level of activity within the contribution period. For example, "spasmodic" volunteers contributed for a brief period of time, but their irregular contributions were punctuated by bursts of intense activity, whereas "moderate" volunteers were steady, achieving intermediate scores on all engagement metrics.

Ponciano and Brasileiro used the Process Model of User Engagement (O'Brien 2008; O'Brien and Toms 2008) as a framework for developing their metrics: the amount of time the volunteer could potentially be part of the project (based on the projects' duration), days the volunteer remained linked in the project, number of active days, time spent contributing on an active day, and days elapsed between two active days. These behaviors allowed the researchers to trace when volunteers became engaged, moved through periods of sustained or active participation, disengaged and re-engaged. By analysing and clustering volunteers' previous behaviors, the authors reasoned that different engagement strategies could be employed to appropriately trigger (increase, decrease, or sustain) activity levels. Their study demonstrates that engagement can look different for different people, yet still result in meaningful contributions: brief but highly active engagement ("hardworkers") can be as beneficial to project outcomes as longer, less active participation ("persisters").

Viewing engagement as a continuum where people operate at different levels of intensity also means that some attributes of UE will mean different things to different people at different times. In my original interview study with technology users I drew upon McCarthy and Wright's (2004) "Threads of Experience" to develop and explain the Process Model of User Engagement (O'Brien 2008; O'Brien and Toms 2008). I plotted the engagement process along McCarthy and Wright's compositional thread and highlighted attributes salient during the point of engagement, period of sustained engagement, disengagement and re-engagement stages based on their connections to the sensual, emotional, and spatiotemporal threads. For example, the aesthetic appeal of the computer-mediated environment and the novelty of the content presented were sensual aspects at the point of engagement, while both

negative (uncertainty, boredom, frustration, guilt) and positive (success, accomplishment) feelings were emotional components of disengagement (O'Brien and Toms 2008: 948). Fluctuations in intensity may come about due to changes in the technology user, e.g., changing needs or motivations as one uses a digital application over time, or they may be a consequence of interactions between the individual and the technology. Unfortunately, it is difficult to discern when and why engagement changes, and this is further complicated by the rich contexts in which digital interactions unfold.

6.5 The Context of User Engagement

Context is an important variable in user engagement, yet extremely challenging to contend with. We can consider context on many levels to the point that we can ask, "what is not context" (Absar et al. 2014)? Returning to Bagnara and Pozzi's (2016) not notion of digital eco-systems, we can look at contextual variables as ways in which to better understand UE in a given scenario, and to acknowledge cross-contextual differences in engagement. However, the messiness of context can also threaten our ability to evaluate UE.

Cross-contextual differences are understood through recognition that different values and interests guide behavioral interactions with technologies. Based on the idea that online communities form to bring people with shared values and interests together, Zhang et al. (2017) developed a typology of community identity based on the language used in online community spaces. Their typology categorized community's interests as distinct versus generic, and dynamic versus stable over time, and was used to examine four unique Reddit communities. Word level measures within each community were explored. For example, the word "kitchen" was specific and frequently used in the Cooking community, while "Easter" was highly volatile (i.e., used irregularly) in the BabyBumps community. These word level measures were investigated with respect to typical community engagement measures, including community size and activity level, as well as retention, acculturation (the use of community-specific language by frequent versus rare commenters) and content affinity (volatility of language used by active and non-active users). Zhang et al.'s linguistic approach provides a more nuanced view of online community members' interests than examining behavioral data alone, or failing to account for unique characteristics of particular communities that pertain to their endurability for specific members. For instance, BabyBumps may be useful for expectant mothers but less applicable once their babies are born, whereas participating in Cooking might reflect an ongoing and long-term hobby.

While Zhang et al. (2017) captured contextual differences in online communities linguistically, Aristeidou (2016) applied a design-based research (DBR) methodology to investigate two online citizen science communities: Weatherit and Inquiring Rock Hunters (IRH). Specifically, the author used online focus groups, interviews, log files, questionnaires, researcher notes, and participants' reflections on the

researcher's findings to understand Weatherit and IRH's members' engagement, motivation, and learning, and how these were influenced by the design of these online communities. Aristeidou (2016) found different aspects influencing participation and motivation in the two communities. The type of software used and propensity for inquiry within both projects induced engagement and disengagement for members. However, mentoring and collaboration were key in IRH, whereas Weatherit's success was dependent upon acts of community creation and sustainability (e.g., active community e-moderators). The distinction between Weatherit and IRH is important as it reinforces that the same metrics may not be useful for the investigation of all citizen science projects due to the influence of contextual factors. In this case, users' motivations and levels of expertise for participating, the ability of the projects' software to support communication, mentoring, and collaboration activities as needed by members, and even members' perceptions of the purpose of the community (science versus hobby) all distinguished what made for an engaging citizen science community.

Mathur et al. (2016) performed an interesting study of smartphone users that moved results from the lab to the field, and showed how these distinct contexts can be used to inform each other. In the first phase, they asked ten people to perform fourteen tasks using their smartphones while wearing an EEG headset; the tasks were intended to be of different types and durations to produce variable EEG ratings. They also gathered self-reports using select items from the UES pertaining to focused attention and involvement (O'Brien and Toms 2010). By examining the strength of self-reported engagement in relation to the EEG ratings, the authors built a proxy inference model for EEG Benchmark Engagement Scores (BES). Subsequently, an additional ten people were recruited to wear an EEG headset and have their personal smartphone use logged over a 24 h period (wearing the headset as much as possible). The researchers examined the EEG and log data in concert and generated algorithmic models based on the applications used. The outcome of phase one was a Random Forests classification model that identified "high" versus "low" engagement based on application usage features. In the second phase of the study, 130 smartphone users from twelve countries were followed over a four-month period. Mobile use was logged according to events (e.g., call, screen and application data) and sensory interactions when the screen was turned on and at 15-min intervals; the idea here was to examine usage behaviors over time and in ecologically valid settings. Based on data obtained from over 250,000 usage sessions, the researchers extracted five types of context features to conduct predictive modeling of high and low engagement. Mathur et al. (2016) demonstrated how the controlled environment of the lab can be used to better understand mobile users "in the wild," and how the use of neurophysiological signals can be used to make sense of everyday life mobile use patterns.

However, the intricacies of context in digital interactions also leads to difficulties in translating findings from one study or setting to another, and may mask significant and non-significant results. In Martey et al.'s (2014) study of the 2D puzzle game discussed earlier, the authors considered explanations for why their results were not as anticipated. They speculated whether customization was operationalized

effectively in study one (or whether customization was even an important element of engagement in educational games) and whether the incorporation of learning content was incongruent with the goals of the game in study two. Interestingly, the EDA data they collected indicated that arousal levels were highest in the most complex (rich narrative/detailed art) and least complex (light narrative, simple art) conditions. This parallels the findings of Freund et al. (2016) in their study of engagement and comprehension in digital reading environments. Comprehension gains were highest for the group who interacted with texts in the simplest reading environment –black font on a white background; the group assigned to the most complex environment, which contained paratextual cues ("in context") and interactive Reading Tools, had the second highest gains. The results of Martey et al. and Freund et al. speak to how computer-mediated environments with minimalist design may be better for attention focus; when minimalism is not possible or desired, creating an immersive environment through aesthetic, interactive and narrative elements may direct attention to key components.

Digital interactions – even when observed in the lab with greater control – are "messy" (Harrison et al. 2007: 12), and researchers may need to rely on prior research and other data sources to make sense of the findings. Martey et al. (2014) were particularly perplexed about the non-significant differences between the rich and light narrative groups, given the prominence placed on narrative engagement in the literature, leading them to question how they designed their narrative conditions. Freund et al. (2016) examined behavioral measures collected during the study using screen capture software, specifically total reading time and time spent on different components of the texts, e.g., introduction and conclusion. They reasoned that the interactive Reading Tools affected the comprehension scores of those in the plain and in context conditions differently because these two groups formed two distinct mental models: "one based on print reading, in which Reading Tools are used to facilitate in-depth reading and engagement with texts [i.e., plain], and the other based on web reading, in which Reading Tools are used primarily to facilitate navigation and marking trails through content [i.e., in context]" (p. 90).

This messiness is extended in field-based research. Flores (2016) used an iterative, design-based approach to examine the health of emerging adults (EAs) as they transitioned to university. Flores conducted three pilot studies using interviews, online diaries, questionnaires, virtual scenarios and participatory design exercises. The main study explored engagement with one of the three fidelities: virtual, 2D and paper prototypes, and was conducted in stages with two in-person design sessions separated by a two-week online collaboration period. The author collected observations based on the in-person and online interactions, and this presented opportunities and challenges. The rate of attrition over the main study made conclusions involving questionnaire data difficult to reach. Qualitative exploration of participants' utterances during the design and collaborative processes showed evidence of engagement but we cannot know why the participants who dropped out of the study disengaged, or what aspects of the experience might have been different for them.

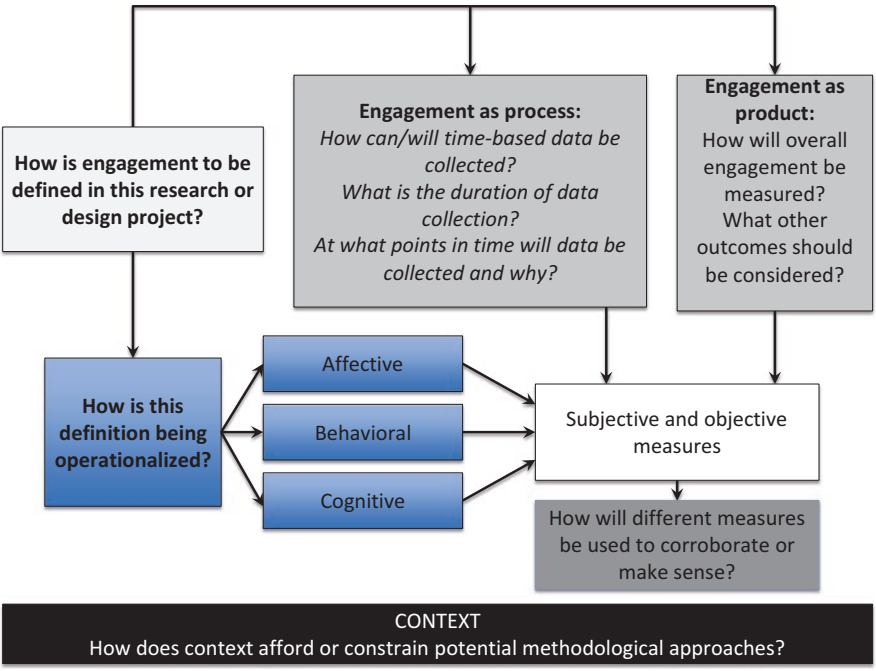

Fig. 6.1 Methodological framework for evaluating user engagement

6.6 A Unifying Framework for Evaluating User Engagement

By focusing on theoretical propositions of user engagement and the range of approaches taken by researchers in the aforementioned studies, we arrive at a methodological framework to guide the evaluation of user engagement (Fig. 6.1).

Firstly, how engagement is to be defined and operationalized is central to selecting an approach. What measures are most appropriate can only be determined once a researcher or designer has determined whether they are interested in UE as a process or product of interaction (or both), and whether they view UE has being affective, cognitive, behavioral or some combination. These decisions can then inform the identification of appropriate objective and subjective measures that reflect the researchers' lens on UE. The use of multiple measures – and the ability to effectively use them in conjunction with each other – is essential for issues of validity and sense making. From the outset of any inquiry, the researcher or designer must consider how multiple data sources can be used for the purposes of corroboration, explanation, etc. and when/how they will be analyzed in concert to provide a rich picture of engagement in a particular setting. Finally, all design decisions must be informed by an examination of the context in which the designer/researcher and stakeholders are operating: what affordances and constraints of time, resources, or access to meaningful data are at work? This framework is not prescriptive, but

focuses on guiding questions at key decision making junctures. In doing so, it helps to ground the researchers' methodological approach in their philosophy of UE and acknowledges the limitations and benefits of different types of measures and the settings in which we are working.

6.7 Further Considerations in the Evaluation of User Engagement

In addition to considering how UE is defined, operationalized and measured, a holistic examination of engagement must also take into account broader paradigmatic issues that operate upon researchers and designers. In the following section, I will briefly explore three considerations related to how we characterize the quality of the methodological approach, namely how different measures are evaluated on their own and in concert with other measures, the nature of objectivity, and making space for multiple perspectives.

6.7.1 The Role of Individual and Collective Measures in the Study of User Engagement

It is difficult to draw conclusions about engagement based on a single metric, and multiple measures are more robust. Even in cases where we are using validated measures, we need reassurance that it is behaving as we would expect it to in a new context. I have spent considerable time examining the reliability and validity of the UES through the use of other self-report, behavioral and physiological measures (O'Brien and Cairns 2015; O'Brien 2016b). As previously discussed, some researchers have had mixed results when it comes to corroborating different kinds of measures in the same study. One reason for this is that, while self-report questionnaires, neurophysiological signals, and behavioral metrics all produce quantitative data, the types of variables being measured, time series, and analytic procedures and approaches vary considerably amongst these different types of measures. It is therefore essential not to view the corroboration of metrics as one-to-one mappings where a questionnaire score is "equated" with a physiological measure, or where a behavioral metric is taken to "mean" engagement occurred; the same behavior in another setting may indicate something very different.

Meza-Kubo et al. (2016) took an additive approach to understanding the relationship between self-reports, expert observations, and EEG. Over two studies, the researchers developed, trained and evaluated a neural network using EEG signals to recognize pleasant and unpleasant emotions. The older adult participants were asked to interact with a cognitive wellness system that used a "Snakes and Ladders" like game. In their discussion of the results, the researchers pointed out well-known

pitfalls of all three of the methods used, namely the bias of expert observers, the self-inflation of self-report data, and the potential of neurophysiological equipment to capture "noisy" data. They speculated that the combination of self-reports and EEG methods would increase the accuracy of the results obtained by the neural network to 70%, and that the addition of qualitative participant observation data would further increase this to 80%. In this example, the researchers explored what the self-report and the observations added to the accuracy of the neural network, rather than the strength of associations between measures. Therefore, we need to explore the robustness of individual metrics and the relationships between different measures both in concert and in parallel over time.

6.7.2 The "Goodness" of a Particular Method

Third wave HCI advocates for different ways of knowing, and the integration of multiple perspectives and methodologies to advance the ability to understand and design for user experience (Harrison et al. 2007). Objective methods, such as eye tracking and behavioral measures, may be seen as more concrete and closer to "truth" than subjective methods, such as interviews and questionnaires, that rely on people to describe or rate their experiences. However, even objective methods are subject to some interpretation on the part of the researcher that affects the conclusions reached. For instance, researchers must determine how physiological data will be filtered and sampled and how to handle "noise" (Lebow and O'Brien 2012).

As de Guinea et al. (2012) have demonstrated, subjective self-reports are as effective as other measures when it comes to evaluating engagement. They administered three established self-report measures of cognitive load, engagement, and arousal and collected electroencephalographic (EEG) and electrocardiogram (EKG) data in an experimental study. The Multi-trait Multimethod Matrix (MTMM) statistical technique was used to assess the reliability and construct validity of the various measures and account for common-method variance (a threat to validity). Participants' neurophysiological baselines were captured before they completed a computer-based task. Their findings provided support for self-report measures. While the neurophysiological data was found to demonstrate less measurement error, the self-report data had greater content and construct validity. Self-report measures may capture more dimensions of a construct and "neurophysiological measurement may be subject to interactions with other physiological elements" (p. 568).

Part of the reason why subjective measures may be dismissed is due to the way in which they are adopted, adapted and employed in research studies. O'Brien and McKay-Peet (2017) looked specifically at this issue in the domain of interactive information retrieval. They highlighted that when questions are removed or modified from the original questionnaire, the reliability and validity of the measure is

nullified; there are also issues in how self-report data is analyzed and reported.[2] In addition, these unfortunate practices in the use of questionnaires prevent researchers from evaluating the effectiveness of metrics over time and across contexts of use. In a review of how the UES has been employed since its publication, I was able to conclude that the questionnaire has demonstrated reliability and utility in diverse research scenarios. However, since few researchers have used it in its entirety and reporting practices were not always clear, I could not adequately assess the validity of the tool with confidence (O'Brien 2016b). This comes back to the point that the methodological toolbox must be equipped, but we must also understand the intricacies of the measures we are applying – whether questionnaires or EDA.

6.7.3 Room of Multiple Perspectives and Approaches

Harrison et al. (2007) note that dominant paradigms affect what can be understood about HCI, including user engagement, stating that the dominant views will determine what questions should be asked and how they will be answered methodologically. The inclusion of objective and subjective measures can and should co-exist in the evaluation of engagement, and researchers can articulate their respective frames, recognizing the benefit of multidisciplinary approaches: "whatever our personal stance to research, multiple paradigms allow the field as a whole to develop a more complete understanding of the nature of interaction and good practices around design and evaluation" (Harrison et al. 2007: 13). If we recognize that "good work" occurs in each paradigm then notions of "validity" take on different meanings according to different perspectives (Harrison et al. 2007: 14), and we must concede that there is no one best metric or method to capture engagement, but there is value in doing whatever we do well.

As the discussion of context in this chapter has demonstrated, findings may not be interpretable through statistically supported hypotheses, but may require interpretation of the literature or of other information gathered as part of the study, including the observations of the researchers and the words of the participants. Whether in laboratory environments or field settings, digital interactions are highly complex processes that are influenced by personal, social, and system related factors and may be open to multiple explanations.

Moving to a more nuanced approach to the study of engagement and embracing subjectivity does not necessarily mean abandoning experimental work. Bødker (2015) argues that lab-based research is pragmatic: "we often need to work more directly with technical experiments and participatory prototyping, for simple reasons of time, complexity, and the fundamental openendedness of the design space" (p. 26). However, as Mathur et al. (2016) demonstrated in their study, we need not think of the lab and field as disconnected spaces, but work to move between these

[2] For a more in-depth discussion of issues inherent in questionnaire development, selection, adaptation, analysis and reporting, please see O'Brien and McKay-Peet (2017).

locations of inquiry more fluidly. There is merit in testing effects in a controlled environment and critiquing their generalizability to the real world, or bringing clarity to an aspect of engagement in the lab without the "messiness" of an ever-shifting context, building more complex research designs iteratively.

6.8 Conclusion

This chapter has presented an overview of methodological approaches for evaluating user engagement, and has explored recent studies through propositions of an overarching framework of user engagement. The propositions ask researchers to consider:

- How do I define UE?
- Am I trying to capture engagement as a process or product of interaction?
- What is the anticipated or ideal depth of the users' investment in the digital experience?
- What contextual variables are prominent? How might these enhance or detract from UE in this setting?

In the selection of studies reviewed, how engagement is conceptualized and choice of methodological approach are intertwined. The studies ranged from experimental to field-based, sometimes moving between the two contexts, and utilized qualitative (e.g., observations, interviews) and quantitative (e.g., physiological monitoring, self-report questionnaires) modes of data collection individually and collaboratively. The findings demonstrate the benefits and drawbacks of the methodological approaches and the particular perspective of engagement taken by the researchers. This idea was expanded upon through the discussion of broader measurement issues, specifically what methodological approaches are privileged according to objectivity versus subjectivity, their ability to produce corroborative results, and notions of validity.

In conclusion, this chapter argues for measuring user engagement using a thoughtful mix of qualitative and quantitative methods, considering the particulars of the use context, and balancing established and emerging subjective and objective metrics; in this way we are bridging second and third wave approaches rather than dismissing what we have learned about HCI from the past. It is not the methods of first and second wave HCI that are problematic, but the lack of flexibility with which they are employed. This is reinforced by Harrison et al., who note, "[b]ecause of its emphasis on multiple perspectives, the third paradigm does not espouse a single, correct set of methods or approaches to answer these questions. Instead, we see a variety of approaches that are embedded in a similar epistemological substrate (Harrison et al. 2007: 8). As we move forward, notions of successful interactions have moved beyond efficiency, effectiveness and satisfaction, and humanistic and social science ways of knowing and being have entered the scene. Rather than a "plug and play" approach to measuring engagement, researchers and practitioners

must define what engagement means in a given scenario, and appreciate the limitations and complexities of the methodological tools available to them and the contexts in which they operate. We must also strive to consider and learn from multiple perspectives if we hope to achieve a holistic understanding of what engagement is and how it impacts the users of digital technologies and HCI more broadly.

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Chapter 7
Influencing and Measuring Behaviour in Crowdsourced Activities

Sandy J. J. Gould, Anna L. Cox, and Duncan P. Brumby

Abstract Crowdsourcing psychometric data is common in areas of Human-Computer Interaction (HCI) such as information visualization, text entry, and interface design. In some of the social sciences, crowdsourcing data is now considered routine, and even standard. In this chapter, we explore the collection of data in this manner, beginning by describing the variety of approaches can be used to crowdsource data. Then, we evaluate past literature that has compared the results of these approaches to more traditional data-collection techniques. From this literature, we synthesize a set of design and implementation guidelines for crowdsourcing studies. Finally, we describe how particular analytic techniques can be recruited to aid the analysis of large-scale crowdsourced data. The goal of this chapter it to clearly enumerate the difficulties of crowdsourcing psychometric data and to explore how, with careful planning and execution, these limitations can be overcome.

7.1 Introduction

Crowdsourcing is a way for many activities to be completed remotely by distributed groups of people who often do not know each other and who, in most cases, will never meet. Completing activities in this way can allow for geographically diverse activities to take place (e.g., Biggs et al. 2015; Sullivan et al. 2009), or enable collaboration on tasks where expertise is sparsely distributed (e.g., Haklay 2010).

Researchers are turning to crowds to answer research questions a variety of contexts, from finding out which birds are living where (Sullivan et al. 2009), to developing law reforms (Aitamurto et al. 2017). In some cases, crowds are used because they provide a way to quickly obtain data without having to consume the time and

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space that traditional laboratory studies often demand. For some kinds of research problems however, the only way that researchers can access the phenomena they want to study is to turn to crowds. This is because, working by themselves, researchers would be unable to obtain the breadth and depth of data they need to adequately address their research question.

In this chapter, we explore the methodological benefits and challenges of crowdsourcing data for HCI studies in this way. With a particular focus on the collection of psychometric data, we begin by outlining the different ways that researchers can collect data in the crowd, and assess the quality of data these methods produce. Building on our own experiences and those of other researchers, we explain how researchers can get the best out of crowds and how they should process the kinds of data that crowds produce. Our goal is to give readers who are new to crowdsourcing the tools that they need to avoid some of the most common pitfalls encountered when running a crowdsourced study. For experienced users of crowdsourcing platforms, we synthesize some of the latest research in the area and offer this chapter as an up-to-date desk reference on working with these platforms.

7.2 Types of Crowdsourcing

The term 'crowdsourcing' is a very broad one that captures a wide range of activities. Some of this activity is related to the collection of research data. Much of it is not. Organisciak and Twidale (2015) developed a typology of crowdsourcing, in which they identify five main areas of crowdsourcing; *free and open source software, commons-based peer production*, *citizen science*, *the wisdom of crowds* and *human computation*. The focus of this chapter is on *crowdsourcing for research*, with citizen science and human computation the topics that we draw on most (rather than, for example, creating an online encyclopaedia or developing a new computer operating system). These topics are the most relevant to the collection of *psychometric data for 3rd Wave HCI*. We consider the two modes of crowdsourcing production that are most relevant to these focuses: volunteer-based citizen science and paid crowdworking.

7.2.1 Volunteer-Based Citizen Science

The practice of citizen science has existed for a long time. One of the earliest 'citizen science' projects (although it wouldn't have been called 'citizen science' at the time), was the *Christmas Bird Count*. This bird-counting project started in 1900 (Silvertown 2009). Historical citizen science projects, such as the Christmas Bird Project, involved writing down information and positing it, by mail, to a central location where researchers would aggregate the results by hand. This was a slow and laborious; citizen science has been revolutionised by the internet. While internet-based projects are properly known as *online* citizen science, the overwhelming

majority of citizen science projects are now internet-based. 'Citizen science' now implies 'online citizen science'.

Online citizen science projects usually involve researchers creating project websites, which might host sets of tasks for *contributors* to complete (e.g., labelling images), or data collection tools for them to submit observations (e.g., submitting an interesting plant that has been found). People visit these projects and contribute their time to complete tasks or make observations, and do so without any financial reward. Collaborators are often active participants in research, sometimes discovering new phenomena and appearing as authors on academic publications.

7.2.2 Paid Crowdworking

'Crowdworking' is a term used to describe people who complete crowd-based tasks in exchange for money – hence crowd*working*. Work on these platforms is usually broken down into small components (*microtasks*) that can be completed quickly and independently by a worker (see Cheng et al. 2015 for a comparison of smaller and larger tasks.) Work is normally managed through crowdworking platforms, Amazon Mechanical Turk (or MTurk) being the most visible example. *Requesters* post the work to these platforms (which take a cut for their market-making) and *workers* see a list of available tasks, along with a requester-specified estimate completion time, and the amount of pay. Once a task has been completed by a worker, the requester assesses the quality of the work and approves payment. Generally, crowdworkers are participants only in data collection and generation – they are not normally involved in the latter stages of the research process (e.g., publications).

7.3 Comparative Studies of Crowdsourcing

Attitudes toward the use of crowdsourcing in scientific studies have changed significantly over the last few years. Even in research areas like Cognitive Science, which is less obviously connected to developments in crowdsourcing than HCI, crowdsourcing data is not only accepted, but normal (Stewart et al. 2017). Here we explore the evidential basis for substituting laboratory-based investigations with crowdsourced studies (i.e., whether data gathered from these different groups of participants has any effect of the conclusions that are drawn from the studies). We consider different types of research paradigms, explaining why some are likely to need more care and attention if they are to successfully transition to crowdsourcing platforms.

The challenges of making use of crowdsourcing in research vary significantly from discipline to discipline. Questionnaire-based studies have been run online for around 20 years (e.g., Wright 2005), and have naturally moved onto crowdsourcing platforms (Behrend et al. 2011). Questionnaire-based studies have traditionally been run by physically posting questionnaires to people in remote locations, so

moving a questionnaire study online makes little difference; the same challenges exist in terms of recruiting and giving instructions to remote participants regardless of whether the questionnaire is delivered through a postal form or an online form (Hoonakker and Carayon 2009). Transitioning from postal methods to internet-based methods has therefore been easy: non-compliance, disappointing response rates and mindless responses are something that researchers using questionnaire-based techniques are used to dealing with in their traditional methods of data collection.

For experimental paradigms that have normally been based in laboratories, using crowds to obtain data marks a significant change. The core principle of an experiment is control. As many factors as possible should be fixed, leaving only experimental variables free to vary. The purpose of a laboratory is to offer as much control over confounding factors (e.g., computer hardware, lighting) as possible. When our experiments leave the lab and move into people's living rooms, or, say, onto public transport, we sacrifice control. When our experiments move from standard lab computers with standard lab screens and onto people's computers, phones and tablets, we sacrifice control.

Looser experimental control normally weakens the internal validity of an experiment. But precisely how confounding factors –uncontrolled influences on the dependent variables in our study– affect a study will depend on the kinds of measures that are being used. Some dependent measures are more easily confounded than others. It is important to consider how a given experimental paradigm might be affected by moving it onto an online crowdsourcing platform.

When considering the impact on data quality of running an experiment on a crowdsourcing platform, it is important to think about the types of data that are being collected. If a dependent variable is *categorical*, for instance if the measure is one choice from many, or if a solution produced is correct or not, a loss of experimental control may not be too problematic. For instance, Germine et al. (2012) compared lab-sourced and crowdsourced data from reasoning and decision making experiments where responses could easily be categorised as correct or incorrect. They found that crowdsourced data did not differ systematically from lab-sourced data.

In contrast, when an outcome variable is in the form of *ratio* data, deploying the experimental paradigm online is more challenging. Timing data is a good example of the kind of ratio data we might commonly collect. Psychometric studies frequently use reaction times or task completion times as performance measures. Time-sensitive experiments –where time is a dependent variable – might be particularly susceptible to the loss of control that comes with moving experiments into the crowd. Comparisons of crowdsourced and lab-sourced data of this kind would be the most likely to give us a clearer picture of the limits of crowdsourcing.

Komarov et al. (2013) compared crowd- and lab-sourced data from several menu-search experiments. Menu searching is a common practical HCI problem that has received significant research attention (e.g., Bailly et al. 2014; Brumby et al. 2014; Brumby and Howes 2008; Brumby and Zhuang 2015). Experiments typically involve making small adjustments to the presentation of menus and then measuring search times to see if those adjustments have affected performance. Reaction times

are typically in the low thousands of milliseconds, so even small disturbances of a couple of hundred milliseconds have the potential to distort results. The results of Komarov et al.'s comparisons show that data collected from Amazon Mechanical Turk workers is statistically equivalent to those collected from laboratory participants. In other words, even in their time-sensitive experiments, crowd data were as good as laboratory data.

We have also explored the challenges of using time-based measures in our own work. In Gould, Cox, Brumby and Wiseman (2015b) we compared timing data from a multitasking experiment that was run in a laboratory with timing data from the same task run on a crowdsourcing platform. We found that although there were absolute differences in the data that we gathered, these differences between the online and lab-based timing data were not statistically significant.

Touchscreen input is another substantial research area in HCI that makes use of fine-grained psychometric data (e.g., Dunlop and Levine 2012; Oulasvirta et al. 2013). It is a particularly challenging style of research to conduct on crowdsourcing platforms because of the variety of devices people use, many of which have differently sized screens and different pixel densities. Findlater et al. (2017) compared laboratory- and crowd-collected data from an investigation of touchscreen interactions. When they analysed the results from the two sources independently, they came to two different conclusions about what their data showed. When they looked at the data in more detail, they found that this was because crowdworkers were generally faster and less accurate in their pointing. They suggest that researchers should be cautious about using the crowd for these kinds of touchscreen pointing experiments.

As well as considering the type of data that is being collected, researchers should also need think about what the subject of that data will be. In some research paradigms, participants provide data about the world (e.g., Kim et al. 2011). In such studies, participants act as sensors reporting things about the world. For example, in the eBird project (Sullivan et al. 2009), contributors record the species of birds they have seen in a particular area. Other projects have used crowdsourcing platforms to report driving offences (Aubry et al. 2014). In others, particularly psychological studies, participants are themselves data, whether through their reporting of their attitudes or by objective recording of their behaviour. Jennett et al. (2014) described this form of participant-as-data study as 'citizen psychscience'.

The distinction between data that is from sources endogenous or exogenous to the participants is important when thinking about the potential challenges of crowdsourced research in 3rd Wave HCI contexts. We know from research in personal informatics that people frequently give-up on self-tracking tools, which involve the logging of person-generated ('endogenous') data (Epstein et al. 2016). This is often because people do not form habits for this kind of logging (Stawarz et al. 2015). Researchers looking to crowdsource this kind of personal tracking information must consider the challenges of sustaining participation in these contexts.

Experimental control is, of course, a trade-off. Often in search of greater control and internal validity, we end up sacrificing ecological validity by making contrived tasks developed by the experimenter for the sole purpose of the experiment. The

evidence we have considered so far suggests that crowdsourcing is a good option for many, but not all, experimental paradigms. Researchers must consider the threats to internal validity that running an experiment in the crowd can bring and the options available to them for preserving control and bolstering validity. In the next section, we explore how empirical studies can best be designed for crowdsourcing platforms.

7.4 Designing Empirical Studies for Crowdsourcing Platforms

Much of the comparative literature on lab-based and crowd-based studies yields insights into how experiments can be moved from more traditional experimental media and onto paid and volunteer crowdsourcing platforms. In this section, we consider these findings, integrating them with other insights from the literature to explain how best to design empirical studies for deployment on crowdsourcing platforms. We consider which platforms researchers should choose, the challenges of recruitment, and designing for the human aspects of participation.

7.4.1 Choosing a Platform

The capacity of crowd platforms to produce results at scale quickly is predicated on having a large pool of potential workers to call on. If researchers want to get results quickly and in volume, they should use one of the large crowdworking platforms. Amazon Mechanical Turk claims to have over 500,000 active workers (see Peer et al. 2017). For citizen science projects, researchers might try to partner with one of the larger platforms (e.g., Zooniverse) to find potential collaborators.

Platform selection is not as simple as choosing the biggest platform. Peer et al. (2017) investigated two other paid crowdworking platforms, *Crowdflower* and *Prolific Academic*. They focused on whether different platforms would produce the same results. Results of their comparative study found that Amazon Mechanical Turk workers are particularly well drilled in completing experiments – and are excellent at coping with the mechanisms researchers use to try and ensure participants' compliance with experimental procedures. Workers on Crowdflower were the least likely to spot instructional manipulation checks the researchers inserted (see later section on Attention Checks), and also produced the lowest quality responses, on average. For research where participant naivety is critical for the success of an experiment, switching to platforms where workers are less experienced (and therefore 'streetwise' about experiments) might be a good idea.

As well as having to think about which crowd platform to target (e.g., Galaxy Zoo, Mechanical Turk), researchers must also consider which hardware platforms

they are trying to target. Is a researcher's expectation that people will participate sitting at a desk, using a traditional keyboard and mouse? Lots of crowdworking happens on more traditional computing devices, but people now have all sorts of other devices, like smartphones and tablets, many of which they use for participation, perhaps while out and about.

In many ways, mobile computing has typified changes in technology corresponding to research efforts in the 3rd Wave of HCI (Bødker 2015). Around the world, many people's experience of the internet is solely through mobile technology (Gitau et al. 2010). Mobile technology has changed the way that we work (Cecchinato et al. 2015) and play (Colley et al. 2017). People's mobile technologies, such as smartphones and smartwatches, are a constant source of interruption and distraction (Cecchinato et al. 2015, 2017; Pielot et al. 2014; Rigby et al. 2017). Designing for this context, especially in a crowdsourcing context where attention might be especially limited, means keeping tasks short and interruptible.

Some researchers have taken advantage of the fact we spend a lot of our day unlocking our phones (Harbach et al. 2016), realising that rather than entering meaningless codes or swipes, we could unlock our phones by doing something useful (Truong et al. 2014). Researchers have realised that lockscreens might be a good location for the siting of the kinds of very small microtasks that crowdworkers often work on. Vaish et al. (2014) implemented 'Twitch', a platform for crowdsourcing microtasks on smartphone lockscreens. Working on tasks that took less than 2 s each to complete, the 82 participants in their field study completed over eleven thousand tasks.

Not all psychometric experiments can be completed in the space of a couple of seconds, but phones can still provide a platform for more time-consuming studies. Brown et al. (2014) investigated the potential of phones for crowdsourcing data in cognitive science studies. They developed a game-based environment for running experiments and deployed it as a smartphone app (see Gray 2017 for a broader discussion). The app was used to investigate a number of psychological phenomena, from working memory to attentional blink. Across large samples, they showed that classic findings from cognitive psychology could be replicated through a game-based app that crowdsourced participants.

Smartphones are not just used as mechanisms by which participants submit data about bird counts, or platforms for interactive crowdsourcing tasks. The variety of sensors on modern devices and the ease with which applications giving access to these sensors can be installed on mobile devices means that people can participate in complex sensing studies by doing nothing more than installing an application (Mehrotra et al. 2016). This lowers the barriers to participation in studies that would otherwise be onerous for participants.

Researchers should think carefully before they develop a bespoke smartphone application for a crowdsourcing project. Unlike web applications, mobile apps, particularly ones with complex sensing functionality are not very portable – it may be necessary to develop multiple applications for different platforms (Brown et al. 2014). One way to make development less resource intensive is to build plugins for existing app-based platforms for deploying studies (e.g., Chatzimilioudis et al.

2012). Platforms like the *Aware Framework* (Ferreira et al. 2015) make it relatively simple for researchers to collect and aggregate significant amounts of sensor data. These data can be augmented with other platform-provided data, like, for instance, people's responses to user experience reports. Installing a sensing applications on devices can also be deleterious to a device's performance, making it essential that such sensing applications are as efficient as possible (Lane et al. 2013); lest a slower device and reduced battery life change people's behaviour and influence researchers' conclusions.

In general, researchers should avoid developing purpose-built applications for studies. If simply having to sign-up to contribute puts potential participants off (Jay et al. 2016), then having to download and install a new app is likely to have a similar effect on levels of participation. There needs to be a compelling reason to crowdsource data through dedicated native applications (e.g., extremely time-sensitive studies, the need for sensor data) for them to be worth the effort of implementing over a simple website.

7.4.2 Recruiting Participants

For those designing studies for deployment on crowd platforms, it is important to remember that crowd platforms are not just collections of independent individuals. Crowdsourcing platforms usually have communities behind them (see, e.g., Irani and Silberman 2013; Moore et al. 2011; Reeves et al. 2017). This is often advantageous to requesters and researchers recruiting from crowdsourcing platforms. Existing communities can be a source of well-motivated contributors (Preece 2016). The new communities that form around projects also develop long-term understandings of projects that help contributors perform, for instance, data validation tasks (Wiggins and He 2016).

In paid crowdworking, 'communities' are usually constituted by the financial incentives offered by crowdworking platforms. For volunteer-based citizen science, however, developing a new community is the biggest challenge for most projects. No community often means no contributors, and no contributors means no citizen science project. In the absence of financial incentives, understanding the motivations of volunteer citizen scientists becomes more important. The challenge of building communities is common across a number of 3rd Wave HCI contexts, from the organization of physical communities to political action. Starting new communities is very difficult, but even trying to involve existing communities (e.g., Crivellaro et al. 2016; Vlachokyriakos et al. 2016) is a hard problem to solve. It can help to understand how individual characteristics mediate behaviours. For instance, people's willingness to involve themselves in civic activities (e.g., volunteering, attending neighbourhood meetings) is influenced by personality traits (Kim et al. 2013); for more introverted people social media plays a greater role in their participation in such activities. The internet is a powerful tool for engaging with people who might be missed by more traditional ways of contributing.

The better the motivations of potential contributors to citizen science projects are understood, the greater the chance of a community coalescing around a project. Jennett et al. (2016) looked across the motivations of citizen scientists documented in the literature. One of the most common motivators was a prior interest in the research topic, which suggests successful citizen science projects will tap into existing interests; developing people's interest in a topic while trying to get them to contribute might be difficult. Additionally, Jennett et al. found that people's motivations change over time, so researchers should not assume that contributors who are well motivated will stay well motivated. It is also important to understand the kinds of people that might be attracted to citizen science projects. Not everyone will be interested in contributing to citizen science projects. Contributors to projects may not have science as part of their everyday life, but they tend to have a high level interest in science, and strongly value the contribution of science to broader society (Land-Zandstra et al. 2015).

Having a strong community is mostly beneficial, but there are some important drawbacks of having a community with shared experiences completing similar (or the same) tasks. Information about tasks is back-channelled through communities through tools like message boards. This presents challenges for recruiters. The extent to which the community component of crowd platforms can be a help or hindrance depends on the kinds of activities a requester wants to implement, and the extent to which they engage with and support their communities.

We often assume that participants in our studies are naïve. That is to say that we do not expect our participants to know what the research is about, and how exactly we have operationalized our measures or what tricks and shortcuts there are to get tasks completed as quickly as possible. If participants know these things before they participate, they are more likely to exhibit *demand characteristics*, which is to say that they will express the attitudes that a researcher desires, or they will approach a task in the way that a researcher hopes. This is not desirable, because it increases the chances of the results of a study leading to Type I (false positive) errors.

Different experimental paradigms will vary in the extent to which they are affected by participants already knowing the purpose of a study and mechanisms by which it operates. Econometric studies, for instance (e.g., Rand 2012), are particularly susceptible to this issue. Often, economists are interested in how people make decisions about how to allocate resources between themselves and a collaborator. The capacity for such studies to tell us something about people's reasoning is contingent on the experiments being 'closed systems' – participants should only have the information that is made available to them in the experimental task. Contributors to crowdsourced projects are frequently *not* naïve, however (Chandler et al. 2014). This is because information about the purpose of a study may have been posted in public space, such as a message board. Private out-of-system collusion in collaborative tasks can also skew results. The non-naivety of participants is problematic, because it reduces experiments' chances of detecting effects (Chandler et al. 2015). Researchers must account for this kind of back-channelling behaviour in their studies, particularly if they are running experimental paradigms that crowdworkers frequently encounter on their platforms (Stewart et al. 2017).

Not all non-naivety is a problem. In some instances, 'naivety' represents the first step on a learning curve. The goal might be to complete a given task as efficiently as possible, so the quicker that a contributor can get 'up to speed', the sooner they will be producing useful results. Classification tasks, such as the ones hosted on Galaxy Zoo (Lintott et al. 2008), are a good example of such an activity. Volunteers look at (often fuzzy) images of galaxies and stars, and aid researchers by classifying these images. It takes time for new volunteers to understand which categories exist and how the noisy data they are given should be slotted into these categories. Being naïve in this context does not aid the research – having significant knowledge of the target problem does not inhibit the quality of responses from contributors. In this context, non-naivety is something that's helpful, because it's a skilled task that takes time to learn. Supporting new volunteers with tools is therefore essential so that they are properly taught how to complete the task to a good standard. That said, it is also important to recognize that one of the advantages of citizen science is that it brings in people with different and new perspectives. Sometimes these new perspectives help to correct errors in perceived wisdom. One example of this is Galaxy Zoo's 'Green Peas' (Cardamone et al. 2009). Volunteers on the project noticed a particular kind of star appearing from time-to-time. These kinds of stars had already been classified by experts. But the citizen scientists persevered, discussing their findings on the Galaxy Zoo message boards. Ultimately their resistance to perceived wisdom was what allowed them to realise the existing classification was incomplete, allowing for a new discovery to occur. So, it is important that the learning process, while enabling people to make contributions, does not destroy these valuable additional perspectives.

7.4.3 Designing for Real Participants

The nature of crowdsourcing platforms can often lull researchers into thinking that their tasks are completed by anonymous units of production rather than real individuals. Experiments are sent into the ether; results magically appear within moments. But it is important to remember the people who provide the workforce that crowd platforms rely on. Remembering that they are people rather than units of production will improve the quality of results that are returned.

Crowdwork is based on the idea of task decomposition. Tasks can be broken down into small units that can be independently completed. While the content of two distinct units of work might be independent, they are not necessarily completed by independent workers: workers string together multiple tasks, one after another (or often at the same time). Newell and Ruths (2016) investigated how one crowdworking task can interfere with behaviour on another. They found significant 'intertask effects', where the cognitive style demanded by one task caused participants to behave differently in a completely separate task because of the priming effects of the initial task. For instance, an image labelling task on a given topic might prime behaviour on another image labelling task. Or the framing of a particular labelling

task (i.e., the scenario) affects the subsequent completion of the task itself, even though the framing is not functionally related to the task.

Another important practical thing to consider is fatigue. Crowdworkers typically spend 4 h a day on crowd tasks, and up to five-and-a-half hours if crowdsourcing is their primary source of income (Lasecki et al. 2015). This means that many independent tasks are worked on back-to-back. Fatigue is one of the potential side effects of this kind of working, so researchers have looked at whether inserting breaks into streams of microtasks can help to improve performance. Rzeszotarski et al. (2013) looked at matching microtasks with *microbreaks* – very short breaks inserted between batches of tasks. They found that inserting microbreaks improved worker retention, and also improved overall worker engagement and satisfaction. This is important for requesters, as retaining high quality workers who are familiar with a task improves the quality of results returned. Other more extensive work has also looked at the effect of breaks on performance (e.g., Dai et al. 2015), and come to similar conclusions – giving workers a chance to recuperate improves their performance. For long tasks made up of batches of tasks, researchers should consider giving workers a break.

Once a participant starts working on a task that has been set, the other tasks that they need to work on do not disappear. Other activities that they are working on still need to be worked on. For example, people receive messages from friends or colleagues that need responding to, people have caring responsibilities, and people may have their 'main' job to attend to at the same time. This means that people in the crowd frequently switch to other tasks while they work (Gould et al. 2013, 2015a, 2016a). There are a class of psychometric studies, particularly those studies that test working memory, where such distractions might significantly impact results. While people can be induced to keep focused on their task (Gould et al. 2016a), it is not possible to eliminate such distractions altogether. Instead, researchers might find it better to record switching events, use this measure when processing their data. (See the discussion of data handling later in the chapter.)

7.5 Collecting Data Using Crowdsourcing Platforms

7.5.1 Building and Continuing Engagement

Encouraging participants to engage in paid crowdwork is usually straightforward: money motivates participants, additional money motivates further participation. In the context of volunteer-based crowdsourcing, the question of how to engage potential participants and convert them into regular, high-quality contributors is one of the most important research questions in the area, and probably the most important practical question for a researcher looking to set-up a crowd-based citizen science study.

When people are volunteering their time, any barrier between finding out about a project and contributing to it is likely to mean potential contributors are not con-

verted to actual contributors. One example of a barrier that might turn potential contributors off from a project is having to sign up for an account before they get a chance to see if the activities provided by a project are ones that they'd like to get involved with. Jay et al. (2016) found that removing the requirement that people create an account before participating increased participation by 62%. Participants who subsequently want to claim their contributions can create an account at their convenience. The idea of reducing barriers to entry fits with Eveleigh et al.'s idea of 'designing for dabblers' (2014). In the course of their research, they found that not everyone is a potential significant contributor. Many people are satisfied with participating a little and then moving on to something else. If all contributions are useful to a given project (an important proviso), then encouraging these kinds of contributions, without putting too much pressure on people to become regular contributors, can help to bolster participation levels.

7.5.2 Ethical Data Collection

All experiments involving human participants need to be conducted in an ethical manner, and in compliance with local regulations. Crowdsourcing data brings a number of special ethical considerations, however. Much of the ethical debate in the context of paid crowdworking has centred around payment and working practices. Sometimes these issues range from the obvious, such as people not being paid for the work they have done, to more fundamental issues with the way that online labour systems are organized.

The working conditions of crowdworkers have come under significant scrutiny. Silberman (2010) reported in detail on the issues that crowdworkers face. A lot has been written about the low rates of pay that crowdworks often suffer, with the average worker earning a median of USD$2 per hour (Hara et al. 2017). This is not the only issue. From the cost of requester errors being borne by workers (e.g., tasks being set-up incorrectly, or having bugs in them) to simple non-payment (i.e., wage theft), or being drawn into platform-hosted scams, there are many potential barriers to crowdworkers getting paid for the work that they have done.

There has been some movement towards improving conditions by some requesters. Kittur et al. (2013) ask how crowdwork might be turned into something *"which we would want our children to participate"* in, and enumerate a number of suggestions for making this a reality. Some are focused on improving technical aspects of crowdworking, so that errors are less likely to occur. Other suggestions include ways of developing better understandings of crowdworkers so that requesters can create tasks with which they are more likely to succeed.

One of the challenges for crowdworkers is that they are individuals in unequal power relationships with the requesters they are working for. There is normally little recourse if the crowdworker if they are cheated by requesters, but researchers and workers have made some efforts to correct this imbalance. Irani and Sliberman (2013) set-up the 'Turkopticon' platform in an attempt to give workers more power

in the system, and augment existing channels for worker-worker collaborations, such as message boards. Turkopticon allows workers to report their activity on tasks in Amazon Mechanical Turk. Workers can rate requesters on a number of attributes, from whether the pay was fair, to whether communication from a requester was accurate. Although it has no official role and does not arbitrate any disputes, it is a valuable resource: workers can check on requesters before they agree to work for them. The motivation for this was to reduce their chances of being cheated. A more ambitious idea to allow crowdworkers to take collective action was 'Dynamo' (Salehi et al. 2015), which helped workers engage in collective action over time without losing momentum when disagreements in how to proceed were encountered. An alternative strategy to helping workers regain some control from platform owners and work requesters is to simply put workers in control of the crowd platforms (Fox et al. 2017).

Many ethical review boards are still not well adapted to crowd-based forms of research (Graber and Graber 2012). Nevertheless, researchers should still do their best to make sure that workers are treated fairly and compensated for the work that they do, making sure that they respond to the legitimate concerns of workers in good time.

Citizen science projects are not necessarily in a better ethical position by virtue of not involving the exchange of money. There are a host of ethical concerns that come along with citizen science projects. One of these is privacy, and the exposure of contributing citizen scientists' personal information. Bowser et al. (2017) point to location privacy as a particularly important issue: participants in projects like *eBird* tag their sightings of birds with longitude and latitude coordinates. Across a number of postings, it is possible to work out both spatial and temporal components of people's movements. Bowser et al. report one contributor to a citizen science project writing that *"someone will inadvertently put a comment to say, "temperature was 79 degrees, and by the way this is my last report for the next week because I'm going out of town*" (Bowser et al. 2017: 2131). Of course, between this information and the contributor's contribution history on the project, some potentially undesirable people could work out where their unoccupied house was. Triangulating multiple sources of data – location-tagged contributions, message board posts, social media posts means people end up revealing a lot more about themselves than they might have intend. It is important when building citizen science studies to consider the trade-offs between community building and the potential for personal information leakage.

Resnik et al. (2015) reflect on the ethical concerns of other authors (e.g., Riesch and Potter 2014) in questioning whether citizen science has the potential to be exploitative, given the lack of obvious remuneration in many citizen science projects. We discuss this issue further in the next section on remuneration, but Resnik et al.'s point is that inequitable exchanges between researchers and research participants (as contributors are often characterized) are unethical – participants need to receive something back from their participation. Resnik et al. suggest a variety of strategies to ensure collaborators receive something back depending on the project

and the nature of the contribution that contributors have made. This might range from authorship to certificates to education on the topic they have contributed to.

There is also the question of whether, as co-investigators on projects, citizen scientists themselves have ethical obligations, such as the disclosure of conflicts of interest. We are not aware of any citizen science projects that formally place ethical demands on contributors as well as the researchers running programmes. For some research projects where citizen scientists are involved in data collection and the topic involves sensitive subjects (e.g., the location of certain endangered species), having a degree of ethical training available to citizen scientists might be advisable.

7.5.3 Payment and Non-monetary Remuneration

Paid crowdsourcing platforms have historically been described as 'cheap' and 'cost effective'. Compared to the time and effort of running psychometric experiments in laboratories this is true. We have already considered some of the ethical issues that surround payment (and non-payment) in crowdsourcing settings. Here we will focus instead on the more practical aspects of how participants respond to incentives, and how the choice of incentives that are used affects participants' behaviours. Although issues of remuneration are most pertinent in the context of paid crowdworking, we also consider how non-monetary remuneration affects behaviour in volunteer crowdsourcing contexts.

It would be easy to assume that the relationship between pay and quality in crowdworking contexts is trivial: the more workers are paid, the better the quality of the work that they return. In fact, while the amount paid for a task is an important factor in the contributions a researcher receives, the relationship between pay and remuneration in crowdworking settings is nuanced. Prior research has found, for example, that while workers might contribute less when they are paid less, they do not work less if they are given a particularly time-consuming task for the same amount of money (Horton and Chilton 2010). The same authors found that people tend to target certain amounts of money when working, and are happy to stop at that point, irrespective of whether that is the most 'rational' strategy at a given moment.

A number of studies have attempted to understand the relationship between pay and quality (e.g., Hsieh et al. 2010; Mason and Watts 2010; Shaw et al. 2011). In an early study, Mason and Watts (2010) found that increasing financial incentives for work generally increased the quantity of work people would produce, but did not necessarily increase the quality of the work produced. Other studies have replicated this finding (e.g., Hsieh et al. 2010). The size of the financial incentive is, therefore, not always the limiting factor on performance. Combining incentives with other approaches, like getting participants to think about how their peers might respond (Shaw et al. 2011) can improve performance. Rather than have poor-performing workers continue to contribute low quality data that subsequently has to be removed from analyses, sometimes it is more effective to pay poorly performing workers not to contribute any further, leaving tasks for more competent workers (Harris 2015).

It is important to remember that although financial incentives explain why many people get involved in crowdwork, it is not the only reason, nor is the only factor that people take into account when they are choosing which work to do. Jiang et al. (2015) found that monetary compensation might be the main motivator, but that workers are also motivated by learning something new and feeling fulfilled by contributing to a bigger task.

Factors besides money can also be the primary motivation for participants. In previous work we have explicitly compared monetary and non-monetary reimbursement for participants (Wiseman et al. 2017). One of the things we wanted to study was whether participants could be motivated by being given data about themselves as an outcome of a study. This approach has proved to be successful on platforms like *Lab in the Wild* (Reinecke et al. 2013; Reinecke and Gajos 2015), where people are given feedback on, for instance, their memory capacity. This has produced some very large snowballed samples, where participants recruit other participants. In Wiseman et al. (2017), we compared this kind of data-as-reward approach with other approaches, like simply requesting help for the good of science or in return for payment. We found that that participants in both non-monetary conditions met, and in many cases exceeded, the performance of participants in our control paid condition. Other work has found similar patterns, with participants rewarded with information about themselves performing better than those rewarded with money (Ye et al. 2017). These findings suggest that in the absence of monetary compensation, researchers need to be more creative with the kinds of rewards that they use to keep people involved and engaged.

7.6 Ensuring Quality Data

Experiments can be designed in a way that maximizes the quality of data that they produce. There are two major reasons why otherwise well-designed experimental studies might produce poor quality results. First, participants do not follow the instructions for the experiment, either because they do not read or because they do not understand the instructions. The second is that, participants, whether they understand the instructions or not, do not comply with them.

There are two stages to having participants assimilate instructions for an experiment. The first is to convince participants that they should actually read the instructions. The second is to deliver instructions in such a way that people are able to understand them and act in accordance with them. Getting participants to actually read the instructions that accompany an experiment is also important for ethical reasons. To give properly informed consent, participants need to have read and understood what a study is for and how the data they produce will be used. Getting participants to engage with instructions yields both better data and is a requirement for research ethics.

Satisficing, where people optimize their behaviour to gain maximum return on their effort, is a major challenge in all experiments, but it is particularly problematic

in paid online experiments. Paid work on crowdsourcing platforms are usually offered in a piecework fashion (see Alkhatib et al. 2017 for more background), which means workers are paid for each task, rather than how long they spend on it. This creates an incentive to get through a task as quickly as possible, and so data quality can suffer.

7.6.1 Attention Checks

One common way to try and deal with inattentiveness and satisficing –in experiments of all types– is to make use of *attention checks*. These comprise a variety of methods, but the goal is the same – to detect when participants have not understood the instructions for a study or when their attention has wandered while they are completing it. Kapelner and Chandler (2010) conducted one of the first investigations of satisficing –where people look to get as much return for as little effort as possible– in crowdworking settings. They looked specifically at satisficing by crowdworkers as they completed questionnaires. The temptation for some workers might be to click through the questionnaire as quickly as possible, so that they can finish and claim their payment. This rushing –however well intentioned– has the potential to generate poor quality data. Removing poor quality responses from a sample requires additional researcher time and effort, so such responses are worse than useless. Kapelner and Chandler developed a variety of approaches to reduce satisficing behaviour. One intervention simply involved introducing a small delay between the presentation of a question and the means to answer. Building on this design, they introduced a 'Kapcha', which, on top of the delay in presenting response widgets, also faded the text of the questionnaire into view at a rate of 250 words per minute – this prevented participants from skim-reading. This easily implemented intervention improved the quality of responses by 10%.

Attention checks can be used *correctively* (to encourage re-engagement) or they can be used *surreptitiously* to aid the discovery and handling of poor quality results. Abbey and Meloy (2017) produced a detailed overview of a number of different types of attention checks, and reviewed their efficacy. They found that, on average, attention checks of all kinds improved the quality of results that studies obtained. In the following paragraphs review the variety of attention checks Abbey and Meloy review.

Attention checks have been used in traditional psychological research for some time. Abbey and Meloy (Abbey and Meloy 2017) point to comments made by Rensis Likert –the inventor of the Likert scale– about the necessity of using reversed questions in questionnaires. Reversed questions in questionnaires are duplicate questions but with the meaning of the question inverted. For instance, if a question on a scale were "I always feel down about my prospects", the reversed question would be "I never feel down about my prospects". If participants report strongly agreeing with both of these statements, it is likely that they are not giving their full attention to the questions being asked of them.

One type of attention check that Abbey and Meloy (2017) describe in their review are *instructional manipulation checks*. Instructional manipulation checks are elements inserted into an experiment that can help researchers to be more certain that participants have read and understood the experimental instructions. For example, Oppenheimer, Meyvis and Davidenko (2009) constructed survey questions in a way that meant participants could not skim over them. Participants would be faced with an introductory paragraph, followed by a question and several clickable responses. Participants who had read the instructions as requested would have found in the text instructions to ignore the question and click on the title of the page instead.

Corrigan-Gibbs et al. (2015) investigated what Abbey an Meloy call 'Honesty Checks'. They created a survey that was about the domain name of a particular website they told participants was being developed. Participants in one condition were asked to follow an 'honor code' when completing the survey, which meant agreeing not to ask other people about the survey or to visit other websites for information about the task. Participants were required to retype the honor code. Instead of the honor code, participants in another condition saw a warning text that listed three repercussions of visiting other websites, including non-payment. In this condition participants had to type a one-sentence summary of the warning.

Unbeknownst to the participants, the authors were closely monitoring activity on the domain that participants had been told not to visit; they were able to match-up participants in Amazon Mechanical Turk with visitors to the website. In this way, cheating could be detected. Corrigan-Gibbs et al. found that the harsh warning was significantly more effective than the honor code in discouraging cheating, although the honor code was more effective than the control condition, where no message relating to cheating was shown. The result is not surprising. Workers make a living on Amazon Mechanical Turk, so anything that negatively affects the metrics that represent them on the platform, for instance the number of tasks they have completed, or their rejection rates, materially affects their chances of getting work (see, e.g., Silberman et al. 2010).

Interestingly, Corrigan-Gibbs et al. initially required participants to record themselves reading the honor code aloud. This extra step substantially increased the drop-out rate from the study, suggesting that attention checks need to be carefully calibrated so that they not radically deter participation.

We explored the efficacy of attention checks in one of our own studies. In Gould, Cox and Brumby (2016a), we have also looked at how task-switching behaviour during the completion of a task on Amazon Mechanical Turk influenced overall task performance. We wondered whether participants could be encouraged to stick to the task at hand, rather than switching to other activities while they completed our task. Our approach was not aligned with any of Abbey and Meloy's (2017) different types of attention checks, because it was *dynamically sensitive to participants' behaviour.* We detected when participants switched away to other tasks. When participants returned to our task, they were either met with a notice asking them to stay focused on our task or a question asking them what they had been doing. Participants in the control condition received no indication that their switching behaviour had been detected. We found that participants who were asked to focus on the task at hand

were significantly less likely to allow themselves to be interrupted. Given that participants who switched less performed best, our attention check may have improved the performance of participants in that condition.

Attention checks are not suitable for all kinds of study. Researchers investigating certain phenomenon should consider whether the design of their study is suitable for the deployment of instructional manipulation checks. Hauser and Schwarz (2015) ran an experiment on Amazon Mechanical Turk that investigated how the inclusion of instructional manipulation checks affect behaviour later on, *during the experimental task*. They found that participants who had encountered an instructional manipulation check exhibited increased levels of systematic thinking on decision making tasks. Hauser and Schwarz's explanation was that the instructional manipulation check caused participants to become warier of the experiment as a whole; participants were primed by the instruction manipulation checks to be on the lookout for 'tricky' elements in the main experiment. Consequently, the presence of the check affected participants performance in the rest of the experiment.

Most of the evidence we have comes from studies of paid workers. Satisficing among volunteer citizen scientists is likely to take a different form, as there is no financial reward for volunteers to be had from getting through a task as quickly as possible. Participants might, for example, be satisficing to improve their contribution statistics. There are, to our knowledge, no empirical investigations of satisficing in the context of citizen science research, however, so this is an area that future work could investigate.

7.6.2 Participant Preselection

Even if participants read and understand instructions, and then try their best to follow instructions, their performance might still be poor. Some participants will just find certain tasks difficult. In some experimental paradigms, this kind of poor performance is specifically of interest, for example in investigations of individual differences in behaviour (e.g., Meys and Sanderson 2013). In other experimental paradigms, reaching a certain threshold of competence is necessary before participants start producing useful data, for example in studies investigating typing performance on novel keyboards (e.g., Oulasvirta et al. 2013). If prospective participants cannot meet the threshold required to produce useful data, it might be best to filter them out of the process early on.

Developing preselection processes can help to ensure that participants with certain behavioural characteristics are channelled into the study, while those potential participants who do not can be filtered out. On crowdsourcing platforms like Amazon Mechanical Turk, ideal candidates can be granted qualifications that give them access to the full experiment. It is also possible to predict how a participant will perform on a task based using generic measures of behaviours that are required across a broad range of tasks. Rzeszotarski and Kittur (2011) showed that a collection of standard measures (e.g., typing speed, inter-task time duration), predicts performance in a variety of distinct tasks. Rather than assessing participants on task completion, dis-

positional factors might also be useful in understanding participants' performance. Bored participants, for example, are less likely to be pay attention to details in tasks (Jun et al. 2017). Thus, tasks that require great attention to detail may benefit from deselecting people who say they are participating because they are bored; they may be better directed to other tasks that are less sensitive to inattentiveness.

An alternative to using experimenter-administered tests is to use participant assessment. In the context of paid crowdworking participants have a strong incentive not to accept tasks that they will not be able to complete to a sufficiently good standard. If it is of poor quality, workers will not be paid, and the cost is effectively doubled once the opportunity cost of working on one task over another is factored-in. However, as Gadiraju et al. (2017) point out, even when well-motivated self-assessment are not always accurate, because, as psychological evidence attests less competent participants are less likely to be able accurately assess their abilities (e.g., Dunning 2011; Dunning et al. 2004). In an empirical study on Amazon Mechanical Turk, Gadiraju et al. indeed found that the least competent workers overestimated their ability. To compensate, Gadiraju et al. combined self-assessments with more objective measures, such as results from standard logical reasoning tasks, to weed-out the participants who were poor estimators of their performance. Gadiraju et al. found that, with the help of their tools for supporting self-assessment, workers who struggled with the task deselected themselves. This allowed more skilled workers to complete more tasks. This improved the overall accuracy of the sample by more than 15%.

7.6.3 Analysing Data from Crowdsourcing Platforms

Some experimental paradigms do not lend themselves very well to instruction manipulation or attention checks. Participants might rush through a study, or researchers might overlook the potential for participants to misunderstand the instructions for a task. Regardless, the outcome is the same – the results of studies contain a greater or lesser degree of poor quality data.

Once a dataset has been assembled, identifying and correcting for poor quality results should be the first stage in an analytical pipeline. Detecting and dealing with outliers is a standard feature of psychological studies, but in laboratory-sourced data, researchers might have some ideas about which participants may not have performed well before they start their analyses. There are no hints from observation in crowdsourced studies, so researchers must rely entirely on the data they collected. Xu et al. (2013) looked at how outliers could be detected and removed from crowdsourced experiments, and whether removing outliers improved the quality of results that were obtained. They developed the *LASSO* technique, which automatically filtered outliers based on rigorous statistical measures built on the concept of *robust regression*. This improved the overall quality of the datasets they were creating.

Researchers should consider the characteristics of their own research methods when applying such techniques. In subjective rating tasks, for example, shaping responses using outlier detection can have the effect of homogenising responses that

do not need homogenisation (Riegler et al. 2016). When it comes to subjective responses in tasks without 'gold standard' benchmarks, removing outliers might actually decrease the overall quality of data by removing alternative perspectives. It is therefore important that outlier detection is paired with the other techniques we have described to determine whether outlying responses are the result of non-compliance with instructions or simply a different perspective on the task at hand.

As well as looking directly at the dependent measures that a study has collected to identify poor quality data, collecting additional telemetry can also help researchers identify participants whose performance is hard to explain. In our own work, we have shown how crowdworkers' propensity to switch to other tasks predicts time-based measures of their performance on a task (Gould et al. 2015a, 2016a, b). Browser events, like whether a window has lost focus can give a researcher an indication of how distracted a participant has been. Other measures, like clicks and taps or keyboard interactions can also help build up a picture of how a participant has interacted with a task. The measures can either be used to help clean-up poor quality entries in a data set or, as we have discussed previously, be aggregated at a larger scale to predict performance and pre-select participants before any time or money is wasted (Rzeszotarski and Kittur 2011).

Automated statistical processes can help analyse data quickly and efficiently. They also require a well-developed procedure and a clear idea of what thresholding criteria for removal will be used. Sometimes, particularly when using a new experimental paradigm, it is necessary to 'eyeball' the data collected to look for patterns or potential outliers across the measures that experimental telemetry can yield. Visualizing data can help with this process. Rzeszotarski and Kittur (2012) developed *CrowdScape* with this in mind. CrowdScape comprises a suite of different visualization tools that allow behaviour data to be quickly consumed. For instance, in a task that required users to type relatively long responses, a plot of the aggregated keypress data for each participants would allow a researcher to very quickly see which participants had contributed significant amounts, and which participants had not typed very much. Through this process of visual exploration, researchers can either identify outliers, or, if they are being more systematic, allow them to develop formal selection criteria for outliers.

Ultimately the benefits of crowdsourcing do not come at zero cost. If a tiny minority of participants does their best to circumvent our best efforts to ensure quality data, we do not have unlimited power to detect them. An extra degree of noise is inevitable and is an intrinsic part of the method.

7.6.4 Summary

At the start of this chapter, we aimed to *"synthesize a set of design and implementation guidelines for crowdsourcing studies"*. The most important things to take-away from this chapter are:

- Generally, data from crowd platforms is at least as good as data collected in the lab.
- The success in translating a psychometric study from a lab to a crowd will depend on the type of data collected and what the collected data is about. Not all studies are equally amenable to being run online.
- Attention checks are a useful tool for keeping participants focused on the task at hand, but participants in crowdsourced studies are often alert to the possibility that attention checks may be present. Researchers should ensure that attention checks are not too easy for participants to circumvent.
- Naïve participants are sometimes important, sometimes a hindrance. Think about whether a study will be affected by prior-knowledge. If not, focus on retaining participants who have achieved a good level of competence.
- Paying participants well is important, but it is not the only thing to consider. Good quality instructions can help people produce good quality work.
- Non-monetary reimbursement, perhaps in the form of personal data, can be an even better motivator than money.
- Crowdworkers are people trying to make a living, not anonymous units of internet production. They get tired. One task can blur into the next. Microtasks are not truly independent.
- It is easier to stop bad data getting into a sample than it is to try and remove it afterwards.

7.7 Conclusion

Thanks to the significant efforts of researchers across a variety of domains, crowdsourcing methods have rapidly matured. Many of the practical challenges we have identified in crowdsourcing are similar to ones that other researchers have encountered working on other 3rd Wave HCI problems, and there is potential for successful strategies to transcend narrow research topics. Diverse platforms now have large numbers of potential participants, and techniques for getting the best out of those participants are increasingly well developed and understood. Data collection and analysis techniques have been developed to help researchers improve the quality of the data they collect. On the whole, crowdsourcing platforms work well for most forms of data collection. In some experimental paradigms, crowdsourcing might be superior to more traditional data collection techniques, not just in quantity and quality, but in the kinds of questions that such platforms allow researchers to explore.

In this chapter we have covered a wide range of crowdsourcing literature to find out what works best when conducting a study on a crowdsourcing platform. We have given particular focus to crowdsourcing in the context of the types of experiments (like psychometric studies) that might be particularly affected by the transition from the tightly controlled environment of the laboratory to the more chaotic and unpredictable world of crowdsourcing. Our goal has been to provide a synthesis

that means other researchers nip common issues in the bud, rather than have to deal with them after significant amounts of empirical data collection have already taken place.

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Chapter 8
Design Research: Methodological Innovation Through Messiness

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Abstract The third wave of Human Computer Interaction (HCI) involves more ubiquitous and embedded forms of computing. Making these useful, usable and even delightful for people needs design research. The more technologies become enmeshed in our lives and the more dependent upon them we become, the more essential it is that they are simple for everyone to use and they do not let us down in those annoying ways we have become used to tolerating. Embedding computing into more and more of the objects and environments we interact with makes them less visible but more ubiquitous, making their usability essential but challenging at the same time. Design research is a mechanism which can help researchers, programmers and designers to understand how to create better twenty-first century computing systems and environments. This chapter discusses how design research can contribute to allowing third wave HCI to benefit the lives of all citizens rather than frustrate them.

8.1 Design Research

The third wave of Human Computer Interaction (HCI) involves more ubiquitous and embedded forms of computing. Making these useful, usable and even delightful for people needs design research. The more technologies become enmeshed in our lives and the more dependent upon them we become, the more essential it is that they are simple for everyone to use and they do not let us down in those annoying ways we have become used to tolerating. Imagine that you cannot enter your smart home because you mistyped the password too many times and now you are literally locked out, or your Google Home device does not understand your accent, leading to a constant battle to communicate with your own light switches and power sockets that was never an issue for previous generations. Embedding computing into more

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and more of the objects and environments we interact with makes them less visible but more ubiquitous, making their usability essential but challenging at the same time.

This chapter discusses how design research can contribute to allowing third wave HCI to benefit the lives of all citizens rather than frustrate them. Design research is a mechanism which can help researchers, programmers and designers to understand how to create better twenty-first century computing systems and environments. This has been acknowledged in the field of Information Systems (IS), where there has been increasing focus on design in IS research (Gregor 2006) and IS has been seen as partially a "design science" (Hevner et al. 2004: 76). Let us be clear, by design research we do not mean design practice, which happens in many disciplines from fashion to architecture to user experience (UX) and beyond, and generally is about generating solutions to defined briefs or problems. By design research we mean work intended to produce new knowledge, which should benefit designers by generating new ways to use and apply technologies, providing information about users and their opinions, activities and interactions with the world and the technologies surrounding them, and developing frameworks and exemplars to be used to design in better ways.

Design research has been around as a discipline since not long after World War 2, and has a somewhat controversial background in terms of how it is defined and what is included as design research as well as what it should focus on. A good history which spells out the transition from "design science" to "design methods" to "design research" and beyond is provided by Bayazit (2004). However, more useful for our purposes is to understand how design research can contribute to HCI. Frayling (1993) split design research, by then a maturing field, into the three categories of research by/through design, research into design and research for design. Here we will briefly discuss these distinctions as we believe they are useful for explaining how design research contributes to HCI (and other disciplines).

Research *for* design is research (generally using various other research methods, although it could also utilise a design process) that contributes to the design field, and the knowledge that designers can use to make better designs. Much Human Factors and HCI research actually falls into this category, as does a lot of design research which is focussed in these areas, including many of the examples we will discuss in this chapter.

Research *by or through* design means research which uses a design process or elements of design methods to generate new knowledge. There has been a substantial amount of debate into whether design practice can be research and where the dividing line between the two is (see for a good overview Durling and Niedderer (2007)). From our perspective, although the debate is still regenerated at times, it has been substantially resolved due to the forced clarity of thinking about what elements of designing constitute research which has been brought into being by the imposition of research assessment exercises in the university sector. For example, the Australian ERA (Excellence in Research Australia) has forced universities and research institutions to define what outputs by design academics (and other creatives such as visual artists, creative writers and film-makers) can be defined as

research and what cannot. To do this the concept of research which is generally applied to a PhD has been applied – does it generate new knowledge which is accessible for others to apply and use? Design can thus be a research method used to generate knowledge about technologies, users, systems, or designing itself, or it can be a process used to generate a new product, interface, building, system, etc. If the knowledge generated through this process is new and can be shown to make a unique contribution, it is research. If it simply addresses a design brief and produces a new or re-designed product or interface without making a unique contribution to knowledge, it is not.

Research *into* design continues to follow on from the work on design science and design methods in understanding what designing is and how it is done. Recently this has also included what Cross has termed "designerly ways of knowing" (Cross 2006). Research into design is less relevant for this chapter, although these decades of work into what is special about designing and how designers can contribute to making things, systems, decisions and more has helped to create understanding about the field. This body of work may have contributed to the fairly widespread acceptance of "design thinking" in all sorts of fields in recent years, as well as the understanding that design research can contribute to HCI and other fields.

Thus, despite the controversy around Fielding's categories, in general researchers have continued to conduct research and build the field in all three areas. In this chapter, we will discuss design research which relates to HCI and this overwhelmingly falls into the categories *for* design and *by/through* design. Before describing specific examples in these two categories, we will discuss an issue that applies to much of design research – messiness.

8.2 The Messiness of Design Research

Design research puts people first, not technology. Good design research is about understanding people in relation to their use of technologies, not the other way around. Introduction of design research methods to HCI has over time resulted in new models of collaboration between design researchers and HCI researchers, with one recurring message that design research as a creative methodology is inherently messy. A unique contribution design research has made to HCI is in development of new methods and approaches, which are not used elsewhere (Forlizzi et al. 2008:20), although design researchers often use established methods, too, as we discuss below. Design research brings with it processes and methods that span quantitative methods, traditional social sciences and visual research. Such transdisciplinary design research projects often struggle to strike a balance between rigid, structured and systematic approaches to research and the inherently open, unstructured, and intuitive methods that characterise design practice and which are necessary to engage with, capture and represent the complex spectrum of the human experience needed in human-centred design. In this, design research can be said to make the research process 'messy'. While messiness creates a number of challenges in the

process and outcomes associated with design research, these arguably could be framed as constraints or as opportunities to explore a novel direction or application.

Forlizzi et al. have developed a model that evaluates the contribution of design research to HCI against four criteria, including Process, Innovation, Relevance and Extensibility (2008:22). Importantly, Forlizzi et al. have argued for the value of design research in HCI not on the grounds of proximity to scientific validity and precision in measuring the usability of the final design but on the basis of its opposite. That is, rather than made replicable, the design process is made explicit and design decisions understandable; rather than made measurable, outcomes are made accessible and relevant. While their model is a useful step towards a value proposition for design research in HCI, it does not yet fully respond to the contribution design research makes to the research and integration of human experience with the research and design process, across research *by/through* and *for* design.

Understanding and authentically representing human experience for the purposes of designing better systems, products and experiences – the core aim of design research – relies on researchers' ability to identify the right mix of methods to aid in understanding non-verbal, interpretative and intuitive subjective experiences of people. Such an approach prioritises people in the research process by developing an understanding of people and human experience, beyond the frame of "user". In doing so it aims to understand, access and represent the complexity of the human experience in a more holistic way, something Glaccardi and Karana have termed a situational whole (2015). Such an approach, while adding to the representational complexity, has been agued to provide a necessary "counterpoint to the reductionist approach favoured by the scientists and engineers." (Forlizzi et al. 2008:19).

In the context of technology design and technology use, consideration of human experience helps facilitate a shift towards understanding technology itself as experience (McCarthy and Wright 2005). Conducting research in a more holistic way, by drawing methodological approaches from design practice as well as using more established methods commonly employed in other disciplines, adds multiple levels of complexity to the research process. This brings with it degrees of ambiguity and subjectivity that are difficult to rationalise within a scientific research paradigm, yet form critical elements of design practice. It is this messiness that necessitates a critical engagement with questions such as the role of the researcher, knowledge, evaluation and validation of outputs, and ultimately questions of what constitutes rigour in an essentially non-scientific approach.

Design research is comfortable with uncertainty. It opens up the research process to new possibilities but creates an indeterminability of the final output. The design process is a journey into the unknown and design researchers are comfortable with navigating that journey – e.g. starting it without knowing for sure where it will end or what the stops along the way will be. In other words, design researchers can deal with messiness and even see it as a necessary part of the process of understanding people, their needs and how to best meet them. Messiness allows more potential solutions to problems if you dare to go where it is potentially uncomfortable, appears disorganised and chaotic but is full of rich information. People are complex

and their experiences are 'messy' in nature; this means that understanding people's experiences is full of complex interdependencies. In addition, constant change in how technology affects everyday life has an important impact on how people understand products, systems, interfaces, places, technologies, and environments. People's experiences are constantly being redefined and challenged every time a new technology is implemented in their daily lives. The focus on people as the 'experts on their experiences' (Visser et al. 2005) has taken central stage in many of the design methods aiming at knowledge development, idea generation and concept development (Sanders and Stappers 2012: 23). For design research, the benefits of messiness can be manifest by attending to a number methodological concerns. First, the re-negotiation of the relationship between structured and uncertain open-ended methods provides a way of framing messiness within the design of a study. Second, there is a need to foreground and question the role of *expertise* and expert knowledge, to establish an epistemological perspective. Finally, focusing on meaning-making/Generating generates new frames of reference and can unsettle existing structures and the predictable outcomes.

8.2.1 Messiness and Structure

Experience is by definition pre-linguistic, and generally unstructured. It is through sense-making, which may involve feelings, expression and cognition, that we give experience structure and form (McCarthy and Wright 2005). Experience is thus highly subjective, contextual and ambigious. Looking at this from the lens of the irreducibility of the human experience (McCarthy and Wright 2005:267), it could be said that more traditional HCI methods, based in science and focusing on quantifiable measures of effectiveness, are limited in scope to undertake research outside the fixed parameters of science and engineering methods. On the other hand, the subjectivity of the human experience leads to greater ambiguity, which in turn creates messiness by unsettling existing structures. Meaning, or sense-making, when framed within the constructivist approaches as an individual's ability to make sense of ambiguous situations, reframes existing structures, constructs or models as a given, or as "natural"; yet they are often emergent and are a result of sense-making or resolving an otherwise ambiguous situation as understandable. The absence of an apparent structure in much design research leaves more room within the research process for accommodating fluidity and multiplicity of representational possibilities. Additionally, open-ended processes are often messy and they lead to an indeterminable output (Zelenko 2012).

There are, however, advantages to intentionally unsettling structural coherence in order to generate new possibilities outside established design conventions and in favour of greater 'in-situ' responsiveness to participant response. Indeed, reliance on pre-existing frameworks comes at the cost of a creative response, which, by definition, falls outside of a predetermined structure. In the context of technology and interface design, such an approach limits the emergence of unintended findings:

"Defaulting to design conventions in an attempt to guarantee technology uptake shuts down any unintended uses, resulting also in the negative framing of interaction outside an established structure as erroneous rather than intentional" (Zelenko 2012: 100). To remove constraints is to challenge predetermined processes and open them up to renegotiation.

8.2.2 Expertise

Opening research processes to greater input from participants – including where such contribution may lead to a redesign of a research artefact – opens the role of research expertise and expert knowledge up to re-negotiation. Open processes have the potential to, on the one hand, create opportunities for shared control over the resulting outputs and, on the other, a struggle for control over the process as it is unfolding. Necessarily, knowledge of researchers and participants are curated to be interwoven, as is the case in co-design and joint analysis techniques. Where the research methods are centred on the core of human experience and where participants are the sources of this experience, they enter a position of greater knowledge over most effective method for their *sense-making* of that experience. This involves new ways of articulating, representing and communicating their experience to researchers, adapting research artefacts where needed. At one end of the spectrum, the expertise of participants may be accessed but applied by designers (e.g. experiments, interviews or observational studies), but at the other, participants in participatory design may contribute their ideas and expertise throughout the research and design process.

8.2.3 Sense-Making and Meaning-Making

In general meaning-making can be understood as the process by which we use language and form to give expression to experience and to create self-awareness. In this paper we refer to meaning-making as that part of experience which requires sense-making and understanding in order to engage with the world meaningfully. This involves extending design of research processes that consider specificity of one's local context or situation, promoting a high degree of responsiveness to a unique individual experience or life circumstance. The term sense-making has been used in multiple fields from organisation studies (Weick 1995) to HCI (Russell et al. 2009). McCarthy and Wright (2005) have argued for linking sense-making, subjectivity and agency with HCI). This suggests the importance of research methods that forground the experience of the "user" – and thus recognise the limits of existing structures, conventions and practices associated with questions of usability with a predictable unambiguous process and outcome.

Sense-making is described as a metacognitive process by which we construct narratives to understand ambiguous, new or unrecognised experiences. It is these stories, expressions, of experience that open-ended (unstructured) design methods aim to illicit, without imposing the worldviews or frames of reference of the researcher. Thus, outputs from design research are highly contingent upon the individual subjective experience of the participants. The following case studies and examples each explore the role of messiness within design research. Each contains questions about how structure, expert knowledge and sense-making are addressed and influence research methodologies.

8.3 Examples of Methodologies and Approaches Used in Design Research

This section contains case studies and examples of design research used in a variety of design research projects, both for and through design, by the authors and others. The section is arranged to firstly cover a range research *for* design examples before moving onto examples and a larger case study of research *by/through* design. These examples are intended to illustrate how design research can contribute to HCI and also to compare the various approaches. Design research approaches employed to understand people's needs and experiences has been catalogued and categorised in various ways (Kumar 2012; Sanders and Stappers 2012). Sanders and Stappers (2012) map out several methods and cluster them into four different dimensions: Design-led (e.g. design process) and Research-led (e.g. Usability, Contextual Enquiry); Expert (e.g. user centred design) and Participatory (e.g. generative tools) mindsets. Different methods are positioned into each of these different dimensions.

Participatory design methods and generative research focus on facilitating people in taking part in a design process while eliciting insights and ideas on a given situation (*research through design*). On the other hand, the methods that have been developed the longest and used the most in HCI include methods also used in applied psychology, anthropology, sociology, and engineering. These methods are the ones that we describe here as r*esearch for design,* and which focus on contributing to knowledge while helping designers design products that better meet the needs of users. Although some methods we include as part of design research (such as experiments, interviews, observations, etc.) are also used widely in social and physical sciences, design researchers generally approach them quite differently. For example, experiments are generally designed based on research questions rather than hypotheses, and analysis (such as coding of audio and/or visual data) is often based on coding schemes that grow out of the data itself (commonly in conjunction with established literature), rather than categories decided *a-priori,* as would be more usual in hard sciences, psychology or some traditional HCI experiments.

8.3.1 Research for Design Methods

Research for design methods often follow a reasonably traditional approach to data collection, analysis and interpretation of findings, with a view to developing principles that can then be applied to interfaces, products and services. Methods for data collection involve – but are not restricted to – verbal protocols, observations, interviews, cognitive analysis, usability testing, applied ethnography, visual representation of concepts, contextual enquiry, among others. These methods can be experiment-based or ethnography-based, in the field or in a lab, and are generally guided by research questions (although some experiment-based studies may occasionally use hypotheses instead of research questions). The rigor of the methods relies on triangulation of research methods, replicability of methodology, and/or generalisation of findings.

In experiment-based research methods, the researcher is the expert and translates the data collected from users into interpretations or findings, in the process tidying some of the inherent messiness present in the typically rich and noisy data set. To this end, researchers are assisted with a variety of tools and methods, such as thematic coding analysis, visual and observational analysis, and the use of specialised software (such as Noldus Observer to code video-recorded observations, or ATLAS.ti to code still images and text). In ethnography-based research methods, the researcher can sometimes adopt the role of participant observer and immerse themselves in the research context. Ethnographic methods, such as participant observation, field work and oral histories are commonly combined with qualitative research approaches such as semi-structured interviews, oral histories, and document analysis. Often a Grounded Theory approach, with the use of software for thematic or content analysis, is employed to assist the data analysis process.

Experiment-based design research methods follow a rigorous scientific method-like approach where findings can help inform evidence-based decision making in the design process, can be critically evaluated, and can provide a platform from which to add to the existing base of knowledge or to support an innovation. An example of this approach is Evidence Based Design (EBD), which has been applied to healthcare Design Research and more specifically to environmental design research in healthcare settings (Zborowsky and Bunker-Hellmich 2010). Here, the messy nature of the design research problem was identified as human errors leading to reduced patient safety in healthcare facilities, errors involving medical professionals, the patients, the health care processes, social interactions, and the facilities. A complex matrix of problems led to architects, designers and the medical community engaging in collaborative research work that aimed to deliver theory that contributes to inform decision making towards design interventions as well as theoretical frameworks to inform best practice in the design of healthcare facilities.

Observation-based methods are very common across much of Design Research, as observation is such a valuable tool when seeking to understand people's activities and their use of all sorts of designed objects, environments and services. Hence we have used observation across many projects, both research *through* and *for* design.

However, we need to position observation in terms of what relationship it might have with frameworks such as ethnography, as observation is often strongly linked with ethnography. Ethnography is a research methodology that has its roots in the anthropological study of non-western cultures (Lazar et al. 2017). Borrowed from the social sciences, ethnomethodology, an ethnographic fieldwork-based research approach, has been employed in the context of HCI and Design Research to understand peoples' behaviour and culture (peoples' practices, feelings, and experiences) and their interactions with the designed world in the context of their everyday lives (Button 2003). The use of ethnomethodology in HCI has been traced back to Xerox PARC in the early 1980s, when computers moved from laboratory settings to everyday people's contexts (Blomberg et al. 2009) and developers needed to understand users' requirements. This research approach has developed further and intersects with Participatory Design, Action research, and Generative Design Research, initially described as Critical Design (Plowman 2003). It may also involve an empowerment research agenda, where participatory action research undertakes a critical stance where the researchers' ultimate goal is to facilitate or support collaborative social change (Barab et al. 2004).

Showcasing different methods that aim to contribute with research for design (knowledge that designers can use to make better designs), there follow four exemplars of design research studies that have employed these kinds of research approaches. Here we discuss the methods employed, the messy nature of the research problem, and the outcomes.

Example 1: Understanding human experience through visual representation of concepts

To support designers' engagement with users' experience as an essential component of the design process, a study was conducted to investigate the influence of human experience on users' and designers' differing concepts of products (Chamorro-Koc et al. 2008). Human experience is a complex fabric of elements that comprises many different factors in a person's life, including episodic and tacit knowledge, knowledge from seeing and doing, emotions, memories, etc. Thematic coding of people's visual representations of concepts, alongside the transcribed verbal protocols of the sessions, was employed to uncover the experiential and contextual component of people's understanding of product use. Individual sessions were conducted with designers and non-designers who were asked to draw their idea of everyday products as a process undertaken to reveal concepts emerging from visuals and to identify emerging relationships between people's individual experience and their understanding of a product's use. Retrospective interviews were employed immediately after participants finished the drawing task to gather their explanation of the concepts in the drawing. Figure 8.1 shows exemplars from visual representations of a user's (left) and a designer's (right) concepts of a blender. Here it can be seen that the user's drawing shows several features of a blender described by name, and also that the user has provided some more explanation of what the product and its parts are. In this study it was inferred from the verbal protocol that the user drew a blender she probably owns or uses. Differently, the designer's drawing shows

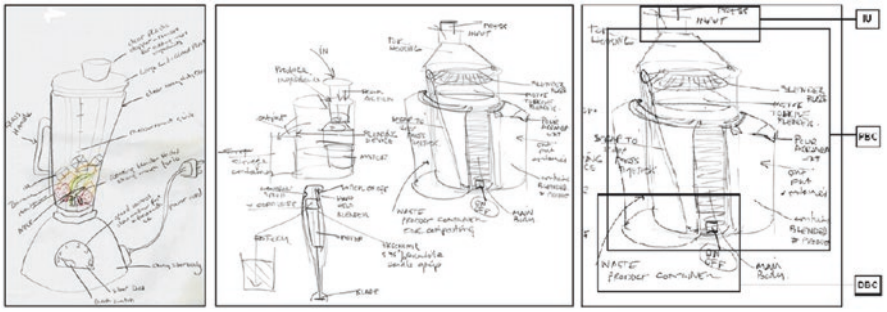

Fig. 8.1 Non-designer's drawing on the left, designer's drawing on the centre. A segment of the coding applied to visuals on the right. Reproduced with permission from Chamorro-Koc et al. (2008)

three different blenders, and names and functionality of their different parts. His drawings suggest attributes such as soft grips; moreover, drawings show the relationships between the parts. It seems that the designer knew details of this type of product and drew features from memory, but his drawings do not reveal experience of using one particular product but experience of designing similar products.

The approach to the use of visual representations together with retrospective interviews in this study, and the use of a thematic analysis, led to understanding of elements from peoples' experiential knowledge. Based on the evidence of relationships identified between peoples' experiences and their understanding of a product's use, the interpretation of findings converted those causal relationships into design principles to assist the design of product usability by informing designers about the specific aspects of human experience that trigger people's understanding of products and product usage.

Example 2: Intuitive interaction research

Design research conducted by Blackler and colleagues (Blackler and Popovic, 2015a, b; Blackler et al. 2010) has established a definition of intuitive interaction and built theory around it through a series of experiments. Initial studies comprised experiments to establish an understanding of what intuitive use is by using observation of people with different levels of age and experience using various actual interfaces and products. Experiments were designed and carefully controlled to allow for rigorous statistical analysis so that we could confidently state what contributes to intuitive use and whether differences exist between various groups. Over 18 years of research into intuitive interaction by various researchers on four different continents using a variety of products, interfaces and experiment designs has shown that prior experience is the leading contributor to intuitive interaction (Blackler et al. 2010; Fischer et al. 2014; Hurtienne and Blessing 2007; Hurtienne and Israel 2007; Mohs et al. 2006; O'Brien et al. 2008). Almost all of this work has been conducted using fairly quantitative methods – experiments which compare different groups of people or interfaces for levels of intuitive use, analysed using standard statistical

Fig. 8.2 Typical lab set-ups for observations of participant conducting set tasks

methods – but including methods such as observation (video-recorded and coded), verbal protocols and scenario setting (where participants are given a fictional scenario within which they complete set tasks with products or interfaces, be they actual products or prototypes). Figure 8.2 shows a typical lab set-up for such experiments. In these experiments, variables such as the time and/or number of steps required for optimal completion of the tasks, number of correct uses and intuitive uses were calculated and compared.

In the case of the intuitive interaction work worldwide, use of quantitative analysis is common. It has led to results that help us to understand the complex fabric of people's past experience and how it influences their familiarity with products and interfaces and the way they intuitively interact with them. This is now informing designers' practice in a classic *research for design* scenario. Although this is probably the least messy example given here, it was still approached with a greater level of uncertainty than many other classically-designed experiments. At the start we did not know what we would find and included various potential variables in the design of earlier experiments so that we could investigate several possible options for what was causing the phenomena.

Research through design has also been used as part of this work in order to test the use of tools developed to improve intuitive interaction. Designers or researchers designed new interfaces using the tools developed based on previous experiments, and then used further experiments to test whether the new interfaces were any more intuitive (e.g. Blackler et al. 2014; Fischer et al. 2015; Hurtienne et al. 2015). Results from these experiments have suggested that implementing tools intended to assist in design of intuitive interfaces can lead to significantly more correct, intuitive uses and significantly higher familiarity scores as well as increased user satisfaction or perception of intuitiveness.

Example 3: Novice and expert use of specialised knowledge in security related tasks

For the regular passenger or visitor at airports, security screening is an ordinary and routine task. However, there is a multitude of knowledge required from airport employees to carry out this routine task. Swann et al. (2014) conducted a study

around airport security screeners to understand design implications for interface design. The problem with security screening involves people making sense of the images on the screen in order to action a security related decision-making process. The research, conducted in the field at an international airport in Australia, delved into investigating expertise and the types of knowledge used by airport security screeners, and applied a multi method approach incorporating eye tracking, observation, concurrent verbal protocol and interviews. The study identified that novice and expert security screeners primarily access perceptual knowledge and experience that imposes little difficulty during routine situations. During non-routine situations, however, experience was found to be a determining factor for effective interactions and problem solving. Findings demonstrated that experts used strategic knowledge and a structured use of interface functions integrated into efficient problem solving sequences. Comparatively, novices experienced more knowledge limitations and uncertainty, resulting in interaction breakdowns. These breakdowns were characterised by trial and error interaction sequences, which resulted in a lengthier security screening process. The study led to an understanding of relationships between visual and physical interface interactions and their integration into problem solving sequences.

As part of the study, participants (security screeners) were asked to use eye tracking technology (Tobii glasses) to capture their visual attention on the screening machine. This was later analysed with the use of specialised software for qualitative analysis (Noldus Observer) by implementing coding heuristics informed by eye tracking research to code visual behaviour and infer the knowledge base of the screeners. An example of the analysis is shown in Fig. 8.3; here it can be seen how problem solving sequences can be resolved quickly, indicated by short sequences (Fig. 8.3, bottom), or they can be more extensive, involving a number of shifts between different behaviours (Fig. 8.3, top).

Example 4: Actor-network research and the analysis of complex socio-technical situations

Described as a notion of an heterogeneous network that brings together human, nonhuman, social and technical elements to comprehend complex situations (Law 1992), Actor-network theory (ANT) approach has become more common in design research due to its ability to deal with human and non-human elements simultaneously by considering them symmetrically, as being equally able to influence a situation. The use of actor network research in design takes the perspective that in certain situations ‘things’ can have as much as or more power than people, and is helpful in understanding how a new thing can change an existing situation if everything else remains, initially, the same. This perspective was applied by Kraal et al. (2011) in the study of doctors and nurses’ interactions in a pre-surgical medical consultation procedure with technology, which presented an area of investigation where social relationships, context of use, procedural interactions, and people-

Fig. 8.3 Detail of problem solving sequences showing long (top) and short (bottom) interaction sequences

technology interactions are some of the factors constituting complex sociotechnical situations. The study employed a research frame based on aspects of actor-network theory: 'interressment', 'enrollment', 'points of passage' and the 'trial of strength'. This research frame was used to analyse a medical consultation context where it is considered how the traditional patient-doctor consult could change with innovative technology in two different situations: face-to-face consultation, and a remote telehealth consultation. In this study, a prototype of a digital stethoscope was tested in the context in which it is used. Ten tests using the prototype digital stethoscope were video recorded in a hospital setting in experimental conditions. Noldus The Observer XT behavioural analysis software was employed to assist the data analysis of the video-recorded observations, coding the activities of the doctors, nurses and patients. The use of the actor network research frame identified aspects in the telehealth consultation that could be carried out in similar manner to the face-to-face consultation. By showing which aspects of an existing situation are the most important the research frame can also be used to consider the successful integration of artefacts that are yet-to-be designed into an existing situation. Actor network theory applied in this kind of study demonstrates that the design of an artefact is not enough to ensure successful use; but it is the design of the situation in which the artefact is used that contributes to the success of the artefact.

8.3.2 Action Research and Design

Action research is a research approach that is commonly attributed to Kurt Lewin, a social psychologist who coined the term in 1944 (Adelman 1993), and emerged as a research strategy to address questions regarding the relationship between theory and practice. Thus it involves a blurring of boundaries between action and research, and is described as a "process concerned with developing practical knowing in pursuit of worthwhile human purposes, grounded in a participatory world view." (Grundy 1982: 353) The predominant purpose of action research is to affect change. Research is typically conducted in reflective cycles resulting in change in the research subjects, organisations or societies where the research is conducted (Dick 2000). This approach starkly contrasts with research approaches that promote researchers as disengaged and objective entities aiming to reproduce repeatable results. The closely related concept of participatory action research further highlights the role of participants as co-researchers and as well as the deep dingembedding of researchers in the communities and workplaces studied.

While action research has been applied in the context of HCI, its scope is significantly broader than interface design, or even design in general. Action research has gained traction in the contexts of education research, public health, civic engagement and organisational development (Bradbury 2015). In the context of this book chapter we will look at potential overlaps between action research, design research and its inherent notion of 'messiness' and the benefits that can be derived from approaching problems through these different methodological lenses. We will initially discuss the relationship between participatory action research and participatory design and then widen the discussion to consider action research and design research more broadly.

8.3.2.1 Participatory Action Research and Participatory Design

Greenbaum and Loi (2012) situate participatory action research and participatory design on a spectrum of research traditions that are concerned with research *"by, for and with, people who will benefit from it"* (pp. 81). Participatory Design (see Sect 3.1) has a strong social agenda born out of its Scandinavian roots in the 1970's that centred on the active involvement of workers in organisational change, learning processes, the design of ICT systems and more broadly, democratic practices (Greenbaum and Kyng 1991; Bodker et al. 1987). Participatory Design is rooted in a design tradition. Through the interaction with and the participation of people it aims to understand the context of design, identify problems and design goals and design outcomes (Halskov and Hansen 2015). How to design with and for participants is the central tenet of Participatory Design. The involvement and co-contribution of participants in the research process plays an equally important role in Participatory Action Research. However, Participatory Action Research tends to be generally more *outcome-focussed*, reflecting and improving research practices

with the explicit goal to affect positive change for those involved. Participatory Design, by contrast, can be seen to be broadly more *product-focussed*, iteratively designing a solution that best addresses the identified design goals and matches the design context.

Foth and Axup (2006) discuss similarities and differences between these two research approaches based on a set of case studies. They compare the design of a social network for backpackers, using a participatory design approach, to the study of social networks of urban residents, using an action research approach. The study on social information sharing between backpackers used a range of participatory design approaches. The first iteration of the study consisted of an observational study that included shadowing a group of six backpackers while they undertook activities in the city of Brisbane, Australia. Results were recorded using notes, photographs and participant-collected audio recordings. The second iteration introduced design props in the shape of foam mobile prototypes which backpackers took with them and role-played usage scenarios. Results were collected via participants' feedback on the use of props and play acting and scenario building as part of the exercise. The study of social networks of urban residents begin with a series of case studies using a range of methods including surveys, focus groups, participant observation and interviews, aiming to understand the social fabric of residents and their current use of ICT within their neighbourhood. Participants were involved in a critical reflection of their activities and jointly discussed how to make their apartment complex a better, more liveable place. Strategies for practical activities that would positively impact communication between residents were devised and implemented.

This work further confirms some of the differences between participatory design and participatory action research outlined above, including the difference in goals. The design process is targeted and despite its potential and deliberate messiness, eventually moves research towards a specific set of goals, which are defined as part of the design process. Action research approaches, by contrast, prioritise immersive research that asks participants to critically reflect on their own behaviour in order to affect change. Another important aspect in this context is the scope and transferability of outcomes. Design approaches, by their nature, aim to develop outcomes that have a broad appeal and applicability. Specific groups of participants are almost always representatives of a broader group of people for which a product or service is being designed. For instance, the design of ICT products for a group of backpackers is likely to be transferable to different groups of backpackers in similar contexts. While transferability varies depending on how specific the context is and how representative participants are, it constitutes a fundamental characteristic of design research. Action research approaches, by comparison, are concerned with specific outcomes for the same group of people that are involved in the research. By definition, the process of reflecting on specific conditions, behaviours, and contexts is part of the research process itself. Research outcomes are thus inextricably linked to the group of people participating in the research. Transferability, in the context of action research, is less the transferability of outcomes and becomes more of a reflection on how the process unfolded and how it can be applied to different contexts.

Foth and Axup (2006) draw on these different qualities to suggest a combination of Participatory Design and Action Research approaches. Participatory design would be used to design products for given groups of people. An action research approach would complement this research while further considering longitudinal aspects such as shifting communication patterns and the impact of technology on a specific community.

8.3.2.2 Participatory Action Research and Design Research

In addition to the similarities and differences in the involvement of participants, action research and design research more broadly share similarities at a methodological and process level. Swann (2002) identifies the cyclical or iterative nature of both action research and design research as a commonality. Action research is conducted through systematic cycles of planning, acting, observing and reflection (plan – act – observe- reflect) (Kemmis et al. 2013). Design research, in its instantiation of *by/through* design, similarly implements a cyclical or iterative approach consisting of analysing/understanding people and the context within which they live, work and play, setting design goals, designing artifacts or services at different levels of fidelity and evaluating the application and use of these artifacts/services in relation to the design goals. Both approaches are cyclical, they are reflective and take into account to what extent an iteration/cycle has effected change to fulfil goals, they are systematic and, as we have already established, they are generally participatory.

While there are many examples of the applied research approaches in HCI, methodological comparisons specifically between Action Research and Design Research are more commonly found in the interdisciplinary field of Information Systems that considers both the design of technical artifacts and the implementation of these artifacts in organisational contexts (Goldkuhl 2013; Cole et al. 2005). For instance, Cole et al. (2005) suggest that Action Research and Design Research can be effectively combined and suggest a flexible "late binding" approach that allows researchers to defer the decisions as to which methodology to use based on the needs of the specific situation.

8.3.2.3 Action Research and 'Messiness'

Both Action and Design Research deal with uncertain situations and 'messiness' due to the complex nature of humans and their contextual settings, as well as the creative and non-determinate nature of the design process. With regards to Design, Swann (2002) posits: "Design deals in human interactions with artifacts and situations that contain a great deal of uncertainty. Design research is tied to a domain that derives its creative energy from the ambiguities of an intuitive understanding of phenomena" (pp. 51). Action research is comfortable with the 'messiness' of humans and their contextual and organisational settings, but in general does not

utilise designerly approaches to address these challenges. This presents both an opportunity and a challenge to effectively link Action Research and Design-based approaches to benefit from designers' experience of dealing with uncertainty. As a counterpoint to this, Design as a discipline, rather than bestowing a mythical gift on humanity, increasingly faces questions of accountability and the responsibility of designers to the environment (Swann 2002). This trend is reflected within the design community by the reflection of the role that design can play in the context of social responsibility and more broadly design for behaviour change (Niedderer et al. 2017). Action research and its long tradition of reflection and enacting change can make an important methodological and conceptual contribution here.

8.3.3 Co-design/Participatory Design

In developing methods that enable researchers to study individual experience more effectively, the third wave of HCI gives rise to a greater focus on "experience-oriented technologies" (Bodker et al. 1987:26) In this chapter, we have argued that this shift to a focus on individuals and experience-oriented technology design calls for alternative approaches to the process of design that are tolerant of greater ambiguity, uncertainty and accommodating a higher degree of emergence than before. As shown, formalisation of such approaches is still in its early stages (Forlizzi et al. 2008), with limited insights into ways of ensuring rigour across a multitude of experiential, unstructured and highly subjective processes and design artefacts. As mentioned, our aim is to contribute to this debate by showing that such approaches, at the very least, impact the design research process across three key areas. First they require a reconceptualization of the experience of the research process, or its structure, from fixed and measurable towards open-ended. Second, there is a reframing of the role of design and research expertise to include users as experts in their life experience. Finally, there is a focus on the way participants make sense of technology within specific contexts of use.

Perhaps one area that provides a clear context for demonstrated applications of design research to technology design in ways characterised by the third wave is design for eHealth. Applications of participatory and co-design methodologies for innovation in health have over the past 5 years proliferated to the extent that has seen its primacy in innovation acknowledged as part of funding strategy at State Government levels. In the Australian context, "co-design' and "user-centred design" forms part of a long-term approach to innovation endorsed by local Government as part of the Queensland eHealth Strategy 2016–2026. Beyond commercial applications and research-led collaborations across design and health, this sends an important signal about the focus on *people* and their *experience* as core to whole-sector innovation.

The selected case study is from a currently funded Australia Research Council project (involving two of the chapter authors). It focuses on the co-design of a youth help-seeking toolkit for mental health, with young people aged 13–25. Below we

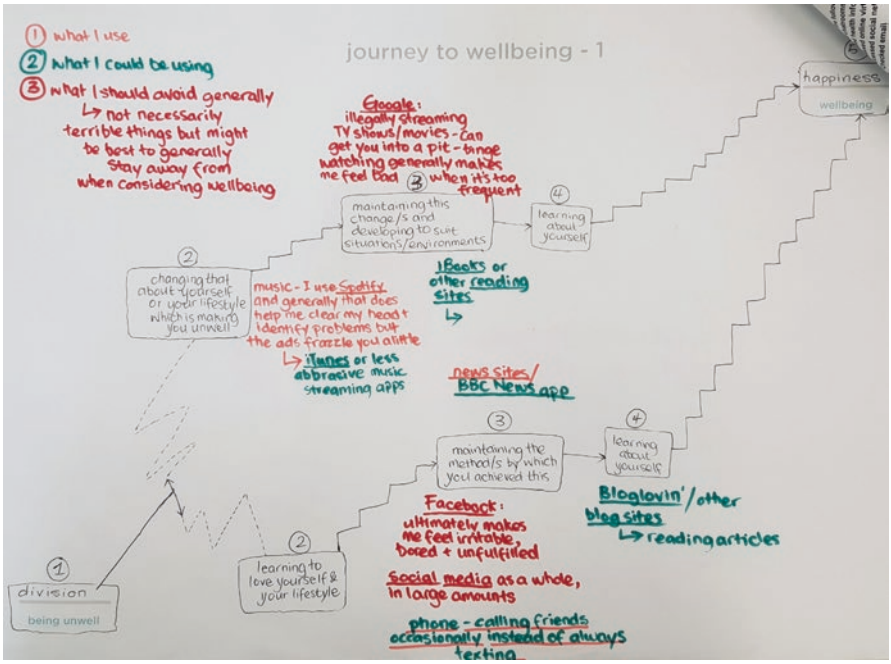

Fig. 8.4 Individual Journey Map: Help-Seeking Toolkit project (Workshop participant, female, 19)

show a series of documented visual examples of participant journey maps created during a participatory design workshop that focused on exploring young people's pathways of decision making during help-seeking on a mental health topic of concern to them, and evaluation of the usefulness – or otherwise – of technology to their individual help-seeking process. The aims of the activity and the template was to discover the way young people seek information or help with respect to a specific mental-health topic, and identify what they consider as the main steps. This was supported by an open-ended methodology which was designed to visualise where sources of support or barriers are located, and the role technology played in help seeking. Finally, the method included an exploration of the potential role technology could play but currently does not.

The templates designed by the researchers aimed to create a broad, open-ended framework and a shared visual vocabulary which participants could ground within the context of their own lives, creating personal decision-making maps, and enabling rich detail and specifics of their individual journeys to emerge. As shown in Fig. 8.4, the template consisted of a point A at the bottom left corner where participants noted their previously generated topic of concern related to 'lack of wellbeing'; and Point B representing their desired (or previously experience) positive mental health outcome (also previously generated). To assist with the process of analysing the maps, researchers had devised a set of visual cues – different types of connecting

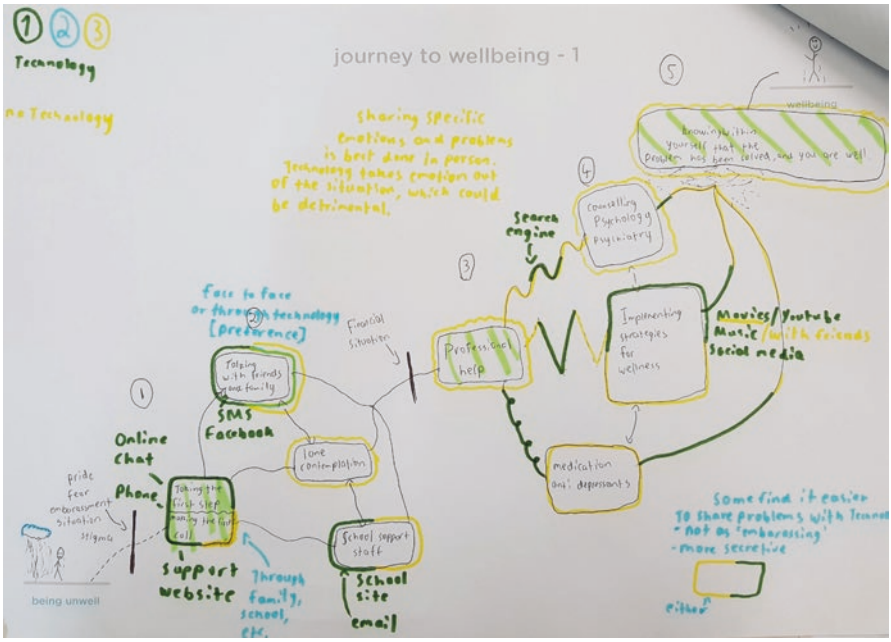

Fig. 8.5 Individual Journey Map: Help-Seeking Toolkit project (Workshop participant, male, 18)

lines, straight, stepped, dotted – each signifying a degree of difficulty or ease of pursuing a noted action. Straight line signified a step that did not required a lot of effort; stepped line indicated an experience that was very challenging or time-consuming; dotted line represented an ambiguous, unclear path towards the next step. Participants could choose a help-seeking scenario from their past to map.

To undertake the activity, participants (young people aged 13–15, 16–19 and 20–25) chose an issue of concern from a previously (individually) generated list of topics. Then they placed the topic in the bottom left-hand corner, nominating their desired 'wellbeing' outcome at the top right-hand corner. Then, using the visual vocabulary, they mapped their experiences and choices, indicating barriers, enablers and then evaluating the role of technology in relation to these. Each participant created three of these maps for three different issues. Outcomes of this process (Fig. 8.5) showed that the broad framework enabled each participant's map to be highly individual, revealing rich and unique details about contextual factors impacting help-seeking – whether technology-enabled or where technology was a barrier.

Importantly, this approach took into account the entire context of young people's lives, including multiple domains: social life, friendships, personal life, family, school, work etc. In this, the activity demonstrates one way of capturing the diversity of multiple participants' experiences in a holistic, "whole of life" perspective that spans multiple experience domains. This is a key focus of the third wave approach, which Bodker describes as "conceptual thinking that helps us embrace people's whole lives and transcend the dichotomies between work, rationality, and their nega-

tions." (Bodker et al. 1987:27). This approach established a method that was partially structured yet open-ended enough to allow for a high degree of interpretation and unique expressions by participants. The researchers iteratively tested prototypes of the templates with people before use in workshops. The resulting method produced far more meaningful responses than traditional structured methods, with each participant providing unique context-specific responses constructed in situ.

This process enabled a messy *structure*, which was achieved by carefully designing the workshop framework with just enough structure and guidance to prompt rich context-specific responses and open enough to enable non-verbal visual communication of experience. Through use in workshops, the researchers found that it was important to be flexible to accommodate diverse backgrounds, life experiences and prefered modes of expression. As a result, the researchers found it was essential to be open to participant modification of the research artefacts to allow them to express their unique experiences.

Young people used their own lives as the source of the maps, and the open-ended approach necessarily positions young people as *experts* of their personal journeys. The aim was to respect them as experts of their own experience, of the unique context-specific details impacting their help-seeking decisions, and their articulation of perceived value technology in making these decisions and in relation to 'what works' for them. A process such as this foregrounds young people's voices, giving them control and agency over the resulting artefacts. The help-seeking maps enable multiple opportunities for sense-making and *meaning-making*. A process that allows participants to make sense of their experience progressively; and, to actively construct meaning. The aim was to create a process that would accommodate multiple contexts relevant and meaningful to multiple participants, which we refer to as context specific. McCarthy and Wright would describe this as "putting felt-life, that is life as lived, sensed and experienced, at the centre of human–computer interaction (HCI)" (2005:262), so as to enable "local, context-rich research".

Within the shared visual vocabulary, each participant was free to articulate the specifics of their recovery journey, or where participants found the vocabulary limiting they were able to modify it to suit their experience. Each participant created unique maps, providing a glimpse at how they make sense of complex and difficult lived experiences. Such subjectivity, from a scientific perspective, makes validation impossible, but in this context it is the open ended and subjective nature of the method that is critical in providing new knowledge required to successfully develop designs that are sensitive to the specific context of use. Something that is of the utmost importance when the context of use involves young people's mental-health and wellbeing. Figure 8.6 shows the map of the whole project and demonstrates how these maps contributed to the design process for the apps that were developed through this project.

This case has been included for its potential to illustrate the 'messiness' of the process of researching human experience using visual journey maps. It also shows the way participants are engaged as experts, and highlights the role of meaning-making in the process. It shows that bringing design research into HCI creates a space for intentional messiness that opens new challenges to design researchers and the HCI community.

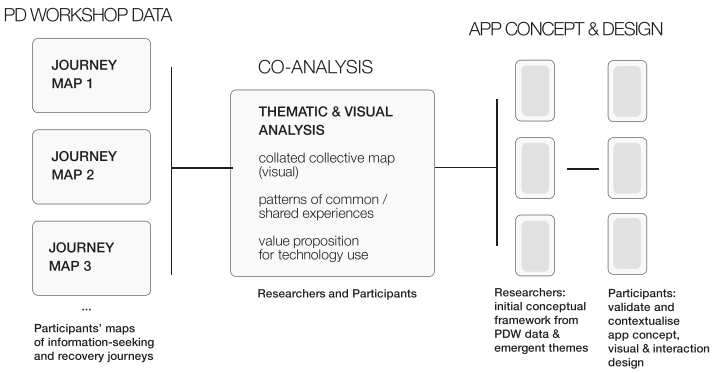

Fig. 8.6 Top level flow of synthesising PD data into initial two iterations of health app design

8.4 Discussion and Conclusion

These very varied examples show the breadth of design research and illustrate the potential it has to contribute to third wave HCI. Design research is applied in a wide range of ways to a wide range of projects and research endeavours. However, these examples have shown that it is essentially focussed on understanding people and ultimately on delivering the best design solutions for the issues that they face.

In this chapter we have argued that design research has made a unique contribution to the 3rd wave of HCI with the development of methods and processes that contribute to the understanding of peoples' experiences beyond the concept of people as 'users'. The discussion of research both *by/through* and *for* design has highlighted how design researchers have dealt with the messy nature of people's experiences with technology by understanding technology itself as experience, where methods employed involve processes to work with the complexity of people's experiences and the ambiguity of the data captured by those processes. The transdisciplinarity of the methods employed in design research is what makes possible a distinctive approach to human-centred design and the understanding of people's experiences. It achieves this by: adopting messiness in *structure* through open-ended processes that accommodate for fluidity and indeterminable outputs; the increasingly changing role of *expertise* and expert knowledge from participants' and researchers' input and contribution to the research process; and by *meaning-making* processes from the participants' views that generates new frames of reference for understanding research outcomes.

How much messiness is suitable for a particular project and which design research methods are chosen generally depends on the aims of the project and the expertise of the researchers. If a designed outcome is needed then a *research through design* approach such as participatory design or action research is the best approach to explore. If specific outcomes relating to information or guidelines for design are needed, or an outcome needs to be tested, then methods associated with *research for design* are available. Not to forget that these approaches can also be combined, as

demonstrated with the intuitive interaction projects. Each design research method gets messy, although it could be argued that the more participants are involved in the outcome, the messier it will be as the researcher concedes some control. However, the richness of outcomes from design research and the potential to really answer real world research questions is well worth the effort.

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Chapter 9
Problematic Milieus: Individuating Speculative Designs

Tyler Fox

Abstract This chapter explores the method of speculative design. It considers the role of speculative practices as an aspect of design that allows HCI practitioners to explore problematics rather than problems. Problems need to be solved, whereas problematics are localities, situations, or experiences, where one can trace the connections between structural, political, and social forces and their implications to foster dialogue and reflection. As such, speculative design offers a theoretically rich approach through which to consider design implications of future and alternative conditions. Such work is discursively generative. To aid in deepening the philosophical aims of speculative design, I employ some of Gilbert Simondon's philosophical concepts, then examine several examples of recent speculative design.

9.1 What Is Speculative Design

Methods are chosen for what they produce; that is to say, methods provide certain kinds of data, or outcomes. Qualitative and quantitative methods provide us with different outcomes; they produce different forms of information. Why a method is chosen depends on the kinds of inquiry one wishes to conduct, and the information which one wishes to generate. As a method, speculative design is also overtly discursive and authorial; this positions the designer politically, beyond traditional understandings of the field. We may ask what kind of information does speculative design produce, and why would we use such a method? We may also ask, what differentiates speculative design from other design practices? This is difficult to answer, for as we shall see with our examples, the practice of speculative design is divergent.

Speculative design is related to critical design, design fiction, design as inquiry, anti-design, radical design, design futures, and other forms of design practice that critically interrogate society through the tools and materials of design, which are

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widely considered alternatives to traditional design practice (Auger 2013; Bratton 2016; Dunne and Raby 2013; Malpass 2017; Wakkary et al. 2015). As a group, we can refer to them collectively as discursive design. Speculative and critical practices are intended to provoke discussion about our world and our use of technology; they interrogate existing and new affects, means of production, affordances, scenarios of use, mechanisms of control, latent and emergent values within technology, and power asymmetries produced through certain technological forms, among other aspects of contemporary technoculture. James Auger asserts that while similar in practice, the names of discursive design signal important semantic differences to their audiences. Probes imply "investigation;" fiction lets us know that it is not real; critical signals a provocation of debate through its design, and so on (Auger 2013). Speculative, he claims, "suggests a direct correlation between 'here and now' and existence of the design concept" (Auger 2013). This distancing between the audience and the design, between the 'here and now' and somewhere else is a signal of possibility and potential. This is not to be confused with prediction, but a tracing of potential, tendencies, and energy. Speculative design begins with a "what if?" Traditional design, which also goes by other names such as normative, mainstream, or "affirmative design," is often described as design that affirms the status quo of our contemporary, capitalist, consumerist condition (Auger 2013; Dunne and Raby 2013). Speculative design (and its relatives) provoke conversation and debate about our status quo by explicitly exploring and presenting design provocations that clearly differ from our everyday. Speculative design offers new forms of the everyday, what Matt Malpass refers to as "future mundane" (Malpass 2017).

It is a well-worn truism that design is in service to a problem. Designers are trained to find and understand problems, then provide solutions for them (Koskinen et al. 2011). Design in this form hinges on the problem to which solutions are sought. "Above all, [designers] are trained to imagine problems and opportunities to see whether something is necessary or not. It is just this imaginative step that is presented in discussions on innovation in industry" (Koskinen et al. 2011). John M. Carroll provides a slightly different understanding of design. He also begins with a problem, or "current state of affairs" to be changed through design (Carroll 2000). The relationship between design and problem solving, may stem from Herbert Simon's definition of design. Simon describes design broadly as "courses of action aimed at changing existing situations into preferred ones" (Simon 1996). As with Carroll, the existing situation is the problem, and preferred situations are the results of action, that is, the implementation of designs. Design is about understanding future states as alternatives to existing states, where the solution to the problem is unknown at the outset (Carroll 2000).

Some argue that design is overrun with normative, capitalist values. "Design became fully integrated into the neoliberal model of capitalism that emerged during the 1980s, and all other possibilities for design were soon viewed as economically unviable and therefore irrelevant" (Dunne and Raby 2013). Implicit to this argument is an escalation, or acceleration, of capitalism during the late twentieth century, that according to Dunne and Raby has subsumed mainstream design practice. Speculative design, and its surrounding practices, are seen as attempts to stem the

tide of market-driven logics about what design is and what it can do. This argument is not just a pushback on design practices, and their neoliberal entwining, but perhaps on mainstream life in general. Dunne and Raby write, "it strives to keep alive other possibilities by providing a counterpoint to the world around us and encouraging us to see that everyday life could be different" (Dunne and Raby 2013, 45). Auger also argues that speculative practices allow us to delineate trajectories of existing technologies, and see where they might lead, providing "a system for analyzing, critiquing and rethinking contemporary technology" (Auger 2013). Speculative design provokes our thinking of what is and what could be, and tends to leave us with unsettling prospects. "Practitioners of speculative design engage in design as a sort of provocation, one that asks uncomfortable questions about the long-term implications of technology" (Lukens and DiSalvo 2012). This is not just a response to design's complicity in capitalism, in my opinion (though this is a critical point), but instead a rich theoretical shift from the problem to the problematic.

We can think of the problematic as the shifting connections between constituting relations that form a particular context; this might be a new form of technology, the impact of climate change, the implications of an aging population, or other emergent, complex shifts in life. Here, problematic means "ways of establishing new connections between bodies, institutions, and ideas" (Mitchell 2010). Speculative design explores potential outcomes, implications, and scenarios caught up within (typically) technical networks that may imbricate potential users and populations. It often uses contemporary science and technologies as a jumping off point in a consideration of what is possible (Malpass 2017; Auger 2013). These connections are not stable, but in constant shift. Speculative design is a method of envisioning problematic contexts. It offers a means of raising complex issues through design artifacts and scenarios of use and production. Designs resulting from speculation comment on socio-technical practices and infrastructures that are not yet of this world, but could be. More importantly, the problematics of speculative designs shed light on specific aspects of society and technology through a designed artifact in situ. This offers a framing not just of the artifact, but of its situated environment, and the values behind the creation and use of such a product.

One of the main differences in the shift of emphasis from problem to problematic is a de-emphasis on the solution. Problematics are a knotted, complex emergent set of relations; they do not lend themselves to solving, for they often elicit multiple problems at various scales. Solution is not the point. Speculative design is a discursive practice; it raises issues of concern, issues worth thinking about. In raising such issues, speculative design helps us think differently about our contemporary condition. "Since facts seem to end debates, and design seems to open them up, our greatest chance for critical intervention arise in our engagement of shared concerns—even if that means we cannot solve a problem" (Galloway, quoted in Malpass 2017, 131). It is a means of exploring not the just future, but also the present, and perhaps how we got here.

There are a number of approaches to raising concern through design, but speculative designers often use satire, irony, and humor to inflect their designs. At its best, these approaches help increase audience engagement, but may also lend themselves

to scorn or shame. Satire in speculative design is one of the means of offering a new means of perception of the problematic context "through methods of exaggeration or understatement" (Malpass 2017, 114). Humorous exaggeration helps emphasize Auger's point on the distance between "here and now," and Dunne and Raby's emphasis on imagining the everyday differently. Speculative design often places the designed artifact within a context, or environment to highlight underlying values embedded in technology. This may not be fully narrative as one finds in similar approaches, such as design fiction. Speculative design explores the context, not necessarily creating full diegetic detail.

Thus, speculative design provokes discussion about the intersection of technology and society. Rather than point out specific problems, speculative design focuses on the problematic—the material and social relations that give rise to new designs. Often, but not always, it is future-oriented, considering emergent conditions and technologies. However, designers may also choose to question latent values and logics in existing practices and infrastructures. The provocations of speculative design foster a more sophisticated understanding of the stakes of particular technical objects, raising critical awareness of affordances—what material capacities new technologies have and create—and values that form problematics. Speculative design is a rich, diverse, theoretical tool for exploring the environments of how things come to be in the world. Or, at the very least, how things come to be designed in the world. In this way, we can consider speculative design as a means of material speculation. It is an exploration of future potentials through our present conditions. Gilbert Simondon, a philosopher of technology and individuation, or how things come to be, provides a number of philosophical concepts that can help deepen our appreciation and understanding for this form of discursive design.

Simondon, writing in the mid-twentieth century, helps understand how environments and individual entities are related. He extends this thinking to technology and invention, which he describes as "a case of the future conditioning the present" (Simondon 2017, 60). Such an understanding of technical activity can also be applied to speculative design. His philosophy can help highlight the theoretical strengths of speculative design, that is the relations between technology and culture that are constantly evolving. Here I wish to briefly explore his concepts and their relation to speculative design, to which I will then return my attention.

9.2 Technical Individuation and Futural Functions

Much of Gilbert Simondon's writing has yet to be published in English. Yet, his influence can be felt in the works of contemporary theory and philosophy (such as Gilles Deleuze, Bernard Stiegler, Brian Massumi, Erin Manning, to name a few). I want to frame the following brief explanation of some of Simondon's concepts through one of his primary concerns, the separation of culture and technology. In the opening prospectus of one of his major works, *On the Mode of Existence of Technical Objects*, Gilbert Simondon identifies a "gap" between culture and

technology, one which he sees critical to reduce. Culture lacks an understanding of how technologies function, he argues, with a focus only on the use of technologies. The emphasis of use over function, that is, how technologies physically interact with the world around them, is one of his ongoing lamentations. In a posthumously published essay he refers to the need to develop a "technical mentality" (Simondon 2009). Arne de Boever claims that this can this notion "can arguably be used to sum up the contributions of Simondon's entire oeuvre" (de Vries et al. 2014, n.p.). There is an ethical component to his emphasis on technical mentality, for not understanding the ways in which technology changes the world is dangerous. Technology is a both a mediation between humans and the natural world, as well as an organizing force of humanity itself (Simondon 2017). I see this aligned with speculative design practices.

Simondon offers us a philosophy attuned to processes. He eschews a consideration of the individual (person, object, or thing) in favor of underlying processes which produce such an individual, which he calls *individuation*. He stresses that we must understand the world through individuation, rather than by studying specific individuals to understand retroactively how they came to be. This, he argues, is too late and misses the mark. For Simondon, individuation is ongoing; we are in a constant state of becoming, as individuals, cultures, societies, as are our surrounding technologies, organisms, the planet, and the universe. Creating new technologies is an important way of thinking, but also an important catalyst to real change in the world. Brian Massumi, writing about Simondon, says, "There is an individuation of thought, he said, by the same token by which there is an individuation of matter, on the physical plane and from there on to the plane of life, and following—or prolonging—the same constitutive principles. He recognized technological innovation as a key theater of thought materializing in matter becoming, in ways imbricated with life transformations" (Massumi 2009, 37). Transformation is key to Simondon's philosophy.

Simondon argues that the world operates through *metastable* conditions. Metastability is a physics term that describes a precariously stable state where slight disturbances create new states of existence. Water cooled to a temperature below freezing, yet still in liquid form, is metastable. The slightest disturbance, such as a speck of dust, sets off a chain reaction of rapidly forming ice crystals (Combes 2013). Crystallization is Simondon's paradigmatic example of metastability and resulting individuation. Individuation, he argues, begins with difference, or disparity (Simondon 1992). Individuations are resolutions of these tensions and potential energies (disparities) already existing within systems, be they social, physical, technical, and so on. Simondon refers to the process of transformation of liquid to crystal as *transduction*. Transduction can be considered a restructuring of energy (or information) from one form or another, and a process that works across all domains (physical, mental, social, technological). Transductive processes undergird individuation in Simondon's philosophy (Simondon 1992).

He describes transduction as a process "in which an activity gradually sets itself in motion, propagating within a given area, through a structuration of the different zones of the area over which it operates" (Simondon 1992). This restructuring

produces new, or different, results. Transductive results do not "pre-exist" in the systems from which they emerge (Simondon 1992).

Specificity of relations is key to Simondon's philosophy. While he claims a certain universality within his concepts of individuation and transduction, he stresses the importance of understanding the actual relations of any individuation. This is clear from his description of crystallization: "It is the organization of energy in a metastable system that leads to crystallization and subtends it, but the form of the crystals expresses certain molecular or atomic characteristics of the constituent chemical types" (Simondon 1992, 303). In other words, individuals do not just appear in the world, they are results of specific environments, or milieus (Simondon 1992). He claims that individuals and their milieus are linked together as dyads; they are co-emergent in the world. Environments change as new individuals emerge in them, and individuals change with their environments. This recursive relationship of co-emergence is governed by transductive processes, that is resolutions of tension that bring into the world new states of being. Simondon identifies technology as a form of mediation between humans and the world; it is a constant disturbance, bringing about new tensions and potentials in the world. As these tensions resolve, new individuals emerge into the world, forming new relations, possibilities, and new tensions. Here, we can see a connection to speculative design as well. Speculative design imagines not just new technical objects, but the underlying conditions of its invention, and the new tensions and potentials these objects produce in their environments.

Technologies that exist within specific milieus are 'technical individuals', according to Simondon, and they are not just tools, such as a hammer or a needle, but technologies dependent on a specific environment to function. He argues that they only come to be through the act of invention, which is a specific human endeavor. Invention is a highly creative act for Simondon, for it requires an understanding not just of the technical components of the individual, but an understanding of conditions and factors of its milieu, and how they will affect one another.

> Only a thought that is capable of foresight and creative imagination can accomplish such a reverse conditioning in time: the elements that will materially constitute the technical object and which are separate from each other, without an associated milieu prior to the constitution of the technical object, must be organized in relation to teach other according to the circular causality that will exist once the object will have been constituted; thus what is at stake here is a conditioning of the present by the future, by that which is not yet. Such a futural function is only rarely the work of chance; it requires putting into play a capacity to organize the elements according to certain requirements which act as an ensemble, as a directive value, and play the role of symbols representing the future ensemble that does not yet exist (Simondon 2017, 60).

It is easy to read this quote and apply it to all forms of design. Design is a creative, imaginative field that anticipates its use and context; design seeks to make products that fit its environment. However, I believe that speculative design takes one important step further, and it hinges upon Simondon's primary concern of the gap between technology and culture, that is technical mentality. Speculative design uses the tools of design to make clearer the connections between the technical

objects and the societal context, or milieu, to which it belongs. It focuses on the potential transductive qualities of design to create new milieus. The "futural" functions of speculative design are not only attuned to the technical, but also to social milieus—the collective of society. Speculative design builds on the operations of technologies, their use and modes of production to also consider futural and alternative milieus of specific concern. In other words, speculative design is concerned with the intersections of technology and culture and especially attuned to critical awareness of the resulting tensions and potential effects of new technical objects. Speculative design is indicative of a transductive form of thinking, it is the creative attempt to understand affects and effects of new technological milieus. "In the area of knowledge, [transduction] maps out the actual course that invention follows, which is neither inductive nor deductive but rather transductive, meaning that it corresponds to a discovery of the dimensions according to which a problematic can be defined" (Simondon 1992, 313).

In sum, Simondon's philosophy provides an undergirding to speculative design. He helps us recognize the tranformative potential of technologies within specific contexts, the problematic. The knowledge speculative design produces, comes through the design artifacts and the means by which they interrogate their problematic. The reticularity of the technical object and its milieu as presented by speculative designers is the critique; it is this relationship that raises critical insight. At this point, examples may be particularly useful.

9.3 Examples

Speculative design is a divergent practice. The following examples were chosen in part to highlight the different approaches in form and area of interest. The designers below use videos, scenarios, and prototypes of varying fidelity to consider new technologies, alternate means of production, and showcase different scenarios of use and impacts upon society. Some contexts are far-fetched, or near term, others are only theoretical in their proposal and minimize scenarios of use. From a Simondonian perspective, these are not general worries, but specific problematics. They explore not just a technical individual, but its associated milieu and imaginatively engage with transductive potentials to spur discourse among society. They help the audience understand potential technical functions, functions that may only be possible within certain milieus.

9.3.1 The Red String of Fate

Sputniko! is an artist/designer who speculates about possible technological outcomes, prototyping provocative works and then disseminating her work through pop music videos. Her work, *Red String of Fate – Tamaki's Crush* (2016) examines

biotechnology through an East Asian myth of the same name. The work consists of both a music video and a bioengineered "oxytocin-induced red silk" (Sputniko!). In the myth, a red string from the gods ties destined lovers together. Her music video tells the story of a young female scientist in love with another male scientist, incidentally played by Sputniko!, problematizing heterosexual norms while also emphasizing other stereotypes. The young woman, Tamaki, genetically engineers her own red silk by "inserting genes that produce oxytocin, a social-bonding 'love' hormone, and the genes of a red-glowing coral into silkworm eggs" [ibid]. The highly stylized video offers rich layers of social commentary, including gender roles, Japanese popular culture, the ethics and science of biotechnology. This is a deft example of the problematic: technology, culture, and societal norms are woven around the myth and potential of biotechnical engineering. Though the emphasis may be on the technical possibility of biotechnology, it is important to note that it is the surrounding relations that provides a rich problematic to her work. The social tropes of nerdy girl falling in love with a dream man (portrayed by a woman) is both commentary on heterosexual norms, as well as the role of pop culture in amplifying and/or subverting those norms, and the cultural baggage attached to engineering biology. Such baggage colors our perception of the ethics of tinkering with nature.

One of the most important aspects of this project is that the red silk featured in the story is actually created, or prototyped, in a collaboration with scientists from the National Institute of Agricultural Sciences (NIAS) in Japan. Thus, Sputniko! actualizes the central premise of her story by genetically engineering red silk embedded with oxytocin. This makes her scenario all the more plausible, pushing the speculative nature of her project past the realm of potentiality and into the universe of actualities. This string exists. Here, practices of inventing new biotechnical forms intertwine with existing sociopolitical milieus, from cultural myths to nonbinary understanding of binary and cultural tropes of "nerds."

In the music video, we see the story of Tamaki who engineers her own red string of fate to tie her to Sachihiko, her crush. The video offers subtitles that help tell the story. Tamaki asks, "Who decides what is forbidden?" She asks if she can create her own string of fate. In the video, Tamaki explains her approach, injecting red fluorescent protein and oxytocin into silk. The video concludes with success and failure. Tamaki's red string of fate works too well, turning all passers-by into red-glowing eyed zombies chasing her chasing Sachihiko. Though satirical and absurd, the music video quickly brings forth the hope and peril of genetic engineering, while making the technology more understandable to a lay audience. Through absurdity Sputniko! explores the side-effects and unintended consequences of biotechnology, while all the while grounded through the engineering of novel materials. Sputniko!'s work uniquely speculates and produces the very matter which sparks dark speculations about our future.

Dark though it may be, the work is also buoyed through an upbeat J-pop soundtrack and stylized music video, plunging the video into the everyday. Like many of her projects, the video is highly aestheticized across multiple layers through high-level production values. It is subtle in its nature, while simultaneously being over the top and ridiculous. It is an exemplar of the use of satire and absurdism to

question everyday practices of science. As mentioned, satire, irony, and absurdism are common strategies of critical and speculative design (Malpass 2017). Here, they provide an entry into the critique of emergent scientific practices.

Sputniko!'s work humanizes potentially mad science by placing it within very human relationships of unrequited love, which is a well-known trope of popular culture. Sputniko! depicts a confluence of relations between individual bodies, institutions, and technologies to explore the problematic of engineering new biological materials, through popular culture - pop music, video culture, nerdy stereotypes, and zombies. We, the audience, are asked to consider what the side effects of this work are, while also bringing forth a bioengineered red fluorescing string imbued with oxytocin. To invoke Simondon, the scenario deftly illustrates the potential for a milieu to shift rapidly due to technical individuation. One can draw an easy parallel between the hordes of love-struck zombies, with the hype, and fear, of genetic modification. Our milieu is already transformed by the technology. The project nicely brings forth the fictitious with the actual, acutely provoking the audience to consider the possibilities of a bioengineered world. *The Red String of Fate* deftly explores technical invention in a cultural context, bringing forth technical knowledge and ethical questions related to it. The whole scenario is structured through a stylized approach that is unique to speculative design, but redolent of Simondon's philosophical project.

9.3.2 Happy Life

In *Happy Life* (2010) designers James Auger and Jimmy Loizeau (Auger and Loizeau N.D.), in collaboration with scientists Reyer Zwiggelaar and Bashar Al-Rjoub, explore the implication of real-time emotional monitoring of family members. Building off of existing research, the project imagines real-time profiling techniques in the context of the family home. Computer scientists Zwiggelaar and Al-Rjoub are currently investigating thermal cameras as a means to detect emotional fluctuations of humans for security monitoring at border crossings, airports, secure entries, etc. Auger imagines this kind of "non-invasive" observation in a new site: the family home (Auger and Loizeau).

The project builds on the increasing efforts of technological surveillance meant to deter or dissuade terrorist attacks, imagining it as a domestic object that reveals the emotional health of family members. The prototype consists of round dials, lit by colored LEDs (one for each family member), that provide a relative readout based on thermal imaging. In addition to the physical prototype, Auger and Loizeau create storyboard vignettes to contextualize the moments when family members may encounter emotional shifts of their loved ones. Parents leaving on trips; the reminder of the untimely death of a child or loved one; a normal night of domestic life of children and parents.

A thermal camera is used in conjunction with algorithms to manipulate the dials on the display, which visualizes physiological changes that suggest emotional shifts.

"We built a visual display linked to the thermal image camera. The system employs facial recognition software to differentiate between family members. Each personal dial has two pointers; one showing the current state taken from the most recent thermal image capture and one showing the predicted state where the system would expect the dial to be based on the processing of accumulated statistical data" [ibid]. Auger states it would have been more accessible to a lay audience had the project used dials to indicate happy and sad, but also factually incorrect. This is true both for the technology and human emotion, as we are more complexly emotional than simply happy or sad. This complexity is highlighted though the vignette depicting the passing of the family member, where the algorithm predicts a surge in family sadness near the anniversary of the death. In the caption, the narrator describes this prediction as "strangely comforting" (Auger and Loizeau). Here, the project sits neatly within the problematic, illustrating the complexity of the proposed design. They write, "The Happy Life proposal was designed to sit somewhere between the dystopian worlds of Ballard and Bradbury and the utopian corporate smart home, acknowledging the complexity of domestic human interactions whilst employing near-future informatics technology" (Auger-Loizeau).

Much like Sputniko!, Auger and Loizeau are working with the threads of possibility. The prototype helps think through the speculative nature of the project. Noting that 'happy' and 'sad' while easy, are not accurate means of conveying emotional valence, they are forced to come up with a realistic design that conveys the complexity of human emotion and the technology at hand. This is not simply fantasizing about technology, but following the problematic of emergent science and placing it within a domesticated situation.

Shifting surveillance milieus from security contexts (airports, borders, etc.) to pervasive surveillance contexts of quotidian intimacy immediately brings the ethics of surveilling technologies into sharp relief. It also follows a Simondonian interest in function over use; the technology affords monitoring regardless of its use-case. At once the project is uncomfortable, yet the domestic scenarios - especially that of a lost child or family member (the scenario is cleverly ambiguous) - are also touching. It brings together the thick problematic of technological monitoring in an unsettling way. It also raises the specter of profiling and prediction. What does it mean if the system knows what your emotions will be? What if we cannot hide our emotions when the flushing of skin and other embodied tics tip off an omnipresent thermal system?

As a design object, *Happy Life* exudes contemporary technological aesthetics. A sleek, silver and glass panel with four dials each lit by its own colored light channel the aesthetics of contemporary smartphones and Stanley Kubrick's *2001 a Space Odyssey.* A glowing orb of light assigned to each person slickly displays the emotional trajectory. This appealing, yet somewhat cold presentation, emphasizes the discomfort of being under surveillance in the home. Auger and Loizeau help us understand the milieu as problematic. Family affect is not a problem to be solved, but speculating about these technologies in the home raise important ethical questions, not simply through their presence, but by tracing out their *functions.* Simondon's emphasis on function over use and the ways in which milieus are

affected by new individuations are helpful for recognizing the rich problematic these designers provide us. It also helps us understand why this is an exemplary form of speculative design.

9.3.3 Uninvited Guests

Design studio Superflux imagines the intersection of aging populations, healthcare, and smart objects in their project, *Uninvited Guests*. Their work culminates in a short film in which 70-year old Thomas is surrounded by smart objects (bed, fork, cane, medicine bottles, etc.) that track his activities for his concerned, but absent, children. His smart fork informs him that he has exceeded his recommended daily fat and salt intake during his breakfast. The bed tells him it is time for bed, and reminds him to return to bed as rises to read in the middle of the night. The smart cane encourages him to walk, interfering with reading and watching television. The smart objects also share the data with his children, who send texts encouraging Thomas to go for walks and to get to bed early. The video sets us up to sympathize with him, superimposing texts from children and devices on the video. Anyone with a smartphone can understand this scenario.

These interruptions clearly detract from the way that Thomas wants to live, and he finds clever hacks to keep the nagging, both from the objects and his children, at bay. He eats his fried dinner with a regular fork, pausing to dig around fresh vegetables with his smart fork, and receives accolades. He sends his smart cane off with a neighboring teen for quick jaunt down the street in exchange for a can of Red Stripe beer. Thomas diligently prepares for bed at 22:00 h by piling his stack of books on the bed so that he may return to reading in front of the television.

Superflux set out to research the emergent relationships between humans and autonomous smart objects, the impact upon human agency, and the resultant shifts of rhythms and daily rituals (Superflux). They write, “Situated behind this, is the bigger, more political issue around the future of healthcare and the growing argument to replace human care givers with robots and connected, networked, smart devices. Whilst there are undeniable benefits to monitoring and tracking the elderly in their homes, we wanted to pause and reflect on some of the more complex human behaviours we are likely to encounter along the way. What are the messy, whimsical, unintended human behaviours that might collide with the one-size-fits-all ‘care’ that many smart devices are designed to deliver”(Superflux, n.p.)?

The scenario is almost too real for it to feel speculative, yet this most dystopian future is not quite here. Superflux does an excellent job of raising the friction between the immanent internet-of-things and the reality of how we wish to live. From a Simondonian perspective, their work shows how the milieu and individual transform in response to new individuals. The impact of seemingly helpful devices spark a cascade of comedic work arounds to maintain something of ‘normal’ existence. The project captures what Malpass describes as the “future mundane” eloquently (Malpass 2017, 101).

Perhaps differently than other speculative works, the devices featured in the short video are bright neon green 3D printed objects. They are less functional than other prototypes, but their quotidian nature and the notifications we see—and hear, as each notification is accompanied by a chime or a chirp meant to be innocuous or charming, but ultimately fiendishly annoying—provides a well understood scenario of use. Superflux claims that the simple nature of the objects allow us to project any smart object upon them, they are "symbolic 'ghosts of the future' where with time, their physical presence fades into the fabric of our environment, and all that is left is their invisible halo constantly monitoring, logging, tracking and processing ambient feedback" (Superflux, n.p.). Superflux raises important questions of an emergent world mediated by smart objects, and like Auger and Loizeau injects our intimate home life with a dystopic sense of surveillance.

9.3.4 Crafted Logic

Irene Posch and Ebru Kurbak explore alternative histories of computing in their project, *Crafted Logic*. Posch and Kurbak handcraft logic gates into textiles, via crocheting and needlepoint. They pose the questions, "What if digital electronics emerged from textile handcrafts? How would technology be different if craftspeople were the catalyst to the electronics industry, via textiles manufacturing?" (Posch and Kurbak 2016: 3882). These questions are posed materially, through the construction of working crafted objects. Here, speculation, the questions of how things might be different, are not focused on the future but on the past, in the present.

The work of *Crafted Logic* hinges on a functional prototype. Posch and Kurbak use conductive thread to create functional logic gates, "the building blocks of digital electronics" in textiles (Posch and Kurbak 2016). Their interactive work questions the underlying aesthetics and processes of contemporary consumer electronics. Further, there is an implicit feminist critique in utilizing crafts traditionally associated with women (needlework), that questions the male dominated tech industry. This is a call to rethink not just how technology is made, but the implicit values tied into contemporary technologies, and who is involved in the construction of a technical culture. What are the implications of a craft-centric approach, rather than a code-centric approach to technology?

Craft is time consuming, bespoke, and requires specific skillsets call into question mass produced gadgets. Craft occupies a specific space that constitutes a set of cultural associations with it that we do not associate with contemporary technology. One's iPhone is not considered a crafted object, though it is a designed object. The connections and distinctions between needlepoint and an iPhone are the context of this work. *Crafted Logic* poses a logic that is alternative to today's mass-produced objects speculating how technology could be different.

In one example of *Crafted Logic,* three red hexagonal shapes are crocheted together in a symmetrical layout, with two hexagons placed on the lower right and left of a central hexagon. The outer hexagons are lower than the central hexagon, creating an alternating pattern of low, high, low. The crocheted strip is mounted on a whiteboard with three switches at the bottom of the board. At the center of each hexagon is a small, round magnet with silver conductive thread crocheted above and below it. A silver 'wing' moves between an up and down (1 or 0) position, connecting to the upper or lower silver patches. Switches at the bottom of the board send electricity through the conductive thread to move the wings between the respective positions of 0 or 1. The crocheted work offer two inputs, A (left hexagon) and B (central hexagon), and the third switch on the right is an output (right hexagon). Switching between "1" and "0" in different configurations of the A and B switches provide different outputs of "1" or "0." As such, Posch and Kurbak offer a crafted computer switch, basic though it may be. Its aesthetics of soft thread, patterned and textured through crocheting challenge the aesthetics of contemporary technologies. The work asks us to reconsider the design of our technologically-dependent world.

The bespoke quality of *Crafted Logic* questions not just the aesthetics of technology, and of mass produced items, but also the underlying logic and practices by which technology is created, reproduced, and disseminated in the world. Replacing the sleek, smooth designs of contemporary electronics are interactive, relay doilies. Computer fundamentals are depicted in a craft associated with matronly grandmothers, rather than an army of male coders armed with laptops covered in stickers from the most recent hackathon. This shows alternate paths of what is possible, highlighting different trajectories of creative computation. It also subtly raises critical awareness of our existing milieu.

As mentioned, the work highlights craftwork generally associated with women. At a time of considerable critique of the technology industry's general lack of diversity, this implicit critique is poignant and needed. How would HCI and the technology be different if our designers were more diverse? How can such projects help us remember the vital role women have played in the history of computing? Could craft draw more women into design and engineering roles? How does the notion of craft change our relationship to computing? *Crafted Logic* provides a lens through which to consider our current socio-technical milieu, offering an alternate approach as both example and critique.

One of the great strengths of this speculative project is its lack of answers. *Crafted Logic* provokes a great number of questions through its physical presence. It poses a deeply entwined problematic, pulling together questions of aesthetics and production through an implicit feminist lens, but does not provide a simple answer or way out. If speculative design is meant to provoke thought, *Crafted Logic* succeeds by bringing forth a rich problematic of our contemporary, technical condition.

9.3.5 Parasitic Products

Studio PSK, led by Patrick Stevenson-Keating, imagines an "alternative route for product design, where competition, and product interdependence shape the design of the objects in our environment" (StuidoPSK). This statement is understated in its profound reimagining of technical innovation and invention, creating an "alternate paradigm" to both contemporary and historical practices. Three "specimen" prototypes (A, B, and C) modeled on parasitic organisms offer new perspectives on product design. Patrick Stevenson-Keating, head of the studio, says that he was inspired to work with radios, because as a new technology it too was somewhat parasitic. The parasitic radios are traced back to the early twentieth century products. Designers seeking to find the right form factor placed radios in armchairs, side tables, and cabinets. StudioPSK writes, "As more objects become connected to the internet, and one another, it is plausible to imagine devices which pervert and exploit systems and objects to their own advantage. Parasitism has been a practice exhibited for millions of years. What effect would parasitic devices have on a product ecology" (StudioPSK)? StudioPSK worked with parasitologists and entomologists to understand parasitic behavior and organisms more thoroughly, deciding on their three model organisms, hookworms, Knopper gall wasps, and Ichneumon wasps.

Specimen A is modeled on hookworms. It is a radio that plugs into a landline telephone, thereby engaging the landline and powering *Specimen A*. When powered, this parasitic radio emits a signal that blocks Wi-Fi within a ten-meter radius (http://www.studiopsk.com/parasiticproducts.html). The activity is correlated to the hookworm's ability to produce chemicals that mask its presence from its host.

Specimen B is modeled on The Knopper Gall Wasp, whose parasitic actions are of a chemical nature. "By injecting a cocktail of chemicals and genetic information into a budding acorn, it causes a change at the genetic level in the plant, causing it to grow into a hard, horned structure providing food and safety for the wasp larvae" (StudioPSK). *Specimen B* is made to push into a cardboard carton of juice or milk; "the radio pierces two metal electrodes into a carton of milk or juice, and injects a small amount of salt" (StudioPSK). When zinc and copper are introduced to an acidic solution they produce electricity, the salt helps speed the chemical reaction of juice or milk, allowing the metal electrodes to eventually produce energy, which charges a battery. StudioPSK does not state whether this radio receives, transmits, or both. The charging battery seems to be the main goal.

Specimen C is modeled on Ichneumon Wasps, which StudioPSK claims are so prevalent they can be found "parasitising [sic] other parasites" (StudioPSK). Fittingly, this parasitic radio is made to feed off the battery of an iPhone, which often feeds off of a laptop, distributes code and software through other devices and the internet, and "it has changed the behaviour [sic] of its users" (StudioPSK).

The three prototypes are nondescript. Each are black, and fairly small—just a few inches long. The shapes are simple, a cylinder, a rectangle, and a slightly tapered cylindrical shape with a flat cutout just the right size to slide an iPhone into it on one side. Each prototype has a metal antenna topped with round, black ball on top pro-

truding from one end. The shared visual forms signal a shared belonging, but also seem easy to overlook, just as might be expected from a successful parasite.

Along with the three parasitic prototypes, the studio created an alternate timeline of production and a video explaining each of the products. The timeline depicts the parasites as direct descendants from radio cabinets and "'easy chair' radio" (StudioPSK). This is a line that parallels the history of radio production, highlighting it as an imagined alternative, quietly evolving, hidden in plain sight. The video features a parasitologist and an entomologist with whom Stevenson-Keating worked with to better understand parasite behavior when researching the project.

Here we find an elegant interpretation of milieus and technological development, mimicking biological relationships. It sparks immediate insight into our own fetishized relationship with technology, but also follows a Simondonian attention to function over use. The human user here is absent, these are purely functional technologies. By this I mean there is no imagined use, other than to suck power from another existing technology. The speculation of these technologies is one about production, the underlying motivation and rationale of creating such a product. Much like *Crafted Logic*, *Parasitic Products* question the underlying epistemologies of how things are made, and why. They also cast a wider eye to technology and the world, drawing upon evolutionary strands from insects to consider technological affordances. This broader milieu of the natural world and the technical world decenters humanity by eschewing use scenarios, but it also clearly critiques consumerism and capitalist modes of production. There is a subtle jab to our current relationships to technology; radios, telephones, and mobile phones modulate and mediate our human relationships, both intimate and at large scales. *Parasitic Products* provides an orthogonal view of a contemporary problematic, our own parasitic relationships to communicative technologies, radio, phones, and the internet.

9.4 Prototyping Problematic Provocations

Speculative design allows designers the opportunity to use their skills and tools to explore a problematic, or a dense set of contextual relations and their potential results. The results are designed objects, scenarios, and provocations that help us realize the affects and effects of these relations. While mainstream design often seeks to understand and solve problems in the present or near future, speculative design reframes our understanding through the problematic. It encourages a deeper consideration of how individuals and milieus (subjects, objects, and their environments) come to be. Importantly, this is speculation through design, and thus all speculative design can be assumed to comment on design's implicit and explicit role in producing new technical objects, users, and milieus. It is a value-laden activity that speculative design critically examines. Auger-Loizeau, Superflux and Sputniko! explore the potential impacts of new technologies. These designers take different approaches, one heavily mediated through satire and genre-specific approaches (the

music video, and video prototype), another explores the unsettling invasion of privacy in an intimate family setting. These works emphasize the complexity of the issue at the heart of the problematic, in these cases bioengineering, "smart" devices, and surveillance technologies. This complexity requires consideration of prevailing attitudes, scenarios of use, emergent technologies and trends, and the social and cultural structures that enable, or not, such technology. These works do not settle our understanding of the technology, but just the opposite. They unsettle our understanding of the technology and their imbricating milieus in which they emerge.

Posch and Kurbak, and StudioPSK offer us a different approach, but one that is no less unsettling. By rethinking digital computation and contemporary manufacturing processes through analog craft, or parasitic insects, they unsettle our expectations and assumptions of what already exists. Their work offers an opportunity to reconsider what we take for granted in technology. What logics shape our current condition, and what does thinking about different forms of production afford us? How do the notions of craft and parasitism help us evaluate our technically mediated world? These examples offer an existing problematic - contemporary techno-culture and design practice - for us to contemplate.

One thing that binds these disparate examples together is a focus on the prototype. Prototyping is an essential design skill, and through these projects we see various prototyping forms (lab work, scenarios, functional prototyping, etc.) that flesh out the projects in meaningful ways. They help us, the audience, gain a better sense of the project, and the problematic as envisioned by the designer. The social and technical systems are bound together through the prototype in all its unsettling ways. Speculative design helps us think through the potential of design to change and shape our world and to help the audience feel, to some level, the implications of the problem at hand. From a Simondonian perspective, these designs explore not just the technical object, but the associated milieu of the project. For Simondon, milieus and individuals are bound together, just as the proposed designs, and their underlying contexts. One of the strengths of speculative design is to help the audience understand the reverberations of technologies within their milieus; it offers a deeper understanding of how designed objects change the world.

Prototyping is a form of thinking through making. Speculative design and its surrounding practices do not differ from the mainstream design here—all designers prototype in one form or another—but they emphasize critique. Critique through prototyping is a specific form of thinking, predicated on materials and affordances. Designs "give material expression to the insights generated" (Dunne and Raby 2013). Again, this echoes Massumi's comment that Simondon, "recognized technological innovation as a key theater of thought materializing in matter becoming" (Massumi 2009). Prototyping is a critical step of such technological innovation. However, it is more than that. Prototyping reveals the individual-milieu dyad that forms the problematic.

"Importantly, we stress that this type of critical inquiry occurs through the conceptualizing and crafting of design artifacts to generate theoretical articulations and intellectual argumentation" (Wakkary et al. 2015). Prototyping is theorizing. As designers entwine their area of concern, their problematic, and their material design

ideas, this prompts new experiences and insights. Transduction, is a form of structuring thought and material; within speculative design there is a restructuring of socio-political order through a design object, or at least a proposal of such restructuring. This is critical, for speculative design challenges our everyday through its alternatives, both emergent futures (surveillance, biotechnology) and existing values that shape and temper technical culture (craft, parasitism).

Prototyping becomes a way of highlighting certain potential outcomes. Thus, rather than offering a solution, speculative design may instead highlight "unintended consequences" of the speculative prototype (Lukens and DiSalvo 2012, 26). Speculative design draws out the connective strands that form a problematic—the bodies, technologies, and social forces that produce a set of contingent issues—and provides a focal point of this problematic through the design artifact, or prototype. Working in this way strengthens not just our design savvy, but our understanding of technology. Lukens and DiSalvo argue that this kind of thinking enhances our ability to consider ethical, environmental, and social implications of technology, what they call "technical fluency." (Lukens and DiSalvo 2012). This clearly aligns with Simondon's technical mentality, and adds a specificity to his arguably murky goal of reducing the gap between technology and culture.

9.5 Conclusion

Speculative design is a discursive practice; it aims to raise complex issues of technical society for discussion and debate. It uses design language and process, such as prototyping and scenarios, to explore problematics of particular concern. Problematics bring together the constituting milieu, the bodies, institutions, social practices, etc., in ways that help elucidate what connects them. Speculative design takes a critical stance also found in other approaches, though it does so by providing problematics focused on the intersection of technology and the everyday; speculative design imagines possible milieus that may comprise our future mundane existence. The examples here offer two broad approaches, consideration of future technologies, and a consideration of the inherent logic and values of design and technical culture. In either approach, the problematic is not solved, but presented as an unsettling form; we are meant to be provoked to consideration. Considerations both of how we currently live, and how we will live in the future.

Gilbert Simondon can help us think perhaps more philosophically about this practice, with his emphasis on both the specificity of milieu and individual—the crystallization of specific technical forms in specific contexts. Use is not the most critical aspect of the speculative designs above, but affordances of control, the unintended consequences, and the values taken for granted within our world. How technology interacts with its milieu is a deeply specific problematic. The prototypes of speculative design offer moments of transductive thinking and insight, the technical objects impact their environment in specific ways, through specific operations.

The examples in this chapter show divergent approaches to speculating through design, and the (overly) brief introduction of Simondon's philosophy is but one lens

to think of this practice. In reality, speculative design must be a voracious practice, considering many different emergent and latent problematics in our world. It should also be an open practice, incorporating other speculative approaches, such as speculative philosophy, speculative fiction, and speculative art. There is a need for more speculative design. Benjamin Bratton points out that technology advances at a rate that exceeds our existing logics. Speculation is needed "…to search the space of actual possibility (even and especially beyond what any of us would conceive otherwise" (Bratton 2016). Thus, speculative design requires a more experimental and expressive approach to technology than designers may be accustomed to doing. Speculative design must come before affirmative or normative design, for we must expand our understanding of the possible, the problematics, before questions can be formed and subsequently solved. As Bonnie Nardi writes, "A challenge is to adjust design practice so that it more expansively encounters the future, lifting its gaze from the designed object to the complex realities of the world in which the object will be used" (Nardi 2015, 30).

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Chapter 10
Speculative Design in HCI: From Corporate Imaginations to Critical Orientations

Richmond Y. Wong and Vera Khovanskaya

Abstract In this chapter we analyze the rhetorical work of speculative design methods to advance third wave agendas in HCI. We contrast the history of speculative design that is often cited in HCI papers from the mid 2000s onward that frames speculative design as a critical methodological intervention in HCI linked to radical art practice and critical theory, with the history of how speculative design was introduced to HCI publications through corporate design research initiatives from the RED group at Xerox PARC. Our argument is that third wave, critically oriented, speculative design "works" in HCI because it is highly compatible with other forms of conventional corporate speculation (e.g. concept videos and scenario planning). This reading of speculative design re-centers the "criticality" from the method itself to its ability to advance agendas that challenge dominant practices in technology design. We will look at how practitioners trade on the rhetorical ambiguity of future oriented design practices to introduce these ideas in contexts where they may not otherwise have much purchase. Our chapter concludes with a call for critically oriented practitioners in this space to share their experiences navigating speculative design ambiguity and to document the disciplinary history of the method's development.

10.1 Introduction

Speculative design, along with related practices such as critical design and design fiction, have grown in prominence in HCI since the early 2000s. Initially developed as a practice for divining "new genres" of technology use, speculative design has come to describe critically oriented research practices that create artifacts,

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representations, or depictions of possible and often alternate futures, removed from immediate practical concerns of implementation and commercial viability. Speculative design in HCI takes on several forms ranging from design proposals to built artifacts, which are used to imagine alternate sociotechnical configurations of the world as a way to interrogate questions about values and politics through design.

During the first two decades of the 2000s, third wave lenses have spread in HCI more broadly, critically and reflexively interrogating the relationships between humans, institutions, and technologies; highlighting the ongoing (co)construction of knowledge, expression of values and politics in sociotechnical systems; and reflexively recognizing the situated positionality of researchers and designers. Speculative design provides one useful way to meet the methodological challenge presented by HCI's "critical turn" toward matters of concern beyond the conventional workplace, explicitly engaging with the values and politics entangled in situated activities.

While speculative design's lineage is generally tied to a series of critical practices from art practice, the humanities, and social sciences, our goal in this chapter is to situate—and in some cases, reconnect—speculative design as commonly discussed within HCI with a history of speculative design as a corporate project. We do this by highlighting a broader set of speculative, future-oriented, and imaginative practices that may not immediately strike the eye as critical or reflexive. By tracing these practices, we argue that the uptake of a critically-oriented speculative design in HCI is both a testament to the disciplinary blending that is third wave HCI, and we identify new opportunities for speculative design going forward.

Third wave HCI, as articulated by Harrison, Tatar, and Sengers, is distinguished by reframing "interaction": from seeing the human mind and computer as symmetric coupled information processors to be optimized; to viewing interactions as situated, meaning being constructed in the moment, and foregrounding values and politics (beyond those of efficiency). This was also coupled with the spread of computing beyond the workplace into home, leisure, and other spheres of life, and beyond the desktop into mobile, physical, and other devices. These shifts emphasize the roles of understanding context (Dourish 2004; Harrison et al. 2007). With these shifts in viewing "interaction" and shifts in computing practices, a range of new methods and epistemological stances were brought into HCI, including ethnography, practice-based research, critical theory, and other stances that reflexively recognize the role of the researcher in acting in the world and creating knowledge, and view systems as sociotechnical, situated within particular contexts. Speculative design provides one way to investigate and address third wave concerns.

In this chapter, we first briefly discuss speculative design's growth in HCI by tracing trajectories of critical practices from art, the humanities, and social sciences. Because it is commonly defined against design that addresses practical and immediate concerns, speculative design is generally seen as outside of commercial interests. However, looking to the history of speculative design's uptake in HCI, we also situate speculative design within a trajectory of industry-situated technology practices. We discuss the role speculative design plays in corporate research and

development contexts and argue what while speculative design may seem like an impractical, "out there" and "critical" practice, the tactic actually leverages conventional forms from product development. This reading of speculative design recenters the "criticality" from the method itself to its ability to advance agendas that challenge dominant practices in technology design. We will look at how practitioners trade on the rhetorical ambiguity of product design to introduce these ideas in contexts where they may not otherwise have much purchase. Rather than viewing the emergence of critically-oriented speculative design in HCI as (directly) indicative of a third wave approach, third wave HCI instead provides a lens to understand the reorientation of existing future-oriented, speculative design-like practices toward a new set of explicitly social and political concerns.

10.2 Speculative Design As Critical Practice

There are several origin stories to Speculative Design's flourishing in HCI as a critical practice. Perhaps the most commonly told history traces Speculative Design through Tony Dunne and Fiona Raby, designers and researchers, who termed "critical design" in the late 1990s (Dunne 1999; Dunne and Raby 2001). In their original discussion of critical design, "critical" means a type of dialectic that uses the practice of design to lead to reflective discussion and debate on dominant cultural values; Dunne and Raby contrast critical design with "affirmative design", which supports the status quo or dominant worldviews (Dunne and Raby 2001). They predominantly discuss capitalism as a worldview they are critiquing and reflecting upon, noting that the type of design they are promoting would not be able to exist within the marketplace. Malpass discusses critical design through Dunne's concept of "post-optimal": a move away from using design for efficiency and optimization (Malpass 2016). Critical design works through an ambiguity of "para-functionality"—where design artifacts make use of design conventions to seemingly be able to function or be utilized as a normal product, while simultaneously seeming out of place, unusual, or unfamiliar, allowing "what was invisible and lost in the familiarity of the everyday" to be "made visible" (Malpass 2016).

While critical design artifacts use para-functionality to seem like everyday designed objects, Dunne and Raby write that critical design creates a space for these design practices to exist outside of commercial design processes, writing "Design proposals like these can really only exist outside the marketplace, as a form of 'conceptual design'—meaning not the conceptual stage of a design project, but a design proposal intended to challenge preconceptions about how electronics shape our lives" (Dunne and Raby 2001). Dunne and Raby suggest that this practice might be more amenable in academic settings, or would require structural and organizational changes in the design profession. Nevertheless, Dunne and Raby's practice of critical design is instigated by a critically-minded designer who creates an artifact that leads to discussion and debate among designers and the public.

In the early 2000s and 2010s, Dunne and Raby shifted their terminology from "critical design" to the term "Speculative Design," in part to frame their work as a generative practice, writing that their interest is "in using design to open up all sorts of possibilities that can be discussed, debated, and used to collectively define a preferable future for a given group of people" (Dunne and Raby 2013). Like critical design, Dunne and Raby discuss speculative design as a practice that uses design artifacts to open up and explore alternate possible and plausible futures as a way of generating discussion about what a preferable future might look like. They also discuss speculative design as a practice outside of commercial design processes, writing that "once designers step away from industrial production and the marketplace we enter the realm of the unreal, the fictional, or what we prefer to think of as conceptual design—design about ideas" (Dunne and Raby 2013). While others refer to these practices collectively as "speculative and critical design", in this chapter, we use the term "Speculative Design" to refer to both speculative and critical design.

In HCI, Speculative Design takes on several forms—including built artifacts, media experiences and artifacts, design proposals, and written design fictions—used to imagine alternate sociotechnical configurations of the world. To illustrate this range, we detail two examples of Speculative Design projects, one using a deployed conceptual design proposal and one using a built artifact. In 2014 at the annual CHI (Computer Human Interaction) conference, a series of signs appeared in restrooms describing a project called *Quantified Toilets*, a public infrastructure project to better understand the activities of people in buildings, in which data collected from toilets could provide information about a person's sex, blood alcohol content, drug use, and other medical information. This information was also publicly streamed through a data feed on a website (Dalton et al. 2014). The project by Dalton et al., did not actually collect users' data, but rather presented simulated data in an effort to provoke conversations about surveillance, public design, ethics, and consent. While this project emerged from a workshop on critical making (Tanenbaum et al. 2014), the artifacts created can be seen as examples of Speculative Design. It imagines a future world through a series of proposals—the signs placed in the restrooms and the website—in an effort to generate critical and reflective discussion. While this project imagines a future in which quantified toilets exist, its focus is not about *predicting* the future. That is, its goal is not to simulate a world with quantified toilets and ask "how accurate is this experience to a future in which quantified toilets exist?" Instead, its motivating questions are around "what values and politics are implicated in a design and deployment like *Quantified Toilets*?" or "What types of provocations and reflections can this design help generate?" Speculative Design, while often future-oriented, is not about predicting the future. Instead, Speculative Design serves to ask questions about the politics and values in sociotechnical configurations that we currently experience (or might want to experience in the future) by creating an imagined world configured differently than ours. It is speculative in that it re-imagines the world to be organized into different social, political, economic, and technological configurations, or what Auger terms "alternative presents" (Auger 2013). Furthermore, *Quantified Toilets* highlights new types of questions for HCI to ask and grapple with as computing moves out of the traditional workplace;

the actors and groups of people implicated goes beyond traditional categories of "worker" and "boss" and the goals of evaluating this system expand beyond "efficiency" or "worker-optimization." Instead, *Quantified Toilets* highlights questions related to the realms of civics and public health.

In another example, Devendrof's *Redeform* (or *Being the Machine*) is an alternative system for digital fabrication that gives a human the directions usually given to a 3D printer, allowing the human to interpret and execute the process of making using everyday materials (Devendorf and Ryokai 2015; Devendorf 2016). This system was built as a functional artifact that allows the human to engage in printing, consisting of an actuated laser pointer controlled by software that shows the human where to add new material. The built artifact is used to interrogate and critique a discourse that presents "making" as limited to specific (often male dominated) "maker spaces" and portrays "making" as a practice that highlights a one-way relationship between humans and materials (i.e. humans create fabrication instructions and upload them to a machine, which creates the object). *Redeform* reframes "making" as a practice that can happen in a multitude of situated environments, and highlights an alternative co-constructive relationship between humans and materials.

In HCI, researchers also trace Speculative Design through a range of other traditions from art and the humanities. While Dunne and Raby used the term "critical," they do not explicitly engage with critical theory as articulated by Adorno, Benjamin, and others in the Frankfurt School. Jeffrey and Shaowen Bardzell have written a series of articles connecting Speculative Design's insights that design can both perpetuate harmful ideologies and be a form of resistance to the history of critical theory, tracing critical theory from the philosophy of Marx and Nietzsche through the Frankfurt School to a broadening of critical theories in the 1950s and 1960s including semiotics, poststructuralism, feminism, and psychoanalysis (Bardzell et al. 2012; Bardzell and Bardzell 2013, 2015). Gaver and Martin used the term "speculative design" to discuss their practice of creating design workbooks, a set of conceptual design proposals that help open and explore a design space of possibilities (Gaver and Martin 2000). Pierce et al. link current Speculative Design practices to twentieth century avant-garde approaches including Dada, Situationism, and tactical media, and to activist design approaches (Pierce et al. 2015). DiSalvo et al. and Elsden et al. bring in connections to mid-twentieth century design and architecture groups Archigram and SuperStudio (DiSalvo et al. 2016; Elsden et al. 2017). Elsden et al. also discuss the Japanese art of chindogu, of creating humorous and nonsensical practical tools and everyday gadgets as a predecessor to Speculative Design (Elsden et al. 2017). HCI researchers have also cited histories of Speculative Design from fields beyond art and design, including urban planning's histories of imagining cities, the future of governments, and life in the public sphere (DiSalvo et al. 2016); In this volume, Fox expands the range of philosophical lenses applied to Speculative Design, using the philosophy of Gilbert Simondon. Others have cited practices from literature, including practices of literary criticism, to articulate practices of critique that Speculative Design engages in (Bardzell and Bardzell 2013), and to link practices of science fiction with practices of critical reasoning. Wakkary et al. write that

"the practices of science fiction bring to design research the reasoning on multiple futures that challenge assumptions and the sociological, cultural, and political tendencies that underlies our representations and considerations of design and technology" (Wakkary et al. 2015).

10.3 Moving Toward Third Wave Concerns

In HCI research, the early 2000's marked a critical turn to "third wave" HCI, recognizing knowledge as situated and socially constructed; foregrounding and contesting values and politics embedded in and associated with design; and embracing the use of interpretive research methods (Harrison et al. 2007). Speculative Design was one such method of inquiry that supporters of this research agenda adopted. The common story of Speculative Design is that the practice of imagining alternate sociotechnical futures removed from commercial constraints, seeing the future as multiple and uncertain, and not immediately focusing user needs, are what makes it a third wave approach.

With the development of third wave HCI came renewed and explicit focus on values in design (Harrison et al. 2007) and the "marginal user" (Bardzell 2010). The turn also signaled an opportunity for methodological innovation as new avenues of inquiry for the field "in experience, emancipation, domestic life, intimacy, sustainability, and the good life" (Bardzell and Bardzell 2015). Because computing had moved out of the traditional workplace context and outside the sphere of simple efficiency optimization, these new third wave concerns were mismatched to HCI's dominant method and evaluation paradigms. For example, Bardzell and Bardzell's work on digitally mediated sex toys examines the import of HCI design methodologies for evaluating sex toys. The study of digitally enabled pleasure thwarts easy quantification and makes clear that traditional evaluation in terms of "efficiency" along a narrow metric (i.e. Likert scales) risks reifying patriarchal and normative understandings of sexual pleasure. Because the nature of this experience varies between subjects in ways that carry political significance, the case of the sex toys pushes HCI practitioners to be (as sex toy designers already are) responsive to aspects of embodied and situated experience and social activist oriented design (Bardzell and Bardzell 2011).

A range of new practices were emerging to try to address these issues, often framed as critical methodological interventions against dominant HCI practices which were mismatched to explore these questions. For instance, Dunne and Gaver's project *The Pillow*, which presents a plastic inflatable pillow with an LCD screen displaying colored patterns reflecting ambient electromagnetic signals (Dunne and Gaver 1997), can be seen as a forerunner to Speculative Design, contributing the idea that design practice can be used for cultural inquiry rather than usability and efficiency. While appearing similar to a product prototype, they pose the project as

a "cultural thought experiment" to probe at what types of electronic technologies we value as practical or useful. Dunne and Gaver explicitly frame this project against dominant HCI practices of user centered design, writing "The aim is not to assess the design's usability, of course, nor the degree to which it fills recognised needs. Instead, the purpose is to trigger people's imaginations, to challenge them to consider how this sort of technology might fit into their lives" (Dunne and Gaver 1997). The later uptake of Speculative Design methods, which echo older product design techniques while explicitly raising questions about embedded values is an example of a methodological maneuver to meet the challenges of the third wave. For HCI practitioners, Speculative Design was one way to fill the methodological grey space that opened up when new third wave concerns were introduced.

In this common story, Speculative Design reflects a shift toward third wave HCI by calling attention to the ways that critical practices from other disciplinary fields, including design and the humanities, have been adopted by HCI researchers and integrated into their disciplinary practices to explore questions beyond the immediate concerns of product development (while still invoking notions of traditional product design through para-functionality of Speculative Design artifacts). In this sense, Speculative Design itself can be viewed as a critical methodological intervention into HCI—the introduction of a method or approach that was more forward-looking and expansive beyond studying the cognitive behaviors and interactions between a single user and an interface. However, framing Speculative Design as a critical intervention into the field of HCI raises the question of what continuities Speculative Design might have with existing HCI practices, rather than viewing Speculative Design as a new novel practice. We turn to a different history of Speculative Design's adoption in HCI, based in corporate design and HCI practices.

Some HCI researchers have conducted overviews of the ranges of speculative, future-oriented, and fictional work done in HCI (Mankoff et al. 2013). For instance, Blythe writes that "Design is a fundamentally imaginative act that involves picturing the world other than it is. Many forms of design (e.g. scenarios, personas, sketches, speculative design and design fictions) can be thought of as research fictions" (Blythe 2017). Bell and Dourish discuss the role of a shared future vision in shaping the research practices of ubiquitous computing (Bell and Dourish 2007). Much in the same way Speculative Design utilizes the ambiguity of para-functionality to allow conceptual design artifacts to be seemingly situated in everyday life, Speculative Design often utilizes the ambiguity of the meaning of "speculative" to be situated in both critically-oriented and more generally future-oriented contexts and practices. Thus in the remainder of the paper, we use "speculative", "speculation," and "speculative design" (in lower case) to refer to general future-oriented and imaginative practices focusing beyond immediate practical concerns. We use "Speculative Design" (in upper case) or "critically-oriented Speculative Design" to refer specifically to a critically-oriented set of practices.

10.4 Speculative Design As Corporate Practice

While the previous section provided the common narrative about the origins of Speculative Design in HCI, we trace an alternate origin of Speculative Design methods as part of the research and development arm of the technology corporation. Our argument is that speculative design, as a future-oriented and imaginative practice, was established as a method before any explicitly "third wave" concerns began to make headway in the field. If we look to the archives for the Association of Computing Machinery Digital Library (ACM-DL), the first ACM conference paper to introduce "speculative design" as a keyword is a paper from the Research on Experimental Document (RED) Group published at CHI in 2000. This paper describes the group from Xerox PARC and their exhibit on the future of reading at The Technology Museum of Innovation in San Jose, California (Balsamo et al. 2000). The group was formed in 1997 and its goal was the following:

> "….to create and study new genres focusing on opportunities offered by emerging media and technologies. Trained in such fields as architecture, computer science, engineering, product design, critical theory and theater, the eight members of this group had diverse experiences with a range of research philosophies and methods. One of the broad aims of the group is to develop a framework for the realization of our research charter. A related objective is to develop methods appropriate to our research objectives and a language for communicating the insights of our research to our colleagues at PARC and those in our various professional communities." (Balsamo et al. 2000).

In short, the group was tasked with prototyping "new genres" (new forms of documents) as part of Xerox PARC's longterm research and development strategy. Since these new genres were defined by not only their potential technical specifications, but also their social uses, the group was also charged with devising methodologies to explore and communicate a holistic vision of how technology could be embedded into the sociotechnical contexts of the future. "Speculative design research" was one such methodology. When approached by the museum to install a temporary installation, the group chose to pursue the topic of reading both because it "afforded an opportunity for the study and creation of new genres" of document use and because it was relevant "to the core technology of Xerox": "[w]e [Xerox] make things [printers] that make things [documents] that people read" (Harrison et al. 2001b). (Indeed, Xerox's corporate tagline at the time was "The Document Company.") The group also committed itself to an authorial stance, "challeng[ing] the dominant paradigms of user testing," by not conducting traditional HCI user tests of the exhibits (Harrison et al. 2001b). This also highlights a reflexiveness about how presentation and meaning-making in museums differed from lab-based settings.

Their papers provide a couple examples of what was exhibited in a speculative experiment on the future of reading. One of the exhibits was of a reading device that could be tilted in various directions to move through documents. Another was of a story "tree" with moving branches that could be dragged to the center of the screen to navigate through the narrative of a comic book. In subsequent publications about this exhibit, the authors explain that the interface for the tree, Henry's Hyperbolic

World, used a "hyperbolic browser" which was developed at PARC. They argue for the importance of using design to influence the future by invoking PARC's axiom: "[t]he best way to predict the future is to invent it" (Harrison et al. 2001a).

Another design that the researchers considered but ultimately did not include was called "The Adventures of the Red Dot," which was intended to showcase a "paper-moving" technology that was under development at PARC. The design was not included in the exhibit because, as the authors described, "the technology was not ready—or more accurately, the technology developers were not ready" (Harrison et al. 2001a). From here we can see that speculative design was being used to imagine not only alternative "futures," but also alternative "(very near) presents"—in which interdisciplinary teams of academic researchers collaborated with product development to experiment with and evaluate specific research prototypes that were on the imminent cusp of becoming 'real'. Though the specific organizational relationship between RED and the rest of PARC is not discussed directly, it is clear from these designs that RED interfaced significantly with the product development teams, finding ways to showcase early prototypes and give their input about what future to design for. Funding for the exhibit was also provided from a marketing division at Xerox (Balsamo et al. 2000). This exhibit was one way for researchers to engage with technology developers while generating hype for the company and their role within it.

It is worth noting that PARC presents a somewhat unique disciplinary blending in a corporate-funded research organization. At its founding in the 1970s, PARC researchers were largely independent from working on improving existing Xerox products, described by journalist Michael Hiltzik as a "corporate research center as a sort of public benefit, like…underwriting opera performances on television" (Hiltzik 2000). In the 1980s, they employed anthropologists and social scientists, including Lucy Suchman, Julian Orr, and others. The RED group brought together researchers from a range of technical, social, and artistic disciplines. This is not to say PARC was separate from Xerox, in fact they interfaced in many and complex ways—the RED group's reading exhibit had funding from Xerox marketing and their papers contextualize the exhibit in terms of Xerox's broader corporate goals (though at the same time, Xerox the corporation was also reportedly considering selling off PARC (Deutsch 2000)). Seeing speculative design arise in this complex set of relationships provides insight into ways speculative design can move among different audiences, disciplines, and purposes.

10.4.1 Blurring the Boundary Between "Speculative" and "Practical"

The idea of employing interdisciplinary teams of researchers within Research & Development branches of organizations to explore sociotechnical aspects of technology development was not unique to Xerox PARC. For example, Intel's move into mobile technologies was credited to the work of a group founded by anthropologist

Genevieve Bell, who was able to "sense the market and identify the emerging signals and what is going to matter to the end user" (Singer 2014). What is relevant though, is that these research teams did not just try to divine the future, but also developed a language to 'push' sociotechnical implications of developing technology to the rest of the company (or as Bell termed it, "I am firmly in the present… but sometimes, I want to drag the future here and see if we want it" (Singer 2014)). Leveraging the tools of prototyping and product design was part of this language. So while the PARC RED group positions themselves as explicitly designing "against convention" (Harrison et al. 2001b), part of their ability to appeal to professional audiences was rooted precisely in their ability to appropriate industry norms using forms that would appear conventional to the rest of the company, sometimes literally weaving existing technology under development at PARC as part of their speculative design installation.

When the authors from RED explained where they got the idea of speculative design, they drew from and cited a litany of disciplinary backgrounds, including architecture, engineering, arts, and humanities in a way that follows from their interdisciplinary composition. Yet as a historical moment, we see that the first instance of literal "speculative design" within HCI comes from a corporate research context to balance the opportunities and constraints presented to these researchers by their organizational location. While the disciplinary history often traced in HCI when writing about Speculative Design as a method is rooted in references to critical theory and radical art practices (etc.), the practical uptake by people writing in HCI and publishing to HCI conferences, happened in context of unique disciplinary blending in a corporate-sponsored research and development lab.

As history shows, the complex interface between "speculative" and "corporate" did not stop with corporate research and development. In 2004, speculative design was ported over into an academic research context and employed to help explore the design space of cleaning product needs for an elderly population. After presenting the designs (including book shaped bottles so that cleaning products could be stored in easy-to-reach places and a "hands-and-knees" shaped brush extension for people with mobility issues), the author writes that "these concepts were well-received by S.C. Johnson, because they challenged the company's traditional ways of thinking. In corporate settings designers can become stymied by their familiarity with their company's products; speculative designs provide a fresh perspective" (Wyche 2005).

In these early examples of using speculative design, there is undoubtedly a tension between how, on the one hand, speculative design is meant to be in contrast with what is practical pragmatic design focusing on immediate user needs, but on the other hand, speculative design is being used to speak to the same audiences who participate in corporate design–either to communicate or predict what the future could hold, as RED was doing, or "open new spaces" for what product designers should or ought to design. Certainly for the people employed in corporate research and development fields (who themselves bear a complex relationship to what is immediately "practical") this distinction has already been always troubled. In these early examples of speculative design we can see that the distinction between

"speculative" and "practical" design is riddled with situational complexities that make it hard to say that speculative is the opposite of practical.

Our argument is that Speculative Design methods easily took root in the corporate context because conventional corporate research and design were already rife with other speculative practices. What it enabled researchers to do was move between different forms of "speculation": from forecasting the future, divining future trends so that the company may better prepare for them, to critically interrogating the version of future that is currently being imagined by technologists and asking whether it is the right one. Researchers are able to leverage the rhetoric of speculative design to advance this critical orientation in part because of the ambiguity of what is "speculative" about speculative design, and in part because the method of design speculation "works" in corporate contexts due to its high compatibility with corporate business-as-usual. Ultimately, we believe that the method of speculative design itself—the designing of artifacts to communicate what the future could hold or opening new spaces for design— may be the most *conventional* part of critically oriented, third wave practice, and that the critical project lies in leveraging these practices to take a political stance on sociopolitical issues.

In order to make this argument, we will compare the rhetorical work of Speculative Design (which HCI has accepted as a critically oriented method) with two other methods that have purchase in corporate contexts: concept videos and scenario planning. We will read the two methods through the lens of Speculative Design—that is, reading them as if they were speculative design with an explicitly critical orientation. This reading will help us see the rhetorical work Speculative Design does, and how critical agendas can be legitimated by speaking the language of corporate stakeholder communities.

10.5 Corporate Concept Videos

Concept videos and vision videos are speculative practices (i.e. future-oriented, imaginative, and looking beyond immediate concerns; not necessarily critically oriented) in which videos are used to depict short stories or scenarios about possible technical futures. They have historically been used in both commercial product development processes and in HCI research contexts. Concept videos depict a near-future technology being used in a variety of environments, often created by companies in advance of the release or manufacturing of a product. Examples include Apple's Knowledge Navigator video in 1987, Google's video of their heads up display glasses Glass in 2012, Microsoft's video of their augmented reality headset HoloLens in 2015, or Amazon.com's video of their proposed automated drone-based delivery service Prime Air in 2013.[1] Sometimes a system similar to the

[1] Knowledge Navigator Video viewable at: https://archive.org/details/youtube-hb4AzF6wEoc; Glass Video viewable at: https://archive.org/details/GoogleGlass_201307; Hololens Video viewable at: https://archive.org/details/HoloLensAd; Prime Air Videos viewable at: https://archive.org/details/AmazonPrimeAir (Accessed December 2017).

depicted artifact becomes produced and sold (such as Glass and HoloLens), while others do not come to fruition (such as the Knowledge Navigator, and at the time of writing, Prime Air).

Concept videos create a narrative world that takes place in the future, depicting technical artifacts and how humans interact with them, sometimes including a narrator or voiceover as well. For instance, a narrator in a 2015 video for Amazon Prime Air invites viewers to step into "the not too distant future" and imagine using an automated drone delivery service.[2] The viewer is then shown a family that lives in a suburban home. The family's daughter has a soccer match that day, but the family's bulldog tore up her shoes. The mother uses a tablet to orders a new pair of shoes using Amazon's Prime Air service. The viewer is then shown an Amazon warehouse, as a worker's hands packages a pair of shoes which is then automatically loaded into an Amazon drone. The drone then takes off on its own, flies to the family's house, lands by itself in their backyard, and deposits the package before departing again. Inside the house, the mother takes the new pair of shoes out of the Prime Air box and gives them to the daughter, and the bulldog, gets a new chew toy. Concept videos such as this one embed a vision about the future sociotechnical configuration of the world—including ideas about how computing should be done, for whom, and the norms that might exist in that world.

Vision videos similarly provide a form of corporate speculation, helping to articulate a company's research vision by representing a future world (often one that is amenable to products and services relevant to that company). These videos imagine a broader world (rather than a specific product), such as the "future of productivity," bringing a vision of a possible future into the present (Kinsley 2010). An example includes AT&T's 1993 "Connections" video[3] which explores a range of virtual reality and screen-based communication and collaboration systems in different settings, against the backdrop of a story in which a city planner encounters a group resisting the demolition of a community center to build new apartments. Within this world, the planner's son uses a virtual reality headset to play a fantasy game with his friends; his daughter introduces her parents to her fiancé using a public video phone-booth at the airport; and his wife conducts a medical diagnosis remotely via videophone. Depicted interactions hint at a broader range of technical capabilities and social arrangements: human-like avatars of "artificial agents" on videoconference screens suggest changes in the ways that business responsibilities and labor arrangements are delegated among human and non-human agents. Throughout the video are suggestions that video-based communications, live video translations of language, database access, and voice-based interface commands are easily possible and accessible throughout the world. These types of videos are not limited to HCI contexts; for instance, SpaceX's "Interplanetary Transport System" video[4] depicts the imagined flight stages of a large manned spacecraft flying from Earth to Mars,

[2] Video viewable at: https://archive.org/details/PrimeAirVideo01 (Accessed December 2017).

[3] Video viewable at: https://www.youtube.com/watch?v=yFWCoeZjx8A (Accessed December 2017).

[4] Viewable at: https://www.youtube.com/watch?v=0qo78R_yYFA (Accessed December 2017).

suggesting the technological advancements that might be made in this future. While not explicitly addressed, the depiction of a large-scale interplanetary system implicitly hints at social and political changes that might have to occur in order for a mission of this scale to be feasible.

These videos tend to play out as short scenes or vignettes with characters in short plots and stories. The videos are highly produced, often with high quality acting, lighting, camerawork, and background music. Some have narrators, though most use tropes from television, depicting short dramatic or comedic plots which often involve characters utilizing imagined technology systems to solve problems or accomplish tasks.

Concept videos and vision videos exist on a spectrum; nevertheless, both use videos to imagine technology use in the near future. (For the rest of the chapter, we use the term "concept videos" to refer to both of these practices.) Like speculative designs, concept videos try to bring an imagined future to the present, asking viewers to enter these worlds *as if* they are real. At the same time, these concept videos portray technologies that companies *intend to make* real in some form. Knowing that these videos are authored by large corporations with existing products may serve as a perceptual bridge to allow viewers to more easily imagine the concept videos as real. Yet these videos are still speculative in that the specific sociotechnical configurations of the world of the video are unlikely to come to fruition. The scenes depicted in these videos tend to assume that technologies will always work as intended, and often assume that the social norms and societal roles that exist during the production of the videos will remain constant decades later. Thus these videos are not divining the future; rather they rhetorically use the creation of an imagined future to set an agenda for research and development, or to articulate a shared corporate vision.

Like in our earlier discussion of Speculative Design, there is some ambiguity and multiplicity to the purposes of concept videos. At first glance, these videos seem to predominantly reflect corporate agendas or advertising imperatives, fueling demand and creating markets for new products and services. In this sense, the future they imagine is one in which corporate products are highly desired objects. However the videos are not necessarily apolitical. For instance, Apple's Knowledge Navigator video shows a computer interface in a professor's study allowing him to interact with an artificial agent while checking messages, preparing a lecture, and video conferencing with other researchers. Yet the content of the professor's research is about deforestation and global warming, suggesting environmental sociopolitical commentary. The aforementioned AT&T "Connections" video raises socioeconomic questions about urban development, balancing community desires with housing needs. In this sense, while concept videos do the acceptable work of corporate speculation—imagining and forecasting new products and new contexts for use—the videos also provide some ambiguity and maneuverability to ask sociopolitical questions, suggesting political standpoints in debates which continue to be prevalent decades later.

10.5.1 Concept Videos As Corporate Prototyping

Concept videos have a longer history, as throughout the twentieth century corporations have released short films imagining future technologies in domains ranging from telecommunications to transportation to the home. But the practice of creating concept videos also has historical interfaces with HCI through the practice of video prototyping.

Several HCI researchers adapted the form of the concept video to create video prototypes or video scenarios. In a 1994 CHI paper, Bruce Tognazzini writes about the creation of Sun Microsystems' "Starfire" concept video in terms of a video prototype, trying to articulate a "believable ten-year vision," and discusses a range of decisions about how they depicted interactions, hardware, and users; how they created a scenario; and choices in filming techniques (Tognazzini 1994). Tognazzini discusses the concept video in several ways, including common HCI concerns about exploring user interactions, input devices, and use cases. But he also discusses the rhetorical power that a professionally produced concept video can have with multiple audiences:

> When at Apple, several Starfire members, including this author, worked on a project to develop a series of vignettes showing future users accomplishing tasks with experimental interfaces. The final results were shot inhouse in video with practically no budget. Managers and outsiders were unable to look past the dearth of production values and appreciate the ideas expressed. The project had virtually no impact on Apple's future direction. […]
>
> We were interested in "Starfire" having a profound effect. We launched a full-blown fundraising effort, garnering support not only within engineering, but within marketing, sales, and public relations. These latter people do not intend to shell out money for a film showing people with dour expressions making errors while stumbling through a prototype system. They want happy people basking in the warm glow of a computer that always works. We wanted to do our best to ensure that those happy people would be just as happy ten years from now when they sat down at the real thing. (Tognazzini 1994)

These reflections highlight tensions in situating concept videos as both a part of HCI prototyping practice and corporate visioning practice; and they highlight the ways in which concept videos' ambiguity around how they are speculative allows the videos to shift across different audiences and purposes. In this telling, a professionally produced video (showing happy users) was needed to create a perceptual bridge for the marketing, sales, and public relations viewers who the authors wanted to reach and get funding from. This also highlights how the video, beyond showcasing a series of interactions, also serves a broader corporate visioning imperative. During the same time period, others doing HCI work adopted the notion of concept videos toward other purposes, often focusing on depicting a specific interface design and interaction, rather than situating the technology in a story or scenario. Others, while inspired by highly produced concept videos "intended for marketing purposes," began to use hand-based animation, computer animation, and other video-making techniques for prototyping (Vertelney 1989).

10.5.2 Critically Re-imagining Concept Videos

While concept videos are speculative in a future-oriented imaginative sense, third wave HCI researchers can approach concept videos by reading them as artifacts or texts for critical analysis using the lens of critically-oriented Speculative Design. While the videos often present flashy and clean, almost utopian futures, analyzing the videos as speculative artifacts helps surface aspects of the companies' narratives that may not be at their central focus, but could have significant implications for people if those narratives come to fruition. For example, prior critical analysis of the aforementioned Amazon Prime Air videos through the lens of Speculative Design suggests how the videos' camera angles and depictions of drone behaviors construct a notion that the drone is conscientious of some aspects of homeowners' privacy (Wong and Mulligan 2016a). Relatedly, critical analyses of the future visions presented in philanthropic IT advertisements through this lens suggest that these visions represent "impossible futures" of competing promises and moral imperatives that organizations should pursue and adopt in order to be seen as "good" (Harmon et al. 2017).

Additionally, concept videos are situated differently than Speculative Design artifacts originating from academic research. They are authored by companies, and viewed by numerous public audiences who experience, interpret, and critique the videos in multiple ways. In this sense, concept videos correspond with Latour's account of things seemingly having lives of their own, taking on new meanings, actions, or consequences when placed in different assemblages (Latour 1992). Heeding Latour's call to "follow the actors themselves" (Latour 2005) suggests looking at the ways in which concept videos act and are acted upon in the world. Authors in HCI and science and technology Studies discuss how representations of technology influence broader perceptions, reactions, and debates, and how collective processes of imagination are expressed through and facilitated in part by processes of cultural production (Jasanoff and Kim 2009; Dourish and Bell 2011; Harmon and Mazmanian 2013). For instance, analyzing press reaction to the Google Glass and Microsoft HoloLens concept videos shows that media authors used the videos as a starting point to further imagine the future world with Glass and HoloLens, and the implications of living in those worlds (Wong and Mulligan 2016b). Yet the media authors portrayed the future in two different ways: some discussed the future by critiquing the world depicted in the companies' concept videos, while others accepted the depicted worlds. Wong and Mulligan term these two orientations of reading concept videos as "speculative" and "anticipatory." "Speculative orientations" toward the future acknowledge multiple possible futures, often with a critical lens. People utilizing this orientation may critique the future that the video depicts or present an alternate future. "Anticipatory orientations" toward the future foresee a singular future, where people's practices in the present work to maintain and move toward a *particular* vision and expectation of the future.

Speculative and anticipatory orientations are similar to Hall's description of how viewers may decode discourses (Hall 1980), mapping onto oppositional codes and dominant-hegemonic codes, respectively, where oppositional means that the viewer interprets the media in a way that contests the author's intended meaning, while dominant-hegemonic means that the viewer interprets the media with the author's intended meaning. This acknowledges the role that viewers play in creating the meaning of the videos. The speculative and anticipatory orientations also add a forward-looking or imaginative aspect to the process of decoding. These orientations are not mutually exclusive, but rather lay on a spectrum. However, distinguishing between them allows us to be more precise about ways people discuss and imagine futures. When people adopt a speculative orientation toward the future, it suggests an opportunity to change and refine designs, and to consider other future sociotechnical worlds. The adoption of anticipatory orientations may suggest greater acceptance of a particular envisioned future, but it may also signal lessened space and receptiveness for critique or discussion.

A third code described by Hall, negotiated codes, sits in between dominant and oppositional codes, in which the reader understands and broadly accepts the dominant code, but sometimes resists or modifies it in response to their situated position. As Hall discusses, "this negotiated version of the dominant ideology is thus shot through with contradictions." (Hall 1980). We propose that third wave Speculative Design practitioners can use a "negotiated" reading of corporate concept videos, re-reading them through the lens of third wave Speculative Design, that is, to read the videos through the a critically-oriented lens, highlighting the videos' sociopolitical stances. What is perhaps most interesting in this discussion is that while not intentionally created as critically-oriented Speculative Designs, concept videos can take on aspects of Speculative Design in the eyes of viewers when analyzed through a speculative orientation. The researcher, as analyst, can move between reading the video as a corporate forecasting artifact, and as a critically-oriented artifact by bringing a critical and reflexive lens to the futures presented in the concept videos even if they were not intentionally created as such.

Looking at corporate concept videos as speculative artifacts can be useful in several ways. First, the videos can be analyzed as types of speculative texts by researchers, to critically probe the values and politics imagined in the videos. Second, "following" the videos allows us to see how a broader audience engages with and may contest the politics and values of the futures and worlds presented in the concept videos. Third, the form of the concept video—the clean, glossy focus on an imagined product in a variety of settings—could be useful for creating video-based Speculative Design artifacts that are intentionally critical in their aims, as a way to explore and critique the development of commercial products. Speculative Design artifacts in the form of concept videos might also be used by HCI researchers as a rhetorical tool that is more widely accessible than academic papers and can engage broader audiences, such as Superflux's video Drone Aviary and Matsuda's video HYPER-REALITY (Superflux 2015; Matsuda 2016) which both critique imagined futures around drone surveillance and augmented reality and have both

been viewed by hundreds of thousands of people. The widespread popularity and acceptance of the form of concept videos may serve to legitimize the arguments made through Speculative Designs that take the form of concept videos.

10.6 Scenario Planning

Corporate concept videos are not the only form of corporate-based speculation and forecasting that has historical interfaces with speculative HCI practices. While concept videos tend to focus on how specific products or objects might take place in an imagined world, scenario planning (or "strategic planning" or "scenario thinking") provides a process for thinking about, planning for, or decision making in a future with risk or uncertainties. While working at the RAND Corporation, a think tank closely associated with the U.S. military, Herman Kahn developed scenario planning to think about potential outcomes of nuclear warfare during the Cold War (Kahn 1962). Scenario planning in the corporate world has origins in Royal Dutch Shell in the 1960s and 1970s, during a period of uncertainty about the future of oil prices (Wack 1985). Scenario planning identifies critical uncertainties and explicates multiple possible futures that could develop, helping to prevent failures of imagination. Importantly, scenarios have both a logical "plot line" and a narrative "story" (Weber 1996)—the plot provides a plausible logic underlying a narrative story about the future, not too unlike the para-functionality of Speculative Design artifacts. Scenario planning also tends to focus on deeper uncertainties or trends that may indirectly, but importantly affect dimensions of a particular phenomenon being studied; while originally used for oil prices and Cold War outcomes, scenario planning has been applied to a wide range of areas, such as the futures of work, pharmaceutical drugs, national security, or cybersecurity.

Scenario planning seeks to bring attention to the future's openness, contingency, and irreducible uncertainty, as well as expand people's conceptions of what may be possible or plausible—not just probable (Wilkinson and Kupers 2013). Scenarios generally take the form of text, describing multiple possible futures around a given phenomenon. They generally include a number of fictional artifacts to help make those futures feel more real, such as fictional news articles, personas, websites, videos, or other artifacts from those worlds.

Today, scenario planning is predominantly used by companies and government organizations to understand the effect of potential futures on consumer and financial markets or on national security. However, there are also some new applications of scenario planning in research environments. One example of a scenario planning process in research is the University of California Berkeley Center for Long-Term Cybersecurity's "Cybersecurity Futures 2020" report (Center for Long-Term Cybersecurity 2016). The report describes its methodology for iteratively developing a set scenarios: first creating a set of prototype scenarios with a diverse group of people from academia working in a wide range of disciplines, industry, government, and non-profit organizations; then with a smaller group, identifying "most uncertain

and most important" underlying drivers of change in those scenarios (which might stem from a diverse set of domains, such as changing economic conditions or social norms), using those driving forces to refine the set of scenarios; then sharing the draft scenarios with stakeholders and refining again. It describes its purpose as "creat[ing] a usable representation of an imaginative map of the possibility space—stretched in some respects to the boundaries of plausibility—that researchers, decision-makers, and policymakers can use to help navigate the future" (Center for Long-Term Cybersecurity 2016).

The report presents five scenarios describing five different versions of the world in 2020 in which "cybersecurity" means something different (such as a world in which cybersecurity is tightly associated with the ability to hide one's emotions, or a world in which the stealing of personal data and personal information becomes normal and expected behavior). The text of each scenario includes a description of the world in 2020, a plot line of how events could unfold from 2015 to 2020, and implications for cybersecurity (construed broadly—cybersecurity is discussed in social, economic, and political terms as well as technical ones). For each scenario, the report also presents a number of artifacts "from the future" such as news articles, editorials, product advertisements, personal diary entries, or wikileaks documents. These artifacts help provide insight into everyday experiences as well as contested viewpoints that might exist in the world of a scenario.

10.6.1 Scenario Planning in the HCI Toolkit

Traditional scenarios in HCI work may at first seem different from the aforementioned practice of scenario planning, yet these practices also interface in several ways. HCI scenarios tend to focus on a user's interactions with a particular system rather than describing the world at large. Scenarios in HCI literature began to grow in the 1980s and 1990s, applied to a wide variety of uses including scenarios to illustrate what it is like to use a system; scenarios to specify tasks for usability tests and other evaluations; scenarios as a tool to help design a system; and scenarios to help translate theories into practices (Campbell 1992). Within HCI, scenario practices were used across academic and industry research. Providing a link between scenario planning and HCI scenarios is John M. Carroll, who worked at IBM Research in the 1980s and early 1990s. In his book, *Making Use*, Carroll describes design scenarios in a similar way to scenario planning: "Scenarios are stories—stories about people and their activities," they have a setting, include agents or actors with goals or objectives (which sometimes change), include a plot through a sequence of actions and events, and are represented in ways that make a system's use explicit (Carroll 2000). Carroll later specifically writes about scenario planning (using the term "strategic planning"), writing:

> "Strategic planning is actually the deepest root of scenario-based design…Strategic management scenarios are employed to concretize the complex uncertainties that inhere in envisioning future opportunities and risks. They are used to expose hidden assumptions about

> the present and the future and to allow analysts to contrast entailments of alternate policies, each encompassing a constellation of assumptions and conjectures about the current situation and its likely course of evolution. They have been found to help with the enumeration prerequisite actions that would need to be taken in order for some envisioned future to occur." (Carroll 2000)

Relatedly, Carroll argues that "Creating and using scenarios pushes designers beyond static answers. … This emphasis on raising questions makes it easier for designers to integrate reflection and action in their own design practice" (Carroll 2000). He specifically refers to examples of Kahn at RAND and Wack's discussion of Shell's scenarios to illustrate this point. In later work, Carroll connects the uses of scenarios in scenario planning, HCI, and in software engineering, by arguing that their *scopes* are nested. That is, software engineering scenarios focus at the "keystroke command" level; HCI scenarios focus on a broader "day in the life"; and strategic planning scenarios depict an even broader "year in the life" (Go and Carroll 2004).

In this discussion of scenarios in both HCI and strategic management, Caroll underscores a commitment to imagining futures and questioning one's assumptions, but in service of designing more usable systems. Scenarios are posited as a tool that can help a designer, researcher, or analyst rethink their assumptions about the world (from how a country might react to a nuclear strike to how a person's needs might cause them to interact with a system in a novel way). Scenarios are speculative in the forward-looking, imaginative sense. While they may not be explicitly critically-oriented, they do serve to help people question their assumptions. Scenarios in this sense are a tool to help make decisions. The use of creating narratives, futures, and creating "reflections" is thus legitimated as a normative HCI practice in service of making a "better" design decision, generally by making a system more usable for a population of users or consumers. Left unsaid at this time was the type of reflective (and reflexive) practices espoused by later HCI researchers that recognize designers', researchers', and analysts' complicity in shaping and creating knowledge.

10.6.2 Critically Re-engaging Scenario Planning

Scenarios have a varied history moving among industry, academic, and government spaces, both inside and outside of HCI—generally with a commitment to seeing the future as uncertain, and being willing to question one's assumptions about how the world works. Speculative Design can build on this rich history in several ways.

First, scenario planning's focus on imagining broader worlds might be useful in inspiring the creation of speculative artifacts. Pargman et al. suggest that scenario planning's ability to imagine systemic effects in imagined futures and longer-term perspectives could be useful to help expand and broaden beyond HCI's usual focus "on gadgets and on maximizing the 'wow factor'" (Pargman et al. 2017). Like Go and Carroll, Pargman et al. seem to distinguish between scenario planning and HCI scenarios (including Speculative Design) based on their scope. We instead use the

lens of ambiguity to think about the relationship between scenario planning and Speculative Design, proposing that while both take similar stances toward imagining alternate sociotechnical configurations of the world, they maintain ambiguity at different scopes within their imagined worlds.

Speculative Designs in HCI generally portray a specific artifact, but provide ambiguity about the broader world in which it exits by not fully specifying how or where the design would be implemented, allowing a viewer to imagine those details for themselves. Gaver discusses how maintaining ambiguity and provisionally in conceptual and speculative designs allows them to take on lives of their own apart from their designers, open to multiple interpretations (Gaver 2011). Alternatively, scenario planning tends to be precise about the macro-level trends that help sketch out the world of a scenario. What the scenario's world looks like at a local situated level tends to be ambiguous. While a number of fictional artifacts may help ground parts of the scenario, they only represent a partial experience of the broader world described in the scenario.

Some of this stems from differences in the process of world creation in scenario planning. Speculative Design creates a world from the inside-out, starting by describing the particular. By focusing on specific speculative artifacts, it tries to make a particular piece of the imagined world seem real. It is largely left up to the viewer to imagine what the broader world might look like. Scenario planning creates a world from the outside-in, starting by describing the world's broad outlines by focusing on macro-level systemic trends. While providing a few specific examples to flesh out its scenarios, it largely leaves the particulars of its imagined worlds ambiguous, for viewers and readers to fill in. This suggests utilizing different approaches and starting points to creating speculative worlds based on one's questions and desired level of analysis.

While ambiguity has often been discussed as a resource for design, openness and provisionality can also be confusing for others who encounter speculative artifacts. A variety of "perceptual bridges" have been discussed in speculative design, such as relating speculation to the familiar or everyday through para-functionality, blurring the real and fictional, or providing a familiar "hook" such as basing designs on popular speculative fiction (Auger 2013; Wong et al. 2017). Scenario planning suggests another possible perceptual bridge for future-oriented speculative design. Tracing a fictional yet possible plot line of events from the present to the future world suggested by the speculative artifact may help enable a broader population to suspend their disbelief and engage with the speculation as if it were real.

Second, Speculative Design can be used as a critically-oriented lens to analyze existing scenario artifacts. Similar to how scenarios help highlight how designers can make use of ambiguity at different scopes to move back and forth between particular experiences and broader world-level trends, some ambiguity in the type speculation that scenarios do allows the analyst to move back and forth to view scenarios as both a forecasting tool and as a potentially critically-oriented set of objects. Scenario planning has been an object of study for some in anthropology and science and technology studies, mostly those studying the role of risk in modernity (Lakoff 2008; Samimian-Darash 2013). In some sense, all scenarios and plans are

"speculative", in the sense that they are always uncertain forecasts. They never come to fruition exactly as described; rather they focus on helping a population being "prepared" for a range of possible contingencies. As in our earlier discussion of concept videos, a Speculative Design lens can be used to critically "read" scenarios as speculative artifacts, to question and probe what types of futures scenarios envision, and perhaps more importantly, what types of futures they do not envision. Reading them this way can bring a reflexive eye to understanding the ways in which scenarios help create possibilities and constraints for knowledge production.

Third, with regard to the practice and process of Speculative Design, scenario planning may provide insight for creating, sharing, and communicating design artifacts. Scenario planning's stakeholder engagement in the creation and refinement of scenarios may provide lessons for speculative co-designing activities with non-designers and for engaging with audiences HCI has historically been in less conversation with, such as policymakers. Importantly, scenarios are not seen as end products, but as tools for decision making. This suggests thinking about ways in which Speculative Design artifacts could be used after the process of design. While decision making might be one type of use, one might imagine Speculative Design artifacts in public forums, as educational tools, or even becoming part of infrastructures. Speculative Design work can expand its scope of inquiry to not only investigate the process of design and the artifacts resulting from that process, but in attending to the ways in which Speculative Design artifacts can travel, be shared and communicated, and be (re)appropriated.

10.7 Speculative Design as Legitimating Practice

The common story of Speculative Design is that the practice of imagining alternate futures removed from commercial constraints, seeing the future as multiple and uncertain, and not immediately focusing user needs, is what makes it a third wave approach, contrasting with dominant user-centered design approaches in HCI. In our re-telling of Speculative Design's history, we situate Speculative Design as a research practice situated in a unique space blending corporate and academic research, utilized by Xerox PARC to divine "new genres" of technology use, highlighting the ways in which speculative design has provided purchase in corporate-shaped environments. We further explore other speculative practices with clearer corporate origins—concept videos and scenario planning—which have both been used for at least several decades and have also had some presence in HCI research. These practices, though future-oriented, imaginative, and focusing on sociotechnical issues, are not necessarily explicitly critically-oriented in the way that third wave Speculative Design often is, nor are they necessarily evaluated through the broader set of reflexive tools open to third wave HCI researchers.

From these reflections of speculative design in corporate practice, we suggest that the future-oriented, not focusing on immediate user needs aspects of speculative design are actually the "normal" part of Speculative Design. That is, speculative

design as a method is not necessarily itself indicative a third wave approach. Rather it is the commitment to reflexivity—the situated positionality of the researcher, commitment to a political stance, and a critical reflection on sociopolitical values—within a speculative, future-oriented practice that makes it a third wave practice. As HCI practices are ongoingly translated—between corporate, academic, research, and product environments—wrapping this reflexivity in the language of innovation, speculation, and long term futures in speculative design is what legitimates it as a useful and valuable practice, because these are already seen as valuable in the community, particularly in the corporate community.

10.7.1 "speculative design" and "Speculative Design"

So where does all of this leave speculative design and Third Wave HCI? This outline of historical and current speculative practices situated in corporate technology companies allows us to think about speculative design in new ways. Traditionally, Speculative Design's focus beyond immediate user needs and immediate systems is portrayed as outside commercial design constraints and is used to justify how it might be part of a third wave research agenda. However, industry corporations have historically embraced a range of speculative, future-oriented practices to encourage and motivate research and development, including "speculative design" at PARC, concept videos, and scenario planning. This suggests that the futuring and speculative aspects of critically-oriented Speculative Design are not necessarily "new" but have always been a part of HCI work.

It is in the acts of futuring and speculation that legitimates critically-oriented Speculative Design as an acceptable HCI practice. Perhaps reflective of the collaborations between academia and industry that are present in HCI, the uses of speculative practices bridge academic and industry practice: with the term "speculative design" present in both, the parallel developments in concept videos and video prototyping, and the use of scenario planning along with user scenarios. One way to read the story of Speculative Design, then, is as a tactical method; after speculative design was legitimated through its relationship to normative corporate practice, it has been strategically co-opted to "push" critical agendas in HCI spaces.

Third wave HCI helps us understand the push of speculative design into new concerns, new types of questions, and new areas of inquiry. As speculative design moved out of the corporate R&D lab towards tackling questions such as sustainability, digital technologies in the home, social inequalities, and feminist politics**.** The more common narratives used to explain where speculative design came from, as discussed earlier in this chapter—critical theory, literary criticism, design practice, art movements, civics, the humanities, and social sciences—began to fall into place.

More generally, authors in third wave Speculative Design sometimes cite antecedent critical technical projects. These include Suchman's ethnomethodological account of how human actions are situated (rather than planned), challenging some

of the assumptions in cognitive science and artificial intelligence research at the time (Suchman 1987); Winograd and Flores' similar critique of assumptions cognitive science and artificial intelligence (Winograd and Flores 1987); and Agre's call for a critical technical practice, for engineers to be more reflexive in their own practices (Agre 1997). Within HCI are also earlier strands of critical work, including: Scandinavian participatory design which reimagined relationships around labor and power; value-sensitive design which began to imagine how technologies could embody particular sets of values that societal groups think are important (Friedman 1996); and early work on ludic design or using ambiguity in design which tried to embed technologies with different sets of values or use design towards ends other than task efficiency (Gaver 2002; Sengers and Gaver 2006). These projects all imagined that design could be used to question the dominant programs and paradigms of technology development.

Seen one way, Speculative Design provides a new future-oriented method to continue advancing critical technical projects with perspectives that have roots in the arts and humanities. Seen through the third wave lens of this chapter, however, the futuring aspects of Speculative Design had already been established in a range of speculative practices already existing in industry and academic HCI research and development. The critically oriented version of Speculative Design that emerged as part of third wave HCI—one that investigated new concerns, questions, and areas of inquiry—was legitimated by speaking the established language of accepted forms of futuring in HCI (such as those of scenarios, concept videos, or product prototypes). The aforementioned citation stories of speculative design that draw on practices from the arts and humanities are themselves indicative of a third wave approach—opening existing speculative practices in HCI for adoption, interpretation, and appropriation toward a more critically oriented version of speculative design. Through this adaptation of a recognizable method, the Third Wave version of Speculative Design opens up the space for new areas of concern in HCI. But it is not through the method of speculation and futuring persay, but rather by way of what Speculative Design's focus becomes trained on.

10.7.2 Moving Forward: Doing the Work of Critically Oriented Speculative Design

The story of Third Wave Speculative Design falls into a disciplinary narrative of "critically oriented researchers" within HCI, who have brought critique and reflection of underlying values and assumptions behind normative practices in technology design by tactically engaging with some of those normative practices in their own work (Khovanskaya et al. 2015). Khovanskaya et al. describe some of these processes in the context of HCI evaluation techniques, and the tradeoffs in applying the same sensibilities to "critical" projects. They caution that "the act of making critically oriented design interventions legible to the HCI community—i.e. tactically

engaging with the "lingua franca"—shapes the nature of interactions with participants in ways that can undermine the critical goals of the project" (Khovanskaya et al. 2015). Though Khovanskaya et al.'s project was specifically reflecting on evaluation tactics, we believe that a parallel caution holds for Speculative Design more generally.

As we move forward with Speculative Design, and in keeping with the practitioner spirit of the Third Wave HCI handbook, we present the following recommendations for design researchers and those evaluating Speculative Design. The first is to be strategic in one's engagement with HCI's disciplinary norms. Speculative Design gives researchers the opportunity to remix optics of corporate practice to give the appearance of productive research output to endeavors that might otherwise be relegated to "critique." This allows critical projects to promise and present as tangible "alternatives" to current technology practices. With this privilege of passing as potentially profitable comes the responsibility to focus on the rhetorical program communicated from the speculative design work. Each research project comes with a series of subcomponents that researchers must prioritize (e.g. the theory, the design itself, the deployment, the evaluation, etc.), and our stance is that care needs to be put into making sure that the design is effective in prompting questions and communicating specific stances intended by the researchers. In other words, Speculative Design in the spirit of third wave HCI goes beyond articulating a technical possibility or alternative outside of current commercial constraints; practitioners of speculative design also have the responsibility to communicate a stance(s) on a societal issue (or set of issues) through the language of design (which we recognize may be more or less possible in a given context).

Our second recommendation is that Speculative Design researchers tackle the tensions of adopting the ambivalent stance that comes with using normative design practices to advance critical questions, both within their groups and projects, but also in their published work, for instance navigating tensions when using Speculative Design for multiple audiences and purposes. This includes the ambivalences in tactical moves, rhetoric, or strategies that a speculative design researcher might employ to gain access or legitimacy in spaces or communities (such as funders, companies, governments, or publications), while maintaining commitments to their political arguments. This gives guidance and resources to future workers in this field. As our narrative shows, the future development of what is legitimate in HCI rests on prior work.

Finally, as a critical program becomes more developed and established within the discipline of HCI, the easy fruit of critique is perhaps worn out. Early framings of third wave critiques often latched onto a notion of critiquing from "outside" of disciplinary norms—for instance presenting a range of alternate values to consider beyond usability and efficiency, including "fun," "reflection," or "ambiguity"; or explicitly bringing in methods, theories, and constructs from other fields, including phenomenology, critical theory, ethnography, and ethnomethodology. However, this framing starts to lose its rhetorical power as these "critical" perspectives are brought into HCI and start to become normative in their own right. We propose turn, then, to maintaining *reflexivity* in our disciplinary practices. Inspired by Agre's call for a

critical technical practice, in which "rigorous reflection upon technical ideas and practices becomes an integral part of day-to-day technical work" (Agre 1997), we expand upon this to call for a disciplinary reflexivity about the role of critically-oriented work within HCI. Through this a new program emerges in establishing cohesiveness and understanding within the subfield of critically-oriented HCI. One way to do this is to do a critical (re)reading of prior speculative work—including artifacts, papers, and programs—through the lens of speculative design. It is clear to us, after looking into the disciplinary history of speculative design, that a familiar string of citations belies a more complex story of our disciplinary development. In order to keep disciplinary stories like early speculative design at Xerox PARC, for example, within our working memory, there is work to be done in documenting work in this field.

10.8 Conclusion

In this chapter we have described the program of Speculative Design in HCI and its rhetorical capacity to raise questions central to third wave HCI, and outside of the scope and methodological capabilities of second wave HCI. We give the legacy of speculative design that is commonly cited in HCI papers from the mid-00s onward, describing the disciplinary linkages to radical art practice, humanism, and critical theory. We then look into the history of how speculative design came to HCI by way of corporate design research initiatives and show how speculative design is similar to other professionalized methods such as concept videos and scenario planning that are used to speculate on technology in the future. When a critical lens is turned to look at how Speculative Design "works" as a method in HCI, we see that rather than being an impractical and "out-there" method, Speculative Design functions as the legitimating tactic which allows critically oriented researchers to advance third wave concerns by dressing them in the optics of innovation, speculation, and long term planning, which is then recognizable to varied audiences in the field.

From this we draw some practical recommendations for researchers in this space. If the novel part of Speculative Design is not the "speculation," but rather it is the questions raised by the design and the discourses it brings in (which is indeed what the history of speculative design shows all along, a testament to the third wave blending this whole time); then we call on speculative researchers to focus their energy on tactically communicating the questions and political stances through Speculative Design. Speculative Design can be a form of consciousness building, of introducing third wave concerns to audiences who would otherwise not engage with those ideas, but it can only do if the rhetorical program of the speculation is presented clearly. We also call on researchers to be open about the tensions in navigating the binds of working within the system for the benefit of future researchers, to advance the re-reading of past projects through a critically-oriented Speculative Design lens; to engage broader audiences and publics through Speculative Design; to consider what historical, current, and emerging design genres can be used in

creating speculative designs; to consider deploying speculative design at multiple scales and scopes of world building; and to work together to document the disciplinary history of the method.

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Chapter 11
Designing from Embodied Knowing: Practice-Based Research at the Intersection Between Embodied Interaction and Somatics

Yves Candau, Thecla Schiphorst, and Jules Françoise

Abstract While third wave HCI foregrounds experience and embodiment, the design paradigm was initially terse on methodologies to guide embodied inquiries through actual movement techniques and practices. We consider here a number of related design approaches developed to amend this gap. They incorporate somatic practices into their design processes, and draw on conceptual frameworks interweaving phenomenology, pragmatism, and embodied cognition. Somatic practices are first-person methodologies to investigate and cultivate the embodied self. They involve sustained learning strategies integrating movement, attention, and a range of sensory modalities. While embodied processes are complex and elusive, somatic practices provide instrumental methodologies to circulate between the fullness of felt experience, and a variety of views to articulate and elaborate these experiences. In synergy with embodied interaction, the field of somatics has much to offer to flesh out design practices.

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11.1 Introduction

Within the current breadth of third wave HCI methodologies (human–computer interaction), we consider several related approaches in which the design processes are supported by practices from the field of *somatics*. These approaches share third wave HCI's concern with experience, embodiment, the situated nature of interaction, and the construction of meaning afforded through interaction (Harrison et al. 2007). They are then further characterized by:

- conceptual frameworks interweaving phenomenology, pragmatism, and embodied cognition;
- incorporating *somatic practices* into their design processes as first-person methodologies;
- acknowledging that embodiment can be practiced and refined through these practices.

The term *somatics* was formalized by Hanna in 1976, to recognize the relevance and commonality of a number of existing practices. He defines it as "the field which studies the soma: namely, the body as perceived from within by first-person perception" (Hanna 1986: 4). The actual practices are numerous, and share a focus on deepening embodied experience. This deepening is similar to the refinement of attention developed in meditational practices, with an emphasis on movement, proprioception, and kinaesthetic awareness.

We propose Johnson's notion of *embodied knowing* as an underlying principle to encompass these related practices. In a recent chapter on arts-based research, he develops the argument that embodied knowledge is not a "fixed body of propositional claims" but rather a "process for intelligently transforming experience" (2010: 142). To emphasize this dynamic view of an embodied epistemology, Johnson then adopts Dewey's shift from noun to verb – not embodied knowledge, but rather *embodied knowing*.

Dewey was critical of epistemological approaches in which knowledge is discussed with little regard for the processes through which knowledge is known. In his pragmatic epistemology, he casts off the term knowledge as too vague, to focus instead on *knowing*, and to develop a theory of inquiry (Dewey 2008a). Knowing is not static but emerges from an active process of inquiry. It is rooted in experience, including our sensorimotor experience of being and acting in the world.

Importantly, Johnson advocates that this is a *transformative process*. The very act of inquiring into our experience changes it and ourselves (2010: 146). His argumentation is made from the point of view of arts-based research, mainly the visual arts. It also provides a relevant framework to consider the design methodologies presented here. They design from embodied knowing by leveraging the pragmatic methodologies of somatic practices into their processes. They acknowledge the transformational quality of these practices. And by extension, they consider the transformational potential of interaction as something to design towards.

11.2 Background

11.2.1 The Embodied Turn

From the 1980s on, the *embodied turn* in the humanities has endeavoured to establish embodiment as a keystone to understand cognition. It extends ideas from a number of sources, in particular: phenomenology (Husserl, Heidegger and Merleau-Ponty), pragmatism (James and Dewey), constructivism (Piaget), and ecological psychology (Gibson).

Positioned first as a counter to the classical cognitivist paradigm, *embodied cognition* has since branched into a variety of claims and implications (Wilson 2002). In practice, this is not a unified paradigm, but rather a range of approaches, not all of which are compatible or in agreement (Kiverstein and Clark 2009). We outline two interrelated ones here, each attempting to bridge traditional divides. *Enactivism* delineates the continuity between mind and life, and introduces relevant methodologies to overcome the opposition between objective and subjective views. Johnson's work on *embodied aesthetics* challenges the conventional separation between low-level and high-level cognition, to establish the sensorimotor roots of more abstract or analytical forms of thinking.

11.2.2 Enactivism

Enactivism emphasizes the circularity and multiplicity of cognitive processes (Varela et al. 1991), rejecting the "classical sandwich model of the mind" (Hurley 2002: 401), in which cognition is presented as a solipsistic process bookended between sequential phases of perception (input) and action (output). Enactivism considers instead cognition as a series of nested and concurrent processes, unfolding in ongoing interaction with each other and their environment.

The congruence of these different processes is what Maturana and Varela call the *structural coupling* of the system (Rudrauf et al. 2003: 36). The processes make sense of themselves by attuning to each other through mutual influences and gradual adaptations. The system as a whole self-organizes itself through distributed and dynamic adjustments. Conscious experience and meaning emerge then from these recursive influences between brain, body and world.

Enactivism is a relevant domain to inform the study of interactive systems because it articulates the situated nature of experience, and argues that cognition is a quintessentially interactive process. In that sense, we have been interacting with our environment long before there were so-called interactive systems. Enactivism also leverages a highly interdisciplinary approach to the study of the mind: recognizing the value of first-person inquiry (Varela and Shear 1999), introducing the often neglected perspective of second-person methodologies (Depraz et al. 2003), while also working to bridge or at least reduce the explanatory gap between

experience and third-person approaches, particularly through Varela's program of neurophenomenology (Rudrauf et al. 2003: 46).

11.2.3 Embodied Aesthetics

> Aesthetics is about the ways embodied social creatures like us experience meaning, and these ways of meaning-making emerge from the nature of our bodies, the way our brains work in those bodies, and the structure of the environments with which we are in continual visceral interaction. (Johnson 2015: 36)

Johnson's seminal work with Lakoff on conceptual metaphors approaches linguistics from an embodied perspective (Lakoff and Johnson 1980). It highlights the generative importance of metaphors, arguing that new meaning is created by mapping concrete situations into gradually abstracted concepts. Metaphors are thus grounded in our embodied experiences, conditioned by the specificities of our physicality, and they extend these qualities into cognitive domains that are not traditionally seen as metaphorical or embodied.

This example is emblematic of what Wilson characterizes as embodied cognition's sixth claim (2002: 632). Simply put, it aims to delineate to what extent the ways in which we think, even abstract thinking, are conditioned by the details of our physicality. For instance, how are our concepts of up and down coloured by our bodily structures and experiences as vertical bipeds? And how are these experiential qualities transposed to other cognitive domains?

Johnson follows this line of inquiry in a number of subsequent works, tracing the sensorimotor roots of meaning and thinking. Of particular significance here is his endeavour to reinvest aesthetics with epistemic relevance (2007). Classical approaches typically relegate the aesthetic dimension of experience to judgments based on feelings, and characterizes these judgments as non-cognitive. Such a "subjectivising of aesthetics" thoroughly segregates sensory appreciation from meaning, thinking, and any capacity to generate knowledge (Johnson 2015: 24).

Johnson draws instead on Dewey's pragmatist views to restore aesthetics as a fundamental and unifying quality of human experience, and to position it as the felt dimension from which meaning arises. Notably, Dewey foreshadows enactivism in grounding his aesthetic theory in the premise that "an experience is a product, one might almost say bi-product, of continuous and cumulative interaction of an organic self with the world" (2008b: 220). This interactive view of experience aligns closely with Maturana and Varela's notion of structural coupling between an organism and its environment (Sect. 11.2.2).

In later works Dewey also uses the term *transaction* to highlight the dynamic interdependence at the core of the relationship. Meaning arises then from patterns of felt experiences, co-determined in the transactional flow between self and environment. And these patterns are dependent on the potential affordances brought forth in the interplay between the two (Johnson 2015: 30). This highly interactive

view of aesthetic experiences resonates closely with similar ideas developed in embodied interaction.

11.2.4 Embodied Interaction

> Embodied Interaction is about the relationship between action and meaning, and the concept of practice that unites the two. Action and meaning are not opposites. From the perspective of embodiment, they form a duality. Action both produces and draws upon meaning; meaning both gives rise to and arises from action. (Dourish 2001: 206)

Following the embodied turn in the humanities and cognitive science, third wave HCI has similarly *turned* towards lived experience and the body, drawing mainly from phenomenology at first. The paradigm emphasizes the embodied and situated nature of interaction, and the construction of meaning afforded through interaction (Harrison et al. 2007). Since the 2000s on especially, approaches such as Dourish's *embodied interaction* have gained traction (2001).

Tracing back his conceptual background, phenomenology figures prominently (Husserl, Heidegger and Merleau-Ponty), providing a framework to articulate *lived experience* from a mainly individual perspective. To then consider intersubjective phenomena, Dourish references a second philosophical lineage, from Wittgenstein to Schutz's *social phenomenology* and Garfinkel's *ethnomethodology*. Another influence is Gibson's *ecological psychology*, which emphasizes the interdependence between an organism, its environment, and the activities afforded between the two.

Dourish establishes embodiment as the foundation of his design paradigm, and derives the crucial distinction that "embodiment is not a property of systems, technologies, or artifacts; it is a property of interaction" (2001: 189). Design focuses are then shifted away from systems and objects, to center instead on the 'I' of HCI – *interaction* – as the context within which meaning making unfolds. In effect, the activity of interaction circulates between *meaning* and *action*. Action is informed by meaning, but meaning also arises from action (2001: 206).

Note that Dourish elaborates the idea of meaning making as a characteristic of embodiment independently from the aesthetic lineage which we traced from Dewey to Johnson. He then extends this view of embodiment by considering the long-term influences between practice and technology, a process which he calls *appropriation* (2001: 204). A further implication left unexplored however, is that as practice and technology coevolve, the activity of meaning making also has the potential to transform embodiment itself. And by this we mean not just the moment to moment fluctuations in the flow of our experience, but a gradual evolution of the modalities in which we can and do experience.

This transformation of experience is what Johnson understands as *embodied knowing*, a key process also foregrounded in Shusterman's *somaesthetics*. Notably, both authors do so by complementing phenomenology with pragmatism, an influence which is absent in Dourish's account of embodied interaction.

11.2.5 Somaesthetics

> By integrating theory and practice through disciplined somatic training, [somaesthetics] takes philosophy in a pragmatic meliorist direction, reviving the ancient idea of philosophy as an embodied way of life rather than a mere discursive field of abstract theory. (Shusterman 2012: 3)

In developing *somaesthetics*, Shusterman draws from his background as both a philosopher and a somatic practitioner of the Feldenkrais Method. Like Johnson, he combines phenomenology, cognitive science and pragmatism, to establish aesthetics as a boundary breaking discipline: across conventional partitions between art and everyday life, and against the relegation of sensory appreciation to non-cognitive modalities, incapable of generating knowledge (Shusterman 2012: ch 6).

The term *soma* indicates an intention to obviate dualist views of mind and body, subsuming both to consider "a living, feeling, sentient body rather than a mere physical body that could be devoid of life and sensation" (Shusterman 2008: 1). Somaesthetics then, is an interdisciplinary program of inquiry into both the theory and the practice of this mindful body.

Shusterman distinguishes three interrelated branches in this program:

Analytic somaesthetics consists in theoretical and descriptive research to investigate the aesthetic dimension of experience, and the interdependency between body, mind and culture. This branch is the most interdisciplinary, relying on a range of disciplines, from philosophy to functional anatomy, to understand physical, physiological, psychological, and cultural aspects of embodiment (2012: 42).

Pragmatic somaesthetics elaborates critical and comparative evaluations of somatic methodologies. While relying on the analytical foundation of somaesthetics, it uses this source to engage embodiment with a prescriptive emphasis on purposive agency towards meliorative change. Of particular relevance are discussions on existing somatic practices, and the underlying strategies developed to cultivate various qualities of the embodied self (2012: 42).

Practical somaesthetics finally, concerns the actual practice and performance of somatic disciplines, to go beyond simply reading, writing and thinking about embodiment. This enacted component of the inquiry, mostly lacking in contemporary philosophy, is of crucial importance to ground the research experientially and empirically (2012: 45).

Ideally somaesthetics circulates fluidly within these three branches, leveraging a deep synergy between multiple and complementary modes of inquiry: theoretical reflections, stimulating the development of methodologies, enacted through practices. These are co-dependent processes, mutually enriching each other through recursive and iterative cycles of inquiry.

11.2.6 Lived Somaesthetic Reflection

Both Johnson and Shusterman advance aesthetic approaches in which usually segregated cognitive modalities are shown to be interrelated. Johnson demonstrates how abstract thinking and even logic can be sourced in sensorimotor cognition (Sect. 11.2.3). Shusterman's somaesthetics operates across similar demarcations, and makes notable contributions in a complementary direction.

He argues that the unreflective spontaneity of felt experience – the body as *background* – does not preclude cognitive modalities in which this tacit background is foregrounded through attentional and reflective practices (Shusterman 2008: ch 2). This important distinction leads him to a nuanced distinction. He recognizes phenomenology as a relevant and necessary first step to consider somatic consciousness. But he also draws from pragmatism to seek prescriptive and transformative methodologies to cultivate embodiment.

Merleau-Ponty's embodied phenomenology for instance, is a powerful evocation of the felt richness of being and moving in the world. For him, the body constitutes a primary background against which experience is implicitly delineated. It is "the third term, always tacitly understood, in the figure-background structure, and every figure stands out against the double horizon of external and bodily space" (Shusterman 2012: 48).

He endeavours to rehabilitate the body – philosophically – and restore our spontaneous connection to the felt dimension of experience. What stands in the way of returning to this fundamental subjectivity is our propensity for reflective and representational views. From such vantages, experience is usually masked and obscured. For Merleau-Ponty, embodied qualities elude reflective views because reflection operates in terms of reflective explanations that are reinterpretations overlaid over the original experiences which precede them (Shusterman 2008: 58).

Shusterman points out that this polarization is problematic though, to consider embodiment as a quality that can be deliberately practiced and cultivated. Such a process implies a stance both embodied and reflective. For Shusterman there is a middle ground of *lived somaesthetic reflection* (2008: 63). This cultivated alternative is the instrumental modality through which experience can be transformed through long-term practices such as somatics. In effect, somaesthetic reflection creates an opening to rehabilitate the body – in practice.

11.2.7 Fleshing Out Embodied Interaction

The relevance of these ideas to HCI has been recognized and advanced by authors such as Schiphorst (2009a), and Höök et al. (2016). They emphasize the value of practice-based knowledge derived from somatic practices, and they incorporate these practices as first-person and second-person methodologies into their design processes.

There is a parallel and a distinction to draw here, to delineate the manner in which these contributions extend the approaches that have defined the foundations of third wave HCI. About 12 years after the publication of *Where the Action Is* (2001), Dourish provides a retrospective assessment of his seminal contribution, acknowledging in particular that "the body has remarkably little presence in a book that is ostensibly about embodied interaction" (2013: 2).

His initial work came together in the context of a growing interest into physically embodied interactive systems. The corresponding technologies were making progress by leaps and bounds, and presented designers with novel challenges and opportunities. Within this shifting environment, the crux of Dourish's argument was to point out that a range of emerging questions could be fruitfully considered using existing frameworks – ethnomethodology and phenomenology – and to articulate the relevance of these frameworks for domains to which they had not been applied to yet.

Coming back to the more recent approaches developed by authors such as Schiphorst (2009a), and Höök et al. (2016), they initiate a reflection from a similar premise: embodiment is a core concern for HCI design processes. Then they go further by arguing that inquiries into embodiment should be *fleshed out* through actual embodied practices. Finally, they point out that there is a range of existing practices that have been developed to do just that: somatic practices (Sect. 11.3).

In effect, this fleshing out goes hand in hand with synthetic work to delineate some of the instrumental values and principles that underlie somatic practices. Schiphorst thus distinguishes four values: self, attention, experience and interconnectedness (2009a: 86). And Höök et al. articulate four qualities as guiding design principles: subtle guidance, making space, intimate correspondences and articulating experience (2016).

Aligning with Johnson's notion of embodied knowing as a transformational process, and Shusterman's cultivation of the self through somaesthetic reflection, embodied experience is approached here not only as a multimodal field to explore, but also as an ability to refine. Schiphorst characterizes this potential as *experience as skill* (2009a: ch 2). Importantly, this plastic and dynamic view of embodiment has implications for design both as a means and an end. It can be a source of potential insights and methodologies to design through. It should also be something we design towards, developing systems to support the cultivation of the self.

This dual view operates across the whole breadth of our embodied experiences. A variety of projects have been developed to investigate for instance the somaesthetics of touch, breath, light or heat (Schiphorst 2005, 2009b; Jonsson et al. 2016; Ståhl et al. 2016). Each of these sensory modalities implies specific affordances to be studied experientially and in relation to design processes. Jonsson et al. for instance highlight the "slowness and 'inertia' inherent to heat interaction" (2016: 116).

11.3 Somatic Practices

We present next the field of somatics, or somatic practices, beginning with a brief outline and describing two techniques: the *Alexander Technique*, and Steve Paxton's *Material for the Spine*. Our goal is to introduce what might be an unfamiliar topic through specific examples, and rely then on these examples to delineate some shared themes as well as distinctions. The recurring argument that embodied knowing should be grounded in actual practice applies here too. And thus our choice of these two techniques mainly reflects the fact that we have direct experiences of them. As practitioners we are able to provide deeper and more nuanced insights into their methodologies. Other techniques are discussed more contextually throughout the chapter, in relation to specific projects and principles.

11.3.1 First-Person Methodologies to Cultivate Embodiment

The term *somatics* was proposed by Hanna in 1976 to reference "the field which studies the soma: namely, the body as perceived from within by first-person perception" (1986: 4). Importantly, this was an act of naming rather than founding or inventing. Hanna, a somatic practitioner himself, recognized the relevance and commonality of a number of existing practices. These are quite numerous, going back in one case to the nineteenth century, and they are connected through a web of influences and direct transmission through practice (Schiphorst 2009a: 73).

Looking beyond the distinct methodologies developed in each of these approaches, Hanna identifies an underlying and previously unrecognized field. It entails a dynamic and plastic view of embodiment, and approaches experience as an ability that can be deepened through practice. This deepening is analogous to the cultivation of attention developed in meditational practices, with an emphasis on movement, proprioception and kinaesthetic awareness. Somatic practices operate through a range of strategies, from purely observational exercises in which one uses the mind to listen to the sensory echoes of what is already unfolding, to more active and voluntary movement exercises.

11.3.2 The Alexander Technique

> Give your directions, do nothing and then see what kind of nothing you are doing. (Barlow and Davies 2002: 234)

The *Alexander Technique* (AT) was created at the turn of the twentieth century. Faced with a recurrent problem of voice loss which conventional medicine failed to alleviate, F. Matthias Alexander embarked on a careful process of self-study. From

this pragmatic and experiential investigation, he developed a mindfulness based system to overcome harmful habits of use (2001).

Alexander realized that the issue was, in a sense, something he was doing to himself. He observed that, in the stressful context of live performance, he was tensing his neck muscles just as he was about to speak. This, in turn, strained his vocal cords and affected his voice. To become aware of this harmful pattern, Alexander had to *retune his senses*, using a mirror for instance, to observe with his eyes what was at first eluding his kinaesthetic sense.

Generally, our embodied references are conditioned by our habits. If I am used to stand slightly askew, my sense of standing will gradually align with the repeated experience of this skewed pattern, and the posture will feel centered. By contrast, if I suddenly adjust myself to correct the asymmetry, the unusual stance will likely feel lopsided. In effect, the skewed would feel straight, and the straight would feel skewed. Retuning the senses then, is a *critical deepening* of sensory appreciation: acknowledging that our embodied experiences are partial and biased, yet that they can also be refined and realigned through practice.

This however, is only part of the process which Alexander demonstrated first in himself, then through his teaching. The postural example given in the previous paragraph, while simple to apprehend, sidesteps two important issues. First, it is more or less static, considering set positions as opposed to movement. We might be able to change how we stand, outwardly at least. A shift in terms of how we move however, is orders of magnitude more challenging, implying sustained change at the speed of sensorimotor processes, and engaging the full complexity of our embodied structures.

Second, movement is a by-product of the dynamic flow of forces which underlies it and conditions it. This really is what concerns the AT: not shapes, positions, or even precise trajectories in space, but rather the ways in which we organize ourselves, to do whatever it is we are doing at any given moment.

At a physical level, this organization unfolds as transient patterns of muscular tone, continuously adjusted to coordinate the many parts of our embodied selves. Consider for instance the dynamic balance of the skull poised on top of the spine. Its center of gravity projects slightly ahead of the atlanto-occipital joint, where it swivels on the first vertebrae. And thus the head is not stacked vertically on the spine, but suspended as a forward counterweight, lengthening in turn the muscles in the neck and back that provide it with a counterpull (Dimon 2011: 77).

With each an every movement, whether a step or a reach of the hand, this subtle relation fluctuates and reverberates throughout the whole structure. For Marjory Barlow, a master teacher with close to 70 years of experience in the technique, “what we want is tone, which is length with strength” (Barlow and Davies 2002: 315). Too much tension creates unnecessary strain, as if we were ‘driving ourselves with the breaks on’. And with too little tension we collapse, instead of extending upward in reaction to gravity, and outward into space. Most importantly, too much voluntary intention, in the sense of attempting to micromanage our embodied structures, interferes with the involuntary sensorimotor processes that are meant to coordinate our many parts, and do so at a speed much beyond conscious thinking.

Experientially this complex and dynamic process of organizing ourselves in movement correlates with Alexander's notion of *use*. With this simple term he is reminding us that in everything we do we are in effect using ourselves. Far from implying a utilitarian view of embodiment, the suggestion here is that all of our movements have underlying modalities of use that can be attended to and inflected. We expect that a dancer or a musician would bring a sense of care and subtlety to deepen their artistic practice. The Alexander Technique proposes to extend a similar quality of nuanced attention to the full range of our embodied interactions. And it alludes to the possibility of an art of living in which movement and action are filled with mindful presence.

We conclude this outline with two instrumental concepts and an important methodological distinction. *Directions* are mental intentions that can be put into words, such as 'let the neck be free' (Alexander 2001: 20). In a session these intentions are renewed (spoken or thought), while at the same time the student is given an experience of the 'free neck', guided by the hands and touch of the teacher. Gradually, through many repetitions, a connection is thus created between the intention of a free neck, and the embodied organization which makes the free neck possible.

This two-step process is characterized as *non-doing*. Cognitively it is a detachment and letting go from doing things directly. A distinction is made between sending an intention of movement as a voluntary decision, and then letting involuntary sensorimotor processes enact that movement, taking care of the fine coordination necessary for it. In that sense, the AT elaborates a methodology to investigate the interface between conscious thinking and involuntary sensorimotor processes.

11.3.3 Material for the Spine

> With Material for the Spine, I am interested in alloying a technical approach to the processes of improvisation. It is a system for exploring interior and exterior muscles of the back. It aims to bring consciousness to the dark side of the body, that is, the 'other' side, or the inside, those sides not much self-seen, and to submit sensations from them to the mind for consideration. (Paxton 2008)

Material for the Spine (MFS) is a dance technique developed by Steve Paxton, an influential artist and master of postmodern dance. It aims to "bring consciousness to the dark side of the body" (Paxton 2008). This *dark side* comprises the more opaque elements of our embodied structures, such as the deep layers of spinal musculature discussed in Sect. 11.4.

In a pedagogical context, MFS combines open movement explorations with a set of rigorous exercises. These are practice forms including fundamental patterns such as helixes and undulations. They are important for physical training, but even more so to train the mind. The learning process does not aim to define a fixed taxonomy of movements, but rather through repetition and inquiry to sensitize the mind to the patterns. Just like frets on the neck of a guitar, references are created so that the

mind can orientate itself with ease and efficiency within a continuum of kinaesthetic possibilities, to make movement decisions in real time.

Like the Alexander Technique, MFS operates at the interface between conscious thinking and involuntary sensorimotor processes. Paxton's *small dance* exemplifies one strategy to experience and explore such a liminal kinaesthetic modality. It is a movement meditation in which one observes the process of standing, using attention to listen to the sensations arising from the activity (Paxton 1997a). In this state of lowered activity, in the seeming stillness of the stand, a stream of minute falls and recoveries gradually reveals itself to consciousness. A slight bending of the knee for instance, triggers a stretch reflex, which in turn brings the knee back and closer to vertical alignment (Woodhull 1997).

These are postural reflexes, happening whether we pay attention to them or not. Because they are small in scale, and relatively fast in time, they are usually masked by higher levels of activity and stronger sensations. The methodology here is a minimalist movement focus to foreground through quietness what is usually lost in background to more voluntary actions. Just as Cage discovered the primordial music of his blood flow and nervous system in the silence of Harvard's anechoic chamber (Cage 1961: 8), Paxton leverages stillness to experience the reflexive activity which holds us upright.

Godard similarly defines *pré-mouvement* as our unconscious relation to weight and gravity, which exists before we even start moving (1995). It is involuntary but conditions and colours all of our gestural expressivity. Godard emphasizes the initiations of movements: transient patterns of organization that anticipate our intentions. If we reach forward with the hand for instance, the first muscles to engage are the postural muscles of the calves. This involuntary preparation is necessary to counter the weight transfer that is about to happen when the arm shifts forward (1995: 225). Both Paxton and Godard highlight the importance of involuntary postural reflexes to organize and coordinate our relation to gravity, ground and space. These processes escape intention but are necessary conditions to its enactment.

11.3.4 Mind-Body Pragmatism

> There is something in nature that forms patterns. We, as a part of nature, also form patterns. Our mind is like the wind and our body is like the sand. If you want to know how the wind is blowing you can look at the sand. Our body moves as our mind moves. The qualities of movement are a manifestation of how the mind is expressing through the body at that moment. (Cohen 1994: 1)

Somatic practices operate in ways that are eminently pragmatic. In her introduction to *Body-Mind Centering*, another somatic practice, Bonnie Bainbridge Cohen writes of the mind and body as wind and sand. One can understand the dynamic patterns of the wind by observing the traces it imparts on the sand. This might be interpreted as a dualist statement, yet is seemingly contradicted on the same page as

she expresses that "when the body is experienced from within, the body and mind are not separated but are experienced as a whole" (Cohen 1994: 1).

In somatic practices, the standoff between dualist and monist paradigms is usually left aside as a false dichotomy (between two conceptual stances), based on a second false dichotomy (between mind and body). Philosophical issues such as the failure to bridge the explanatory gap between mind and body are at best secondary to the immediacy of movement and experience. While emphasizing that mind and body are experientially integrated, somatic practices leverage at the same time complementary views to consider the mind and the body through multiple descriptive levels.

This pragmatic approach aligns closely with Dewey's view on "the integration of mind-body in action" (2008c: 29–30). For him it is not an ontological dilemma to speculate about, but rather a practical issue with far-reaching consequences for individuals and societies. The fallacy he argues, lies in substantiating the results of processes as if they were the causes of these processes. Matter for instance is simply the "character of events when they occur at a certain level of interaction". More generally, "the distinction between physical, psycho-physical, and mental is thus one of levels of increasing complexity and intimacy of interaction among natural events" (2008d: 200). Remarkably, Dewey is foreshadowing contemporary ideas on emergence, in which various disciplines are positioned as nested levels of description emerging from underlying processes.

One more point worth mentioning here, often ignored in scholarly accounts, is that Dewey was closely involved with the Alexander Technique. He met Alexander in 1916, and soon started taking lessons over a span of 35 years, during which he also wrote the introductions to three of Alexander's book (Alexander 2001). Dewey recognized that the technique had not only benefited his health, but also informed his philosophy, allowing him to "transform [his theories of mind-body] into realities" (Dewey 1939: 44–45).

We follow a similar approach here, avoiding problematic speculations to focus on matters of practice: that physical movement can be to varying degrees imagined, intended and enacted; and that we can listen to the sensations arising from these activities. And just as Dewey found in the Alexander Technique a means to realize his theories, we argue that design approaches focused on embodiment have much to gain from incorporating actual embodied practices into their design processes.

11.4 Somatic Challenges

To understand the methodological strategies developed in somatic practices, we consider here some of the challenges that they have to address. In his seminal article to establish somatics as a field, Hanna points out that "somatic learning begins by focusing awareness on the *unknown*" (1986: 7). Paxton evokes a similar view when he proposes to "bring consciousness to the *dark side* of the body" (2008). And in the Alexander Technique we aim to let go of the familiarity of our habitual patterns of

use, to cultivate instead an openness to change. Embodied inquiry it seems, leads to a *terra incognita*, which is the always present yet elusive background of our sense of embodiment.

A first challenge we face is that the sensorimotor roots of embodiment are, to some degree, both *transparent* and *opaque*. This apparent contradiction in terminology is resolved by considering that in both cases there is an issue of not seeing: opacity prevents us from seeing what we are trying to see, transparency is not seeing that through which we see.

In our natural attitude, we do not think much about how we move, unless maybe we are learning a new skill. Mainly, we intend, and then expect our intentions to be enacted towards whatever our goal is. Varela draws from Heidegger to describe this unreflective stance as "*transparency* as disposition for action" (1999: 298). Alexander similarly points out our tendency to focus on *ends*, with little regard for the *means whereby* we might attain these ends (2001: 27).

This unreflective transparency recedes if we are jolted out of habit by something unexpected or problematic. The typical Heideggerian illustration is of a tool breaking down. Suddenly we have no choice but to pause and inquire as to what went wrong. Varela insists however that such a shift is not necessarily accidental, and "can also be endogenously motivated". In particular, "the gesture of carrying out phenomenological reduction is a loss of transparency by self-motivation" (1999: 299).

Somatic practices such as the Alexander Technique or Material for the Spine similarly propose to upend the habitual transparency of our embodied processes, particularly in relation to movement and kinaesthetic awareness. Just as with the technique of phenomenological reduction, this implies a sustained practice of attention. Over time we can refine our capacity to experience, and lift portions of our dark side into consciousness, while also realizing that such a process is delicate, and to some extent always partial. Embodied processes, even when attended to, remain elusive. We encounter here the issue of *opacity*.

If we imagine a sort of brute force approach to minding our sensorimotor processes, even a cursory look at functional anatomy reveals an overwhelmingly complexity. The musculature of the back for instance, comprises five layers (Dimon 2008: 104). The superficial muscles just under the skin are most familiar. They are large, powerful, and in a kinaesthetic sense sort of loud, thus easily accessible to conscious experience. Going deeper however, the structure becomes more complicated. The innermost layer, closest to the spine, contains a multitude of delicate muscles connecting pairs of adjacent vertebrae in various parallel or diagonal directions. In movement, all of these muscles have to be coordinated in real time.

This fine control of interdependent elements is further complicated by what the Russian neurophysiologist Nikolai Bernstein defined in the 1960s as the *degrees of freedom problem*. When dealing with the moving body we are faced with a system that has high dimensionality and a high level of redundancy, in every aspect: anatomy, kinematics, and neurophysiology. So there are multiple muscles that act on the same joints, multiple possibilities of movements to accomplish the same goals, and multiple neural connections that can activate the same muscles (Bernstein 1967).

The terra incognita of our embodied structures, it turns out, is a high-dimensional dynamical system, which is bound to elude our capacity for conscious thinking. This is also a temporal issue. The threshold for conscious discrimination between two successive stimuli is in the 100 milliseconds range (Varela 1999: 273). This might seem short, but for high velocity movements a tenth of a second is a rather long time.

11.5 Somatic Strategies

> Given the complexity of natural processes, the developing and growing brain must find solutions based on simplifying principles. These solutions make it possible to process complex situations very rapidly, elegantly, and efficiently, taking past experiences into account and anticipating the future. [...] They may involve detours, an apparent complexity, by presenting problems in a novel way, changing reference frames, points of view, and so forth. Contrary to what we might think, simplifying is not simple. (Berthoz 2012: 3–4)

We face a puzzle, at least conceptually. How do we reconcile the complexity of our sensorimotor processes with the limited and relatively slow nature of conscious thinking? Moravec argues that our reasoning abilities are a relatively recent cognitive development, "the thinnest veneer of human thought, effective only because it is supported by this much older and much more powerful, though usually unconscious, sensorimotor knowledge" (1988: 15–16).

While his reflections are somewhat speculative, they echo a recurring argument from Sect. 11.3. Somatic practices operate at the interface between voluntary and involuntary processes. In the AT we "give [our] directions, do nothing and then see what kind of nothing [we] are doing" (Barlow and Davies 2002: 234). In Paxton's small dance, standing is a chance to attend to our "reflexes as easily observable events that the consciousness is not causing and can take a moment to wonder at" (2015: 39).

Understanding the interplay between different cognitive modalities underpins much of the research done in embodied cognition as well. In addition to the ideas outlined in Sect. 11.2, this includes for instance work on enactive models to account for how high level sociocognitive skills emerge from dynamic interactions between personal, subpersonal, and neural processes (Hurley 2008). For Paxton, exploring these liminal kinaesthetic modalities, while potentially disorientating, is an opportunity. "Dizziness […] signals that we have reached the borderland between these two aspects of physical control – conscious and reflexive. When we linger in the borderland on purpose, we become our own experiment" (1997b: 257).

More generally, Berthoz's notion of *simplexity* is useful to consider here (2012). He defines it as a ubiquitous principle at work in natural systems, as they evolve simplifying solutions to deal with the complexity of their environment and themselves. Simplex principles operate through many of our embodied structures and processes.

A typical example is the stabilization of the head exhibited by mammals and birds. Even in highly kinetic activities, the head floats in almost perfect lines or broad curves, in spite of, or rather thanks to all the activity happening between it and the ground. Stabilizing the head facilitates the work of perception at the expense of increased motor coordination. Berthoz describes this process as "a veritable 'inertial guidance system'". In effect, organizing the whole body from the floating point of reference of the head resolves some of the redundancies discussed earlier in relation to Bernstein's degrees of freedom problem (Berthoz 2012: 130).

Berthoz is analyzing embodied solutions that are primarily evolutionary designs. We argue that his notion of simplexity is just as useful to consider the cultural techniques of somatic practices. They face a similar challenge: the need to find simplifying solutions to navigate the complexity of the soma. Following this parallel suggests that such simplex strategies will entail detours, changing reference frames, and leveraging multiple points of view.

11.6 Multiple Perspectives to Navigate the Soma

The previous point clarifies a potential misconception about somatic practices. Since they are concerned with the felt experience of being and moving in the world, we might assume that they operate exclusively within that single perspective of first-person sensory appreciation. This, possibly, is a lingering echo of reductive views, which merely substitutes one segregated focus for another.

In actuality, the shift from linguistic turn to embodied turn has done more than swivel a narrow beam of inquiry from language to body. Rather, it is most compelling as a widening focus through which embodiment can be considered from a range of perspectives. We have seen how enactivism traces the continuity between mind and life, and seeks to bridge the opposition between objective and subjective views (Sect. 11.2.2). Johnson establishes the sensorimotor roots of language and even logic, to reinvest aesthetics with epistemic relevance (Sect. 11.2.3). And Shusterman proposes somaesthetic reflection as an instrumental modality through which the primacy of lived experience can be intentionally cultivated and transformed (Sect. 11.2.6).

The same methodological breadth is implicit in somatic practices, a breadth which can then be leveraged and extended to design processes that incorporate somatic practices. For instance, the practice of Paxton's Material for the Spine (Sect. 11.3.3) interweaves multiple ways of learning and knowing: studying anatomy, relating this abstracted knowledge to lived experience, going back and forth between the egocentric perception of one's own movement and the allocentric perception of the same movement demonstrated by the teacher, leveraging kinaesthetic empathy to mediate this back and forth… The movement practice also encompasses a range of somatic strategies, from purely observational meditations such as the

small dance, to more prescriptive exercises in which specific patterns are repeatedly honed. In an Alexander Technique session, the one-on-one interaction between student and teacher is similarly multilayered, operating in the moment through touch, sight and speech, and extending beyond the immediate through reading, reflection and day-to-day observation.

These examples demonstrate that somatic practices, while seeking an integrated sense of embodiment, also incorporate a range of perspectives and modes of interaction into their methodologies. This breadth has much to do with the challenges outlined in Sect. 11.4. To navigate the complexity of the soma we need maps, a variety of access points, and multiple views from which to inquire. If we now extend that premise to interaction design, it suggests that technological mediation is an opportunity to further multiply the perspectives.

11.7 Design Methodology: Moving and Making Strange

> Husserl's phenomenological methodology asks us first to make the familiar strange. In effect, through the procedure of bracketing, one defuses reactive or reaction-type responses and lets the sensuous reality of what is present sink in – deeply, into one's bones. (Sheets-Johnstone 2017: 10)

Investigating interaction as an additional perspective to inform somatic exploration underlies a number of design projects, and is perhaps most explicit in Loke and Robertson's *Moving and Making Strange* methodology (2013). The name of the framework is inspired by Sheets-Johnstone's notion of making the familiar strange, and correlates with Husserl's phenomenological technique of *epoché* or *bracketing*. By suspending our natural attitude, and inhibiting our usual patterns of reaction and interpretation, *making strange* aims to return to a phenomena as if experienced in the fullness of a first encounter. Applied to somatic exploration the strategy relies on defamiliarizing familiar movement patterns through slight variations in enaction or attention. In effect, the strategy also supports breaking through the transparency of habitual movements (Sect. 11.4).

Loke and Robertson's work came out of several empirical projects, conducted over a span of 6 years, and involving dancers and performers with a variety of movement and somatic backgrounds. The resulting methodology is developed as a flexible toolkit for designers, and implements the following principles: "making strange, direct bodily experience, multiple perspectives, openness to phenomena, and creativity" (2013: 7:9). In practice, it is structured around three perspectives – mover, observer, and machine – and seven types of interrelated activities.

The *mover* provides the first-person perspective of felt experience, and establishes the primacy of embodied knowing. This perspective operates primarily through activities 1, 2 and 3. The *observer* provides a second-person perspective (or observational perspective in the paper), through which the felt experience of the

mover can be situated in relation to "a range of different and complementary views including, but not limited to, the biomechanical, expressive, social, cultural, and ecological". This second perspective is explored in activities 4 and 5. The *machine* finally provides a computational perspective which is conditioned by how movement is mapped and interpreted by the system. This third perspective relates to activities 6 and 7 (2013: 7:11–12).

The seven types of activities appear below, in Fig. 11.1, reproduced from the paper. As is clear from the diagram, the methodology proposes much more than a list of potential activities. What it does is elaborate a processual analysis of how different types of activities can inform and be informed by each other. This is a generative and flexible approach with a high potential for practical variations. The paper includes a detailed list of examples for each type of activity. It develops important tools for designers to find novel ways of working with movement, and conversely, it also contributes new insights on somatic methodologies, a domain which remains largely undertheorized.

11.8 Design Methodology: Radically Interdisciplinary Dialogues

Schiphorst's approach to embodied design is situated at the intersection between third wave HCI practices and somatic practices (2009a). The two fields overlap through a shared concern with experience, and have developed *technical* approaches to consider embodiment from their respective points of view. They each contribute specific methods to generate tacit as well as explicit knowledge. This common ground forms the basis for a radically interdisciplinary dialogue which is at the core of Schiphorst's research-through-art process (2009a: ch 1).

The methodology cycles iteratively between a series of processes integrating theory and practice (see Fig. 11.2). It interweaves *reflection-in-action* and *research-through-art* and elaborates a balanced inquiry through which the theoretical frameworks and the artworks that enact the frameworks are mutually developed and refined. Schiphorst highlights in particular the importance of determining the *bridging strategies* through which embodied knowing from somatic practices can be applied to and inform design (2009a: ch 4).

Notably, these interdisciplinary influences are not restricted to specific phases of the design process. Schiphorst articulates this instrumental breadth in a series of case studies, demonstrating how somatic practices can be incorporated at every step (see Table 11.1).

Schiphorst also conducts an analysis of the principles underlying the first-person methodologies of somatic practices, from which she delineates four values as guiding principles to orient the design choices (Schiphorst 2009a: 86):

- The value of *self* as enactor of change, knowledge and transformation.
- The value of *attention*, self-observation, awareness in relationship to the self.

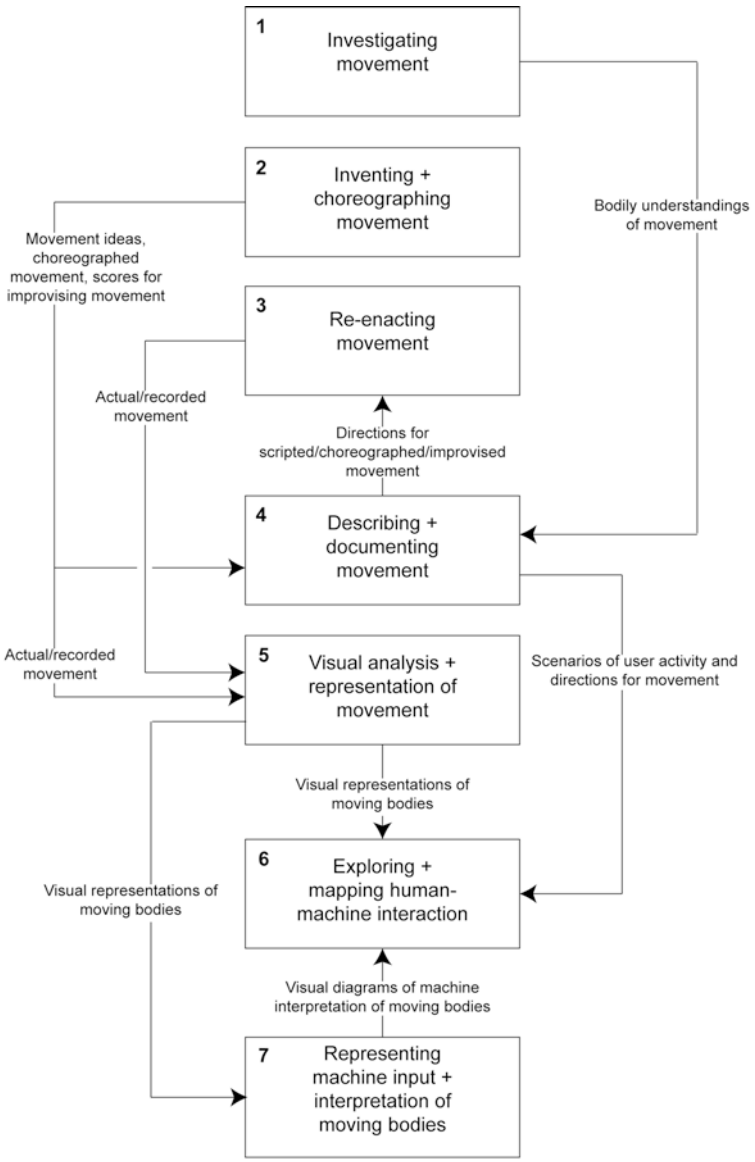

Fig. 11.1 The key activities promoted by the methodology. The labels on the arrows indicate the data generated by an activity and the direction of the arrow indicates the flow of data from one activity to another. From (Loke and Robertson 2013: 7:11)

- The value of *experience* as a source of knowledge, through which language gains its integrity and ethical connection to knowing.
- The value of *interconnectedness*, in relation to mind and body, self and world, subjective and objective, theory and practice.

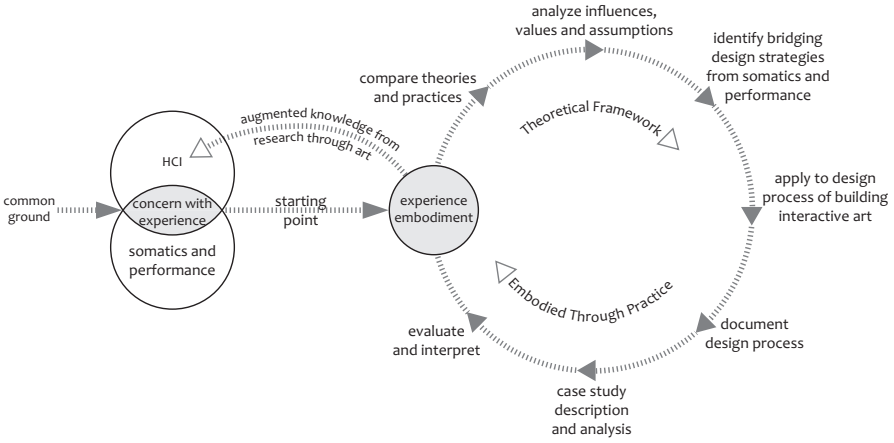

Fig. 11.2 Design process bridging multiple methodologies. From (Schiphorst 2009a: 31)

11.9 Case Study: Designing with Breath – *exhale*

> Exhale is an interactive wearable art installation. […] In exhale, breath, skin and clothing come together within a set of evocative and sensual skirts that are embedded with body-area-networks that exchange and elicit breath within a shared network. (Schiphorst 2009a: 172)

We outline next one of Schiphorst's case studies – *exhale* – indicating in particular how the four values were carried over into the design methodology (see Table 11.2). Coming out of previous explorations into a wide range of somatic modalities, Schiphorst decided to narrow her inquiry to a single focus – *breath* – as a physiological source of information as well as an experiential phenomenon. The project demonstrates a process of "research-through-art […] in the context of experience-design for tangible, wearable and social interaction" (2009a: 32).

Breathing is an unusual physiological activity because it bridges the voluntary and the involuntary. We keep breathing whether we are conscious or not, in wakefulness and in sleep. As an involuntary process it operates independently of our volition, much like digestion or the beating of the heart. But we can also make a conscious choice at any moment to inhale or exhale. This dual nature is leveraged in a number of practices that either attend to or modulate breath. It can be a pool on the surface of which we observe the ripples of affective reactions before they become fully conscious. Or it can serve as an indirect means to shift our internal states, by controlling the quality or pattern of the breath.

Exhale aligns with these practices and extends them through the concept of *wearing our breath*. A series of skirts was developed, fitted with sensors, actuators, and network nodes. Each skirt tracks variations in the quality of breath of its wearer. These subtle cues, as well as gestural inputs, are analyzed by the embedded interactive systems as indicators of state, using biofeedback and what Schiphorst calls "subtle machine learning" (2005: 62). Through the installation as a whole, each

Table 11.1 Use of somatic techniques within design cycle. From (Schiphorst 2009a: 126)

Use of somatic techniques within design cycle
Experiential discovery led processes
Workshops
Attentional skill development
Creativity development
Field studies "of the self" (self-efficacy)
Training acuity of the researcher
Experience discovery of participants
Exploration of use of body, movement, space
Cultural probes
Narrative inquiry
Conceptual design
Articulation of experiential qualities
Interaction design – Mechanisms for choice, sharing, control, presence
Gestural interaction
Conceptual development
Materials design
Materials properties and uses in defining experiential qualities
Materials integration
Collaborative approaches to creativity, conceptualization and engineering
Technology design
As a basis for an interaction heuristics
Collaboration between interdisciplinary strategies
In refining definitions of experiential quality in interactivity
Evaluation
Experiential efficacy
Connection with self
Incorporating first- and second-person techniques to assess and evaluate "wholeness" (Alexander)

participant's intangible state is manifested through the materiality of the skirts, sound, light, physical actuators, and potentially shared through the network.

For the participants it facilitates a deepening of attention, reinvesting a familiar embodied pattern by disclosing it through new sensory modalities, and creating opportunities for playful agency. It also turns this internal experience into a shared and networked one, an emergent group-breath ecology mediated by experience and technology.

Table 11.2 Summary of somatic values and techniques used in exhale. From (Schiphorst 2009a: 127)

Designing with breath – *exhale*	
Value	
Self	Body-state
	Breath
	Inner awareness
Attention	Attention to breath
	Kinaesthesia
	Fullness – Emptiness
	Inter-subjectivity and awareness through shared breath
Experience qualities	Imagination
	Stillness
	Connectedness
	Empathy
Interconnection	Breath relationship
	To self
	Receive from other
	Choice to "hold" or "contain"
	Create larger whole
Somatics systems applied	Body-mind centering (Bonnie Bainbridge Cohen)
	Kinetic awareness (Elsa Gindler)
	Attention to breath (redirection)
	Slowing movement (suspension)
	Expansion (letting-go)
	Wholeness

11.10 Designing for Kinaesthetic Awareness

*11.10.1 Case Study: s*still, moving

This final case study is a project that we recently developed, described in more details in (Françoise et al. 2017), with further reflections on the use of somatic practices and designing for kinaesthetic awareness in (Candau et al. 2017). The next sections cover some materials from the latter publication.

Still, moving is an interactive sound installation, designed to support a person's kinaesthetic awareness, particularly of the micromovements underlying pedestrian activities, as in Paxton's *small dance* (Sect. 11.3.3). The system generates continuous auditory feedback in response to the participant's physical activity, and leverages an adaptive mapping strategy to refine its sensitivity and increase sonic resolution at lower levels of activity. We decided to use Myo bracelets, as these interfaces track both *movement information* and *muscle tension* (8 EMG sensors

spread around each bracelet), which makes them ideal to work with kinaesthetic awareness and reveal the subtle changes in muscle tension underlying micromovements.

The pair of Myo bracelets are placed on a person's lower legs. Muscle tension is tracked by processing EMG data using a Bayesian filtering technique initially developed for prosthetics control. These forces are rescaled using an adaptation level computed as the maximum of the force over the past 10 seconds. This adaptive process provides a kinaesthetic zoom as the system's sensitivity increases when the level of activity decreases. The rescaled forces control the synthesis of sound textures using concatenative sound synthesis, combining two corpuses of environmental field recordings (water sounds and dry rustling leaves).

11.10.2 Somatic Details Matter

We propose here a short comparative discussion, considering *still, moving* in relation to two other systems. Our aim is to point to the diversity of somatic strategies developed in various practices, and emphasize how seemingly small variations in these strategies can have strong experiential consequences, and are actually leveraging distinct affordances.

A range of systems use continuous auditory feedback to improve movement performance, foster kinaesthetic exploration, and support learning. *Sarka* (Bergström and Jonsson 2016) was developed using *Somaesthetic Appreciation Design* (Höök et al. 2016). The system sonifies subtle changes of pressure on a mat to "support the ability to direct attention" while lying on the mat. *Slow Floor* (Feltham et al. 2014) was inspired by the *Butoh* practice of slow walking, using pressure sensitive resistors to sonify the subtle transfers of weight of the walk, and support a heightened awareness and agency.

Our movement focus is closer to *Slow Floor*, as we are interested in the micromovements underlying the unique *verticality* of our biped structure, most obvious in movement patterns such as walking and standing. Both Paxton and Godard highlight the importance of involuntary postural reflexes to coordinate our relation to gravity, ground and space (Sect. 11.3.3). Godard uses the concept of *pré-mouvement* as an analytical tool to observe the fine textures that imbue our larger movements with a "postural musicality" (1995: 224). And Paxton initiates a practice to disclose this world of micromovements to consciousness, which changes in turn our ways of being and moving (2015).

The horizontal and vertical affordances leveraged in *Sarka* and *Slow Floor* resonate with strategies used in somatic and dance practices. Essentially, these are salient variations to explore how we organize ourselves in relation to gravity and the support from the ground. The authors reference respective inspirations from the floor exercises of the *Feldenkrais Method*, and the slow walk of *Butoh* dance. Practices often combine a range of such strategies. In Paxton's *Material for the Spine* for instance, one might first exercise pointing the sitbones to the heels while

lying on the floor, and then transpose this experience into a walk. The *Alexander Technique* similarly combines table work (lying down in semi-supine), chair work (sitting), as well as standing and walking.

Experientially, horizontal and vertical patterns are highly differentiated and afford distinct possibilities. In lying down we are fully supported by the floor, weight crosses the skeletal system transversely, skin pressure easily comes to the foreground, and various rolling patterns are available as support from the floor can be found through many body parts. In standing, we first have to enact our verticality from the narrower base of our footprints. At the same time there is a potential lightness, when we fully leverage our postural structures and channel weight through the skeletal system. The center line of our verticality is then a place of minimal effort, and any deviation from this upright axis propagates through the structure as a commensurate increase in muscle tension. In that quiet suspension of the stand, micromovements that are usually dampened or deafened can be revealed.

This is but a glimpse into the variety of somatic strategies that have been developed and designed to access specific experiential modalities. Within this diversity *details matter*. Differences such as working with eyes open or closed, standing or lying down, are not just mechanical changes. Experientially, these shifts can be momentous: affecting our sense of being, determining our possible futures in terms of available kinaesthetic choices, and changing how we organize ourselves.

11.10.3 The Practice of the System

The previous section relates to the affordances of systems: a mat lends itself to lying on it, a floor to walking on it. Conversely, we also need to consider the affordances of practices, and specifically of the *practice of the system*. For *still, moving* we were interested in drawing from somatic strategies in which the synergy between a range of levels of activity is explored, as opposed to remaining mainly in one state or level. Paxton's *small dance* was similarly developed not only as a quiet meditation, but also as a preparation to 'survive' the sometimes disorienting and high energy dances of contact improvisation (2015). In this meta strategy, the experience of one state is used to inform other states. It leverages the contrast between the states as a dimension along which to clarify a continuum of possibilities. And it relies on our ability to retain qualities nurtured in a privileged state as we shift into another one. The transitions can be fragile at first, the reverberance of a quality easily disrupted and lost. But with practice one develops the ability to retain a quality, or imprint the quality in order to retain it.

These considerations have guided us in designing the protocol for a qualitative study of the system. We structured the interaction sessions in three phases (see Table 11.3). Phase 1 is an open exploration giving participants a first impression of *still, moving* on their own terms. Phase 2 uses the small dance to bring attention to the micromovements underlying the stillness of the stand, and the sensitivity of the system to these minute shifts. Phase 3 opens up the exploration again, but with the

Table 11.3 Structure of the interaction sessions for still, moving. From (Candau et al. 2017: 2)

Phase	Activity	Facilitation	Audio source	Duration
1	Exploration	Open	Headphones	5′
2	Small dance	Facilitated	Speakers	10′
3	Exploration	Open	Headphones	5′

experience of the small dance still fresh and resonant. We took care to walk the participants through the structure before enacting it, to limit interruptions in the flow of their experience, particularly in the transition from phase 2 to 3.

Our overarching goal was to provide subtle guidance while retaining a sense of openness. The small dance is facilitated, but non-prescriptive, in the sense that there are no prescribed movements to enact. Guidance emerges from the act of observing a process that is already unfolding. The structure thus combines open exploration and open observation, letting the participants determine their own experiences. The interaction unfolds mainly on their own terms: motivated by their curiosity, mediated through their movement patterns, and informed by their sense of embodiment. This approach fosters the very process of inquiry and exploration that Johnson defines as a key component of *embodied knowing* (Sect. 11.1).

As must be clear by now, the design of this structure, the *practice of the system*, is as important as the design of the system itself, and largely informed by existing practices in somatics. Working with the soma affords a rich and subtle range of somatic modalities. Simply put, we can at any point lie down or stand up, listen in stillness or break into a run. And within each of these physical activities, there is a whole landscape of sensations to explore with our attention. Sensors and interactive systems are usually comparatively limited, more specialized in their affordances. While our attention can shift almost instantly, to observe from a range of perspectives, the Myo bracelets are only sensing from the point of view of the lower legs. Careful consideration of the specific affordances of the system and its practice is then all the more important.

11.11 Conclusion

We have considered in this chapter a number of related design approaches that incorporate somatic practices into their design processes, while also tracing the conceptual lineages and theories that inform or resonate with these approaches.

A recurring pattern in this conceptual background is that the first-person methodologies of phenomenology are usefully extended through pragmatist philosophy. The ground-breaking work of John Dewey is particularly relevant, yet not always recognized. He is notable as a philosopher who had a direct connection with, and practice of, somatics, through decades of lessons in the Alexander Technique. This privileged synergy between theory and practice is emblematic of what we see as the core dynamic in practice-based-research.

The type of embodied inquiry developed through somatic practices is a meaningful yet also delicate endeavour. Sensorimotor processes are complex, simultaneously transparent and opaque, and to some degree always elusive. For many somatic practitioners there is humility in realizing that while our capacity to experience can be refined and expanded, this process of transformation also reveals that there is always more beyond the horizon of our experience.

To overcome – partially – these challenges, somatic practices have developed a wide repertoire of techniques. These can be quite specific, and often circulate between multiple modalities, perspectives, and points of view. In effect, somatic practices operate through the fullness of felt experience, as well as various gradations of abstraction and synthesis. Note that these abstractions could be principles to work with, but also 'embodied abstractions' such as initiating a movement from a specific body part, and letting the body organize itself around this action.

In essence, we need both the territory of experience, and as many maps and entry points as possible, to navigate the complexity of the soma and orient ourselves. Given this intrinsic interdisciplinarity, the addition of technologically mediated perspectives is a natural extension for an already multilayered process. And the interplay between embodied interaction and somatic practices is of potential benefit to both fields. We can flesh out design methodologies by drawing from the vast repertoire of existing practices. Remarkably, this instrumental relevance is applicable to all stages of design processes. In turn, such a program of practice-based-research also stimulates new insights into somatics, a field which remains largely undertheorized (Ginot 2010).

This brings us to our final point. Much of the *embodied knowing* elaborated through somatic practices is embodied quite literally in communities of practitioners. As much as possible, we encourage interested designers to work with these communities.

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Chapter 12
Sound, Ecological Affordances and Embodied Mappings in Auditory Display

Stephen Roddy and Brian Bridges

Abstract The third wave of HCI has seen the widespread adoption of design principles borrowed from and informed by breakthroughs in the field of embodied cognitive science. These developments have taken place primarily in the contexts of visual media and interaction, but they are also of importance to the design of auditory displays and interactive systems in which sounds plays a dominant role, where they open up new affordances by which information might be communicated to a listener. This chapter examines the relationship between auditory display, sonic interaction design and embodied cognition and explores frameworks from embodied cognition that might inform the design of more informative auditory displays in a variety of contexts. It will do so by addressing these issues from an interdisciplinary perspective, bringing together insights from cognitive science and philosophy, general HCI and computer science, along with music theory and practice.

12.1 Sound and Its Affordances for HCI: Auditory Display, Sonic Interaction Design and Mapping

Sound is a modality with a number of specific affordances (Norman 1988; McGrenere and Ho 2000) which a HCI researcher and practitioner can exploit. It can offer contextual cues to inform interactions whilst not requiring space within a visual interface. Our ability to recognise a wide variety of sound sources allows us to use a diversity of sound materials as cues, either in isolation, or in combination with visual cues. We also have a significant degree of sensitivity to difference

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between successive or evolving sound cues, supporting the use of sound as a 'display' technique in its own right, which can provide us with a means of exploring complex data. Moreover, the apparent tactility associated with sonic responses which are synchronised with particular interactions (for example, the 'key click' sounds associated with certain touchscreen interfaces to reinforce a sense of successful key activation based on their associations with the effect of depressing a key on a mechanical keyboard) draws our attention to sound's embodied affordances and the manner in which our experience of sound may be consistent with a motor–mimetic hypothesis for perception and cognition; see (Godøy 2003). The timbre or textural profile of particular sounds may have implications in terms of our senses of causal connections and semiotics in interactive applications, based on aspects of apparent physicality associated with certain profiles (e.g. high/low energy, stable/unstable, detached/sustained, etc.). Overall, sound's properties as a perceptual modality offer a number of potentials for enhancing our interactive experiences within a variety of application contexts, be they to support reasoning and interaction or the simple presentation of information to a listener. This chapter will explore these properties in relation to both auditory display and broader contexts of sound in interaction design. The question of theoretical framework is of critical importance when working with sound in an auditory display context. Different theoretical frameworks can open up novel design possibility spaces while simultaneously closing down others. Because sonification and auditory display are primarily concerned with making meaning from data, designers must use theoretical frameworks which can account for this kind of meaning-making. This chapter explores a number of such frameworks.

12.1.1 Auditory Display and Sonification

Auditory display involves the use of sound to present information to a listener and sonification is a particular auditory display technique in which data is mapped to non–speech sound to communicate information about its source to a listener. Sonification can leverage the temporal and frequency resolution of the human ear, making it a useful technique for representing data that may be difficult to represent by visual means alone (Walker and Nees 2011). As we move further into the era of "Big Data", sonification and auditory display techniques are becoming ever more important for representing and understanding complex data sets and structures (Rimland et al. 2013).

A variety of different definitions of auditory display and sonification have been offered as these fields have developed. *The Sonification Handbook* defines auditory display in broad terms, as any display that uses sound to communicate information, with sonification being treated as a subset of auditory display that represents information by mapping data to non-speech audio (Walker and Nees 2011). The Sonification Report (Kramer et al. 1997) defines the area slightly differently. It casts sonification as "the transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication or interpretation."

These definitions have been instrumental in marking out the basic process involved in sonification and in guiding the direction of auditory display research.

The rigorously empirical spirit represented in Hermann's definition is of critical importance to the development of sonification research and practice. He argues that sonification is "the data– dependent generation of sound, if the transformation is systematic, objective and reproducible, so that it can be used as a scientific method" (see Hermann 2008). An approach based on design thinking is introduced by Barrass who defines sonification as "a mapping of information to perceptual relations in the acoustic domain to meet the information requirements of an information processing activity" (Barrass 1998: 29–30). With the recent discussions around the role of sonic information design in auditory display research (Barass et al. 2018), this definition has come to the fore again in the area. Worrall (2009) sees sonification as "the acoustic representation of data for relational interpretation by listeners, for the purpose of increasing their knowledge of the source from which the data was acquired." This is an interesting definition that asserts the importance of the original phenomena (data source) in a sonification. A similarly important definition is that of Scaletti, who defines sonification as "a mapping of numerically represented relations in some domain under study to relations in an acoustic domain for the purposes of interpreting, understanding, or communicating relations in the domain under study" (Scaletti 1994: 224). This simultaneously accounts for the 'hard' and 'soft' elements of sonification, acknowledging that it encompasses both formal mathematical concepts of representation and data transmission alongside the framing of data via mapping strategies which support humans in approaching the data via meaningful contexts. The definitions presented here represent only a small portion of those discussed across the literature; Supper (2012) explores the context in which they have been conceived in much greater detail. They are presented here because when considered as a whole, they offer an insight into the multitude of approaches and contexts within which sonification is situated by the research community.

12.1.2 An 'Embodied Turn' in Musical HCI and Auditory Display

More broadly, research in the fields of music technology, creative computing and digital arts is addressing sonic interaction design and the relationships between sound and the modalities of interactive systems, with active research communities engaged in designing new musical interfaces (e.g. the New Interfaces for Musical Expression conference) and sound's relationship with the broader computing field (including related work within the International Computer Music Conference, the Sound and Music Computing conference and the Computer Music Journal). Whilst initial research within the field of computer music was generally more concerned with technical developments within sound synthesis and signal processing than with interface modalities —an emphasis related in part to limitations in processing

power, requiring early computer music languages such as Music N to be based upon a composition–production paradigm of coding ('scoring') and rendering (Wang 2007) —the 1980s saw the beginning of a concern for new performance modes within musical HCI and electronic music, concurrent with the development of the MIDI (Musical Instrument Digital Interface) protocol, which was an early standard for treating sound synthesis/audio processing and performance technologies as separate tasks; see (Mathews 1991; Roads 1996). In spite of these early developments in interface and performance technologies, the tension between sound production/processing and interface technologies was still present enough that Paine (2009) could still lament the comparative "disembodiment" of the computer music field, noting perceptions of disconnection between performer, technology and audience. Roddy and Furlong (2013) have pointed out that part of the reason for this disconnect may also be related to a lack of "transparency" in the conceptualisation of sound synthesis processes and parameters stemming from the absence of the human body in live computer music performance. There is a large community of researchers developing solutions for introducing the body to computer music performance and composition. Roddy and Furlong (ibid.) further note that "modern computer music is composed mainly using techniques and technologies that were developed for a disembodied representational mind that exists in a positivistic world", citing Schafer's (1977) "schizophonic" divide arising from the technological decoupling of sonic or musical effect from physical/performative cause. However, in parallel with developing interests in HCI within the broader computing field, the 2000s has seen a significant degree of HCI–related work developing within the music technology and computer music fields. A notable feature of this work is its consideration of embodied structures on the basis of practice-based explorations of new forms of controller (Cook 2001; Tanaka and Knapp 2002; O'Modhráin and Essl 2004; Serafin and Young 2004; McPherson 2012), commentary on how performance gestures and affordances are treated (Jensenius 2014; Gurevich and Treviño 2007; Magnusson and Mendieta 2007; Hunt et al. 2002), and how these relate to broader HCI frameworks (Wessel and Wright 2001; Wanderley and Orio 2002; Buxton 1987).

A key question which underpins both auditory display and the design of interactive systems is the mapping problem—how to organise the relationship between input and output—be it a data set (in the case of auditory display) or interface (in the case of sonic interaction design). Discussing such mappings in relation to new instrument/interface design, Hunt et al. (2002) highlight the importance of the mapping layer, through a range of parameter mappings which range from simple (one–to–one correspondences) to complex (cross-coupled parametric mapping). They highlight how the latter can be conceptualised through (implicitly embodied) mapping relationships, such as energy (of interacting gesture) controlling brightness. Wessel and Wright discuss musical interactions and mappings within the conceptual frame of "intimacy", and specifically reference the field of embodied cognition as providing models for musical HCI (Lakoff and Johnson 1999), and Wanderley and Orio (2002) reference a target/gesture–based interactive framework from Buxton (1987), which is based on similar embodied discourses. Later work by Wilkie et al.

(2010) applies embodied models in the basic structural framing of WIMP–based musical interactions.

In order to more fully exploit the potential of sound to represent complex data, auditory display researchers have also begun to explore new frameworks for working with sound suggested by research from embodied cognitive science; see (Worrall 2010; Diniz et al. 2010, 2012; Roddy and Furlong 2014; Roddy and Bridges 2016; Verona and Peres 2017). This 'embodied turn' is recent and still developing. The current chapter is intended as a guide for researchers who are interested in adopting insights from embodied cognition to auditory display and sonic interaction design.

12.1.3 Embodied Cognition and Sonic Information Design

Representative of this 'embodied turn' in auditory display research is the burgeoning field of sonic information design. This field has emerged in response to the increasing pervasiveness of embodied interaction and user experience in auditory display research. Sonic information design refers to the application of design research, defined by Faste and Faste (2012) as "the investigation of knowledge through purposeful design", to auditory displays, auditory user interfaces and sonification. In focusing on design this approach aims to enrich user experience as a whole, by considering the role of situated-action, meaning-making, and aesthetic values in the design of data to sound mapping strategies (Barass et al. 2018). As such sonic information design is concerned with designing mapping strategies which can contribute to making a given data set meaningful. This central concern with meaning–making is also reflected in embodied cognition research practices. While the study of meaning–making has generally focused on linguistics and semiotics (excluding meaning-making in aesthetic experience), embodied cognition researchers address meaning-making and aesthetics and have presented strong evidence for the argument that meaning–making and aesthetic experience are underpinned by the common apparatus of embodied of cognition (Johnson 2010, 2017; Varela et al. 1991; Núñez and Freeman 1999). This concern with meaning–making suggests that embodied cognition might provide useful insights into the manner in which sonification can be used to make meaning of complex and difficult–to–represent data.

However an embodied cognition approach to sonification may also be useful in a number of other contexts. Many researchers have argued that some open challenges in the field of auditory display include a need for a comprehensive account of the cognitive processes at work during sonification listening (Vickers 2012; Neuhoff 2011; Gossmann 2010; Worrall 2009; Neuhoff and Heller 2005; Walker and Kramer 2004) and a need to embrace the aesthetic and creative aspects of sound for representing data (Barrass 2012; Barrass and Vickers 2011; Serafin et al. 2011; Vickers and Hogg 2006; Vickers 2005). An engagement with embodied cognition has the potential to offer approaches and frameworks to support these goals; the problem of listening modes and aesthetic engagement during sonification listening

highlights important issues for the efficacy of sonification approaches beyond the provision of meaningful framings (e.g. what types of listening and interaction contexts will support listener engagement).

12.2 An Embodied Cognition Primer for HCI Researchers

12.2.1 Embodied Cognition: Historical Roots

Embodied cognition is a research theme which arose to prominence in the late twentieth century as discontent grew with the growing inability of more purely computationalist approaches in cognitive science to offer adequate descriptions of emotion, culture and aesthetic experience and, most critically, for how symbols on the mental layer posited by traditional cognitive science researchers —see (Gardner 1985)— are assigned their meaning. The traditional computational model of the mind was first codified in 1967 by Hillary Putnam (Putnam 1967) as the classical computationalist theory of mind (CCTM) and further refined in the work of Fodor (1975) and in Newell and Simon (1976) physical symbol systems hypothesis. It claimed that the human mind was an information processor and that thought was a form of computation. Mental content, thoughts and perceptions were rendered as symbols, and thinking was conceived of as the rule–based processing of those symbols. But by the early 1980s, research approaches in psychology, cognitive science and computer science underpinned by the CCTM had attracted harsh criticism from a number of quarters. Even prior Putnam's foundational work, Ryle (1949) had presented the argument that computation could not simulate intelligence, as any mental symbol must derive its meaning from a prior mental symbol, ad infinitum, concluding in what later critics have termed, Ryle's regress. Dreyfuss (1965), in the context of cognitive science and artificial intelligence, argued that symbolically mediated cognitive processes require a context of tacit and informal background knowledge against which to become meaningful, and that because the majority of human knowledge is non–formalisable, computation alone cannot account for human–level intelligence. A decisive 'no confidence' vote in the theoretical domain arguably came with Searle's (1980) 'Chinese Room' problem, which showed that whilst rule–based computation was sufficient to pass the Turing test, it was not sufficient enough to describe human understanding thus revealing some of the shortcomings of computationalism as a description of human–level cognition. Harnad (1990) would later formalise this question of how symbols acquire meaning as the symbol grounding problem, and while traditional computationalist models of the human mind could not solve the symbol grounding problem, an embodied cognition approach which grounds conceptual content in bodily experience since has (Glenberg and Robertson 2000; Vogt 2002; Steels 2008; Barsalou 2010).

Thinking stemming from embodied cognition has led to compelling conceptual developments in a number of sonification–related disciplines, e.g. computer science,

artificial intelligence and human computer interaction (Brooks 2003; Dourish 2004; Imaz and Benyon 2007), computer music (Leman 2008; Klemmer et al. 2006), cognitive sciences (Varela et al. 1991), visual perception (Noë 2009), aesthetics (Johnson 2013, 2017), music theory (Godøy 2006; Zbikowski 2005; Brower 2000; Larson 2012; Cox 2001), and linguistics and philosophy (Lakoff and Johnson 1999). Leading embodied cognition researchers (Johnson 1987, 2008, 2010, 2013, 2017; Johnson and Rohrer 2007; Maturana and Varela 1987; Varela et al. 1991) take as a central point of their arguments that the mind–encounters the world through the intermediary of the human body and so cognition and meaning making are mediated and shaped by bodily interactions with the environment.

12.2.2 Embodied Cognition: Conceptual and Philosophical Underpinnings

Where Gibson (1977, 1978) explored how the environment may be considered to shape perception (and, arguably, 'lower–level' cognition), embodied cognition is more concerned with the manner in which 'higher–level' cognition of conceptual relationships is mediated by the interactions between the human body and its environment and, perhaps, between various conceptual structures which have been 'imported' from familiar bodily and environmental structures (Lakoff and Johnson 1999). Johnson (2008) presents a comprehensive theory that accounts for symbolic, linguistic and conceptual meaning, and also the kinds of meaning associated with emotions, felt qualities of experience, and aesthetic experiences of art and music. Johnson and Rohrer (2007) claim that the "evolutionary embeddedness of the organism within its changing environments, and the development of thought in response to such changes, ties mind inextricably to body and environment." This builds on the work of Varela et al. (1991), who present the similar argument that meaning emerges in the reciprocal relationship, termed structural coupling, between organism and environment, as organisms evolve bodily–mediated minds to aid in effectively asserting themselves in their environments. In this view, any cohesive account of meaning-making must take the role of the body into account, because meaning-making is mediated by the human body and emerges in the interaction between that body and its environments. Johnson (2013) refines his definition of meaning making further in the argument that the meaning of an event, object or symbol is defined in relation to any bodily mediated past, present and possible future experiences it offers a subject.

Critical to this theory of meaning-making is the philosophy of experientialism or experiential realism (Lakoff and Johnson 1980): the claim that experience is the source of all meaning and, as a result, no meaning can exist in a form that is abstracted or separate from experience. This provides a middle ground between objectivist and subjectivist, materialist and idealistic, conceptions of knowledge and meaning. It rejects the idea that knowledge exists independently of the human mind and that perceptual and mental content is meaningful only to the degree that it

accurately represents its real world counterpart. It also rejects the opposite view that knowledge is a purely mental phenomenon and so a person can assign any meaning they choose to perceptual and mental content. Dichotomies between material and immaterial, subjective and objective are rendered meaningless in the experientialist context. This embodied understanding of knowledge and meaning-making relates closely to Husserl's (1913) lebenswelt, Heidegger's (1927) dasein, Dewey's (1934) "lived experience", Merleau-Ponty's (Ponty 1968) chiasm and Tode's (2001) thesis that the human body is the material subject of the world. In this approach perceptual and mental symbols, sonic or otherwise, become meaningful when they are associated with, and grounded in, embodied experiences (with reference to which they can be understood).

12.2.3 Embodied Metaphors and Meaning–Making Faculties

Theories of embodied cognition have described a number of cognitive meaning–making faculties thought to emerge in the shared relationship between similarly embodied organisms and environments. Embodied image schemata, first discussed by Johnson (1987) and Lakoff (1987) and further refined by Johnson and Rohrer (2007) as commonly shared fundamental gestalt patterns derived from recurrent patterns of bodily experience that provide people with a common basis for organising their experience, meaning-making and reasoning. They provide a basis for reasoning and inference by imposing their own unique logical syntax on chaotic raw experience independent of and prior to conceptualisation and language. For example Johnson's source–path–goal schema (Johnson 1987) describes the pattern shared by experiences in which a trajector, an entity that follows a trajectory, departs from a source and moves along a path towards an ultimate goal. According to the logic of the source-path-goal schema the source always precedes the goal and in order to reach a goal a path must be traversed. From this it can be reasoned that if a trajector is on the path then it has departed the source and is not yet at the goal and if a trajector is at the goal it can be reasoned to have departed from the source and traversed the path. These logical syntaxes organise experience into meaningful relations and can be used to lend structure to unfamiliar conceptual domains. In recent years they have be used in the design of intuitive computer interfaces (Imaz and Benyon 2007; Hurtienne and Blessing 2007). There is support for the claim that certain embodied schemata are common to large populations of people at a prelinguistic level (Hampe 2005; Johnson 2013; Lakoff and Johnson 1999; Lakoff 2012).

The concept of mapping appears repeatedly across the embodied cognition literature (Lakoff and Johnson 1999; Fauconnier and Turner 2002). It is used to associate content from one mental space (a broad domain of related embodied schematic knowledge), or domain of embodied human experience with content in another. It is the basic process by which perceptual and conceptual symbols are assigned meaning. For example in the concept of a 'red herring', the concept 'red' is mapped

from the domain of colour onto the concept of a 'herring' from the domain of 'fish', and for a person who is aware of the cultural connotations of the term, the concept of 'decoy' is also mapped onto the red herring.

Conceptual metaphors are a specific type of cross-domain mapping in which embodied schemata from familiar areas of experience, termed source domains, are mapped onto unfamiliar target domains that would otherwise be meaningless or unknowable, in order to make them meaningful (for further details see Lakoff and Johnson 1980). A classic example of a conceptual metaphor is the LOVE IS A JOURNEY metaphor in which the source-path-goal schema underlying a subject's experiences of journeying is mapped to lend familiar structure to the abstract concept of love. This allows 'love' to be conceptualised as a journey with a beginning, middle and end, where the lovers are travellers on a common path along which they may encounter difficulties and perils. In an embodied conceptual metaphor, the source domain provides a grounding within the embodied schemata of sensorimotor experience (Lakoff and Johnson 1980).

The concept of the conceptual integration network or blend was introduced by Fauconnier and Turner (2002) to describe how new structures of meaning can be created from basic embodied schemata during acts of creative and artistic thinking. A blend cross–maps conceptual content and embodied schemata from one mental space to another, thereby creating entirely new mental content that represents a blend of the content in the input spaces; for a more detailed analysis see (Fauconnier and Turner 2002). For example the mythical concepts of the Pegasus and Centaur have been described as blends between the concepts of a bird and a horse and the concepts of a man and a horse respectively (Martinez et al. 2012). It is argued that such conceptual metaphors, mappings and blends are more than useful tools for interpreting and understanding the world, but are the faculties by which the experience of any intelligible world at all is made possible (Lakoff and Johnson 1999; Fauconnier and Turner 2002). Indeed, empirical studies—discussed in (Lakoff 2012)—have shed some light on the neural underpinnings of these cognitive faculties. They show that embodied schemata, conceptual metaphors and conceptual blending recruit neural networks in the human brain and sensorimotor system which are associated with bodily perception and action to perform a sensorimotor mimesis of the patterns of neural activity associated with gesture, perception and proprioception within the nervous system (ibid.).

Lakoff and Johnson's embodied image schema theories offer a range of conceptual metaphors which may be of particular utility in HCI contexts. The aforementioned source–path–goal model encapsulates a key modality within interactions. Indeed, this prototypical action/interaction is described in strikingly similar terms by Buxton (1987), who focuses on the path–goal stages in his pursuit–tracking and target–acquisition models of an action in an interaction design context. This path-based centric/targeting relationships also relates to many of the key embodied image schemata proposed by Lakoff and Johnson (see Fig. 12.1, below): centre–periphery (i.e. a given target as centre), container (targeting region as a distinct space 'containing' a particular function or set of functions), etc. Indeed, Buxton (ibid.) and Wanderley and Orio (2002) also highlight cases of constraints which include both

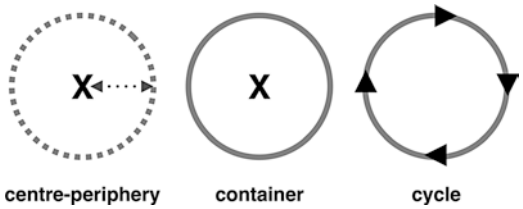

Fig. 12.1 Centric/targeting schemata from Lakoff and Johnson (centre-periphery and container), alongside cycle schema (constrained cyclical, iterative motion); c.f. Buxton (1987); Wanderley and Orio (2002)

linear path–goals, and constrained circular motion (akin to a cycle schema within Lakoff and Johnson's typology). Although Buxton's typology was advanced during an earlier phase of HCI (when WIMP–based interfaces were the state–of–the–art), the importance of arrangement of interfaces based on blending spatial and embodied functional logics can only be reinforced within the context of touchscreen and gesture–tracking–based interfaces. Indeed, Wessel and Wright (2001), writing in the context of computer music performance systems, have specifically invoked the typologies of Lakoff and Johnson, particularly in target–based (drag–and–drop) and cyclical/iterative (scrubbing) contexts.

12.3 Embodied Sonic Meaning Making for Sonic Information Design: Current Models and Potential Applications

Having introduced embodied cognition and explored how research from embodied cognition may relate to key topics in HCI in general and auditory display and sound–based interaction in particular, this section will explore specific frameworks which may be applied in this context. It will address the problem from the twin perspectives of the affordances of interaction gestures and mapping forms, on the one hand, and the affordances of sound in perceptual and cognitive contexts, on the other. The discussion will be informed by a variety of interdisciplinary perspectives beyond embodied cognitive science, including research within cognitive musicology and theories and practices within electroacoustic/electronic/post–digital music composition.

12.3.1 Applications of Embodied Cognition Theory in HCI and Auditory Display

The first wave of HCI in the 1980s has been criticised for designing the user out of the system (Bannon 1991). Card et al.'s (1986) human processor model, drove the adoption of programmable user models (PUMs), as tools for evaluation in HCI research. Consistent with Newel's disembodied concept of cognition discussed previously, PUMs accounted exclusively for the classic computational theory of mind and resulted in the development of systems designed solely for the users' "rational" information processing faculties, which were severely limited in their usability (Bannon and Bødker 1989). Bannon (1991) discusses how frustrations with these approaches led the second wave of HCI to shift in focus from "from human factors to human actors" exploring situated and user-centric approaches and placing empirical testing of real users above the theoretical projections from generalised models. The third wave represented a further maturation of the second integrating something of an embodied turn (Dourish 2004) which according to Bødker (2015) challenged "the values related to technology in the second wave (e.g., efficiency) and embraced experience and meaning-making" as technology "spread from the workplace to our homes and everyday lives and culture" a sentiment echoed by Harrison et al. (2007).

Imaz and Benyon (2007) present an embodied approach to HCI design where image schemata, conceptual metaphors and conceptual blends are exploited in the design of more user-friendly technologies. Hurtienne (2009) adopts an empirical approach in his exploration of the efficacy of image scehmata for conveying abstract information in user interfaces and their practicability as a design language for designing intuitive use, finding image schema to be effective in both regards. Macaranas et al. (2012) make a similar study of image schemata and conceptual metaphors in tangible user interfaces, and Waterworth and Riva (2014) extend Imaz and Benyon's work to the domain of blended physical-virtual reality. Bødker and Klokmose (2016) offer guiding principles for more fully exploiting the potential of conceptual blending in HCI design.

Embodied cognition has been explored and applied in a number of auditory display contexts. Sonic interaction design (SID) is the study of interaction in the context of auditory display. Research in this area draws heavily from Dourish's (2004) concept of 'embodied interaction' as the creation, manipulation and sharing of meaning through engaged interaction with artifacts. Dourish's views are influenced by the embodied phenomenology of Mearleau–Ponty and a consideration of meaning-making in an interaction context. As such embodied interaction is rooted within a phenomenological understanding of embodiment that focuses on the import of bodily movement to meaning-making. It differs from the cognitive science based approach discussed in this chapter in that it is focused on bodily interaction rather than the cognitive faculties involved in sonification listening. Embodied interaction has become the dominant paradigm for sonic interaction design research (see DeWitt and Bresin 2007; Polotti et al. 2008; Kabisch et al. 2005; Rocchesso and

Bresin 2007; Bovermann et al. 2006; Rocchesso et al. 2009; Wakkary et al. 2005, Droumeva and Wakkary 2008; Droumeva et al. 2007).

Whilst embodied interaction addresses meaning–making in an interaction context, it does not account for how sound might exploit embodied cognitive meaning-making faculties for sonification. In recent times a number of researchers have begun to build upon the embodied interaction framework by introducing design principles informed by some of the cognitive faculties discussed previously. For example Antle et al. (2011) apply embodied schemata and conceptual metaphors to link sound and interaction to support reasoning in an interactive sonification system. Breaking from the sonic interaction design paradigm and focusing more heavily on the sonic aspect of auditory display, Brazil and Fernström (2006) draw from conceptual metaphor theory and Varela et al.'s (1991) conceptual framework for embodied cognition to explore the recognition of concurrent auditory icons. A number of researchers have taken the embodied approach further by exploring and applying principles from embodied music cognition to auditory display. Embodied music cognition is a field at the intersection of systematic and cognitive musicology in which researchers offer systematic descriptions of how music works which are grounded in results from embodied cognition research. Drawing from one such framework Leman (2008) and Diniz et al. (2012) have applied principles from this area to design easy to use interactive sonifications by exploiting the embodied cognitive aspects of musical meaning-making.

12.3.2 Environmental Models of Sound: Gestalt Psychology, Auditory Scene Analysis and Ecological Psychoacoustics

Gestalt psychologists, such as Rudolph Arnheim, who focused his much of research on the psychology of art, have created useful frameworks for thinking about and working with sound in an embodied context, derived from principles of organisation within an environment. Gestalt psychology was a school of thought on perception and cognition built around the central claim that the mind organises chaotic perceptions of reality (or a complex environment) into cohesive wholes where unified topological structure emerges on the basis of simple perceptual principles or laws (Köhler 1929; Koffka 1931; Wertheimer 1938). Central to the organisational laws of Gestalt psychology is the law of Prägnanz, which says the mind orders experience in a regular and systematic manner. Gestalt psychology has been extended to offer a systematic cognitive account of music perception on the basis of emergent meanings from gestalt structures (Leman 2008:30). Arnheim (1954) presented a theory of the balancing forces in visual aesthetics, suggesting that 'balance' and 'force' in a visual composition can be described by the juxtaposition of concentric grid patterns (centres) over a Cartesian grid pattern (the frame). The tension inherent in the juxtaposition of these gestalts manifests itself perceptually in terms of force, movement

and balance. Arnheim (1984) expands this to the realm of Western art music, with musical 'meaning' (in the form of aesthetic dynamics of tension and release) emerging from the fulfilment or subversion of expectations motivated by the law of Prägnanz that arise in this musical discourse. Meyer (1956) presents a similar theoretical framework for the emergence of meaning in music, situating Dewey's concept of lived experience and conflict theory of emotions within the context of Gestalt–based meaning–making, with the mind deriving gestalts from environmental, embodied experience, which are then used to structure the listener's expectations of a musical piece. Similarly, Johnson's (2008) characterisation of sonic (musical) organisation through metaphors which are not simply concerned with an individual body's relationships, but also those within the wider frame of an environment (his music–as–moving–force conceptual metaphor) can be seen as compatible with both the origins of Gestalt theories of aesthetics, and the details of their conceptual associations.

Another influential environmental (and Gestalt–influenced) model of perceptual relations within audio, one which has contributed directly to the ideas of many auditory display researchers, is Bregman's auditory scene analysis (Bregman 1990, 1994). Bregman (ibid.) describes describes how the auditory system applies the aforementioned Gestalt principles in ecological contexts to the organisation of streams of sound into perceptually meaningful patterns. Indeed, in an attempt to summarise these organisational (or grouping) principles, Bregman further traces the connection between these structuring principles and the environment by grouping them under the rubric of "environmental regularities" (Bregman 1994), including concepts of grouping by timbral/textural similarity and related phenomena (such as grouping by pitch/frequency proximity) as being due to 'gradualness of change' in streams of activity within an auditory scene. Indeed, the introduction to the chief aduitroy scene analysis text (Bregman 1990: 1) explicitly describes his broader approach and philosophy as being ecologically–based. Auditory scene analysis has drawn the interest of a large range of sonification researchers, and was originally recommended as a focus of perceptual and cognitive research in the field in the 1997 Sonification Report (Kramer et al. 1997), commissioned by the US National Science Foundation, and was again referenced as an important factor in sonification research in The Sonification Handbook (Walker and Nees 2011). A more complete review of projects which explore auditory scene analysis in sonification research is beyond the scope of this chapter, but nonetheless, the perspective of the affordances of sound's perceptual grouping principles as being related to environmental affordances can be seen as establishing points of compatibility with the broader perspectives of embodied cognition. In a similar fashion, Neuhoff (2004) ecological psychoacoustics borrows heavily from the Gibson's ecological approach to perception which structured the premise that an organism's actions are constrained by the affordances granted by its environment. He expands this definition to view auditory perception and cognition as the result of complex physical, physiological, and cognitive factors. This definition does not account explicitly for the nature of human embodiment. Ultimately, ecological psychoacoustics is a framework for understanding sound on the basis of (embodied) perception–action loops, and both Lakoff and Johnson

(1999) and Varela et al. (1991) have engaged with Gibson's theory of affordances in developing their theories. Whilst Varela et al (ibid.) note that Gibson's approach is rooted in a theory of naive realism (the belief that reality is represented to the listener directly), the broad thrusts of the concept of the affordance originating within an enactive environmental–interaction context, is still nonetheless seen as compatible with an embodied cognitive theory of mind and meaning-making. This is of particular relevance for the present purposes given that Gaver (1989) draws upon Gibson's theory of affordances to develop the auditory icon, a sonification technique that maps data to familiar everyday sounds, and Walker and Kramer (2004) also recognised the importance of an ecological approach to sonification.

12.3.3 Embodied Cognition and Cognitive Musicology

Reconsidering sound organisation from the perspective of ecologically–grounded perception and cognition may offer insights into the structural dynamics and meaning-making within the broader contexts of sonic interaction design and sonification. In a broadly similar fashion to the musical model of Johnson (2008), recent years have seen an engagement on the part of musicology (music theory) with principles and theories derived from embodied cognition. Cognitive musicologists such as Steve Larson (2012), Candace Brower (2000), Lawrence Zbikowski (2005), Arnie Cox (2001) and Jason Wyatt Solomon (2007) have all offered in-depth treatments of music in terms of embodied schemata, metaphors, graded categories etc. Larson (2012), Brower (2000) and Zbikowski (2005) each have a specific bent towards a top-down understanding of musical discourse in an embodied cognition context. Cox (2001) and Solomon (2007) focus on a bottom–up description, intended to demonstrate how music is built up from embodied experiences. Johnson's contributions seek to unite the two approaches. Cox achieves his aims through his mimetic hypothesis; see also (Godøy 2003). This suggests that listeners make sense of sounds by relating them to previous sounds they have made through a process of imitation at the sensorimotor level. Cox demonstrates how music cognition is intimately bound up with sensorimotor stimulation which provides the basic "physical" process by which musical meaning is enacted in the form of embodied schemata and embodied metaphors. His theory would go on to influence that of Johnson (Johnson and Larson 2003). Solomon maintains a focus on spatial gesture and attempts to build an embodied cognition framework to explain the spatial aspects of musical forces in terms of embodied cognitive skills, from that angle. Brower (2000) relates meaning and syntactical structure in Western tonal music to physical forces that act upon the human body, gravity for example, by way of embodied schemata and conceptual metaphors (directly referencing the schemata of Lakoff and Johnson). Larson expands his focus to three musical forces, gravity, magnetism and inertia that emerge from the inferential structure of embodied conceptual metaphor and embodied schemata. Zbikowski (2005) demonstrates how harmonic music is understood at a basic level in terms of graded categories of

musical events, in which prototypical members and their graded counterparts give rise to a unique syntax within a piece of music. Meaningful musical discourse can then unfold through the metaphorical cross–domain mappings that project embodied schemata into those category members (such as motives and rhythms) to root their meanings in terms of our embodied experiences. One category member may also blend with either another musical category member or extra-musical concept, and these blended spaces as well as the spaces elaborated through cross-domain mappings may be built up through more mapping to generate conceptual models. The inferential aspect of this blending leads to new understandings of one category member in terms of another. Through metaphorical mappings between schemata, categories and blends one can understand what it means for a passage to rise and fall or become choppy and then flow. According to Zbikowski (2005) and Lakoff and Johnson (1999), human auditory perceptual space is organised in terms of embodied schemata mapped across from other domains by processes of cross domain mapping, metaphorical projection and blending. Without cross–domain mappings of embodied schemata, music and auditory dimensions would not simply be meaningless, but would cease to exist in any cognisant way for the listener. Following this argument, it is only through the mapping of embodied schemata to the auditory domain that auditory attributes become cogent and meaningful. This has considerable implications for auditory display and suggests that meaningful sonification mapping strategies require consideration of the structures, originating contexts and conceptual associations of these embodied schemata and any associated blends within the domain of sound perception.

12.3.4 Auditory Imagery and Gestural–Sonorous Objects in Sound Environments and in Music

If sonic meaning is related to environment–derived embodied schemata, the manner in which we conceptualise sounds and their relationships becomes a crucial point of focus for the auditory display and sound–based HCI researcher. The manner in which these schemata are constructed with particular reference to sound as a sensory and environmental modality, therefore requires particular attention. In this regard, the study of auditory imagery may support the extension of embodied image schema theory into the sonic domain. An auditory image is any imaginatively generated sound experience that happens in the absence of an acoustic stimulus (Intons-Peterson 1992). It is a near ubiquitous and highly systematic phenomenon which can be quite rich and vivid. The term image refers to the imaginative process rather than the visual medium, and auditory imagery is imagined sound not an internal visual picture of a sound. A large amount of everyday auditory experiences involve auditory imagery in the form of sub-vocalisations and musical recount: the phenomena where one mentally re-enacts a piece of music. Armstrong et al. (1995) describe how subvocalisation acts as a kind of mimetic simulation of physical gestures in the vocal domain. Cox (2001) shows that this mimesis is a critical process for musical

meaning-making and describes how subvocalisation is an embodied process that provides some of the underpinnings for auditory imagery. Further studies have used fMRI data to reveal that auditory imagery involves the simulation of auditory cognition in many of the brain areas associated with auditory perception (Halpern et al. 2004; Hubbard 2010). Kiefer et al. (2008) have shown that both thinking about, or the conceptualisation of, acoustic features reinstates the same patterns of brain activity present during the perception of similar acoustic features. Godøy (1997) offers a good account of how auditory imagery is grounded in bodily action by Lakoff & Johnson's embodied schemata and the role that auditory imagery plays in the meaning making process. In an auditory display context, auditory imagery has been explored as a key meaning-making mechanism in sonification (Nees and Walker 2011; Nees 2009; Nees and Walker 2008; Nees and Best 2013).

In a similar fashion (and even closer to the discourse of embodied image schema theory), Godøy (2006) proposes the gestural–sonorous object as an extension of Schaeffer's sound object (objet sonore). He argues that Schaeffer "applied fundamental schemata of bodily experience to sound perception." As a result Schaeffer's original framework of typological and morphological categories for sound objects are all built around sound producing physical gestures. These gestures then become abstracted as image scehmata on the basis of which sound objects are gesturally encoded in the human mind. Godøy (ibid.) further builds upon this embodied image schematic aspect of the sound object incorporating embodied aspects of Smalley's (1986, 1997) framework to more comprehensively account for embodied meaning–making in terms of gestural sonorous objects. A number of researchers and designers have explored and applied Godøy's framework in the context of embodied approaches to sonification design (Tuuri 2009; Jensenius and Godøy 2013; Grond 2013; Worrall 2014; Barrett 2015; Seibert et al. 2015).

Beyond typologies for individual sound–gestures, Smalley's theory of spectromorphology (derived from sound spectrum and morphology) is an analytical framework for electroacoustic music (music based on both electronic materials and electronically–processed recordings) which advances a model for how timbres, textures and groups of sounds may interact dynamically in perceptual, aesthetic and conceptual terms. This model deserves particular attention here because it displays some striking resemblances to the cognitive competencies of embodied cognition, and accounts for sonic experience within composed contexts which utilise materials and structures which are analogous to 'natural' sound environments. The theory of spectromorphology was an extension of Schaeffer's (1966) objet sonore at the level of the perceived sonic footprint across the same dimensions as the spectrogram: frequencey and time. In retrospect Schaeffer's objet sonore has been shown to classify sound in terms of "embodied" categories (Godøy 2006). In developing Schaeffer's ideas into spectromorphology, Smalley has created an in–depth taxonomy for the embodied structure of auditory space. The framework relies on categorisation schemes that derive from "primal gestures extrinsic to music" (Smalley 1997), and is discussed through a framework which uses a language of gestures and forces. This would suggest that spectromorphological shapes are extensions of embodied schemata in the auditory domain. It is suggested here that embodied sche-

Table 12.1 Comparison of Johnson's dimensions of movement with Smalley's energy–motion profiles and embodied associations; after (Graham and Bridges 2014)

Johnson (2008): qualitative dimensions of movement	Smalley (1997): energy–motion profiles	Embodied meaning/association
Tension	Motion rootedness	Force/rate–effort= > overcoming inertia
Projection	Motion launching	Sudden rate-change/transient movement
Linearity	Contour energy/inflection	Coherence of path OBJ

mata provide the structure for the primal gestures upon which spectromorphology rests. Many of the dynamic structures described in spectromorphology share commonalities with the dynamic structures of embodied schemata described by Johnson (1987, 2008) with the compatibility being clarified further in Johnson's (ibid.) proposal of the music–as–moving–force conceptual metaphor.

Similar observations of the similarity between embodied schemata and spectromorphology have been made by Graham and Bridges (2014, 2015) and Graham et al. (2017). Specifically, Johnson's (2008) typology of qualitative dimensions of movement (and, hence, within this line of argument, conceptual structures), includes the dimensions of tension, projection and linearity. These dimensions deal with the connection between the manner of the movement's initiation and the form of the resulting gesture. Graham and Bridges (2014) highlighted the similarities that this model bears to Smalley's (1997) account of the implied energy–motion profiles of individual sound events or groups of sound events within his theory of spectromorphology, see Table 12.1, below.

Tension and motion–rootedness are correlated with an embodied expectation (force–dynamic) of the effort required to overcome inertia: the persistence of a system's grounded/stable state. Projection/motion–launching implies that a significant application of force may instigate a large–scale movement, the degree of which may dictate the form that the continuing gesture's linearity/contour–energy takes (e.g. a more coherent or incoherent path). Given the broad correspondence, these theories may be fruitfully combined to contribute a shared framework for mappings within auditory display and sonic interaction design.

This corollary of an embodied cognitive model based on a metaphor of moving objects and forces draws our attention to the manner of execution of a particular embodied image schema in the context of interaction and mapping. For example, a source–path–goal schema may be initiated via a motion that requires greater effort to overcome inertia. Projection denotes an extremely energetic movement such as a sudden rate–change movement with less inertia that results in an event that continues to sustain itself for a longer period of time. Linearity denotes whether a resulting path is more coherent and incoherent, relating to the manner of its execution. Thus, certain regions within the temporal evolution of a sound event (or stream of sound events) within a sonification may be framed as meaningful based on localised variations upon an overall structural trend. In the context of HCI, interaction based on centre/periphery models can also be informed by force/inertia dynamics, with

velocity of an interacting gesture treated as a surrogate for force (e.g. MIDI, many touchscreen applications, Lemur, etc.). Moreover, Graham and Bridges (2015) and Graham et al. (2017) have proposed ways in which these embodied frames ('embodied narratives') may align with the three–dimensional timbre–space relationships uncovered by Grey (1977), combining the more straightforward embodied associations of a verticality schema (within spectral centroid position), with ideas of spatial/timbral presence (presence or absence of attack transients) and degrees of 'dynamism or inertia' (fast or slow temporal evolution/envelope profiles). These relationships are outlined in Fig. 12.2 and Table 12.2, below.

A number of auditory display researchers have recognised and explored the close relationship between electroacoustic music practices and sonification

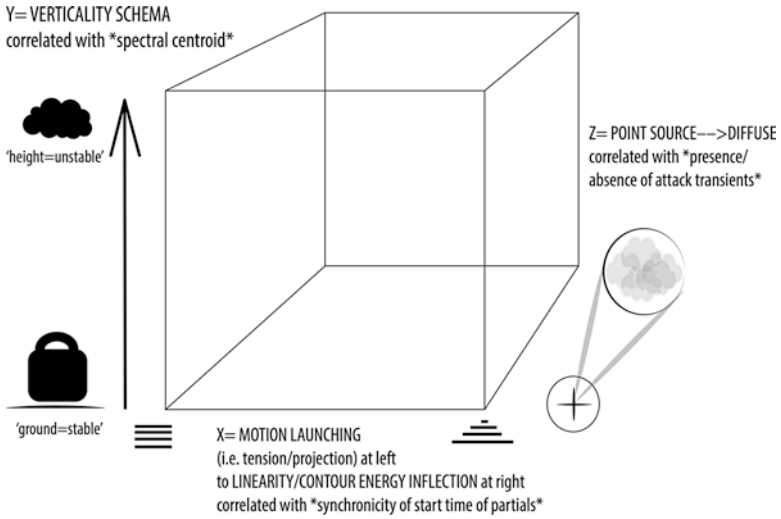

Fig. 12.2 Applying embodied–cognitive rubrics to the classical three–dimensional timbre–space model of Grey (1977); from (Graham et al. 2017); image © B. Bridges (2017)

Table 12.2 Dynamics within the three dimensions of this embodied timbre–space model; after (Graham et al. 2017)

X axis: Dynamic 1: Temporal Synchronicity of Attack Envelopes	X axis ranges from motion launching (rapid dynamic change, more synchronous entry) to gradual contour energy (asynchronous entry of partials)
Y axis: Dynamic 2: Spectral energy distribution: Height vs. rootedness	Y axis via the spectral centroid gives us two parallel scales and dynamics: Contour energy (verticality schema: Pitch height) and associated motion rootedness; regions of stability
Z: Axis: Dynamic 3: Spatial clarity within individual sound sources	Z via presence or absence of attack transients articulates motion rootedness or tension (audible transient products of inertia) to ungrounded events (diffuse or sustained tones). This is related to a diffuse–to–point source spatial coverage schema

(Vickers 2005; Vickers and Hogg 2006; Barrass and Vickers 2011; Fencott and Bryan-Kinns 2010; Worrall 2013; Miranda, Bonet and Kirke 2016). Diniz (2012) draws heavily from spectromorphology and embodied music cognition, as developed by Leman (2008), to develop an empirically grounded conceptual framework and related technological implementation (JOINDER) for non-verbal sound communication within the domains of interactive sonification and musical composition. Diniz is concerned with the important role that interaction in top-down and bottom-up cognitive processes. As such, his framework uses spectromorphology to inform the design of data to sound mapping strategies where the data is derived from from technologically mediated spatial explorations and aims to provide a "human centered foundation for the design and implementation of more efficient tools within the auditory display and musical production community." Drawing from a number of similar threads to those discussed in this chapter, Barrett (2015) adopts an embodied cognition approach to sonification which integrates Godøy's gestural sonorous object framework with Cox's (2001) mimetic hypothesis and the concept of surrogacy from spectromorphology (Smalley 1986). This is undertaken in the context of the development of an interactive parameter–mapping 3D spatial sonification program called Cheddar (Barrett 2015).

12.3.5 Embodied Cognition and Solutions to the Mapping Problem in Auditory Display

We now return to the central issue of the mapping problem within auditory display and related applications. As noted earlier, this is a key problem within both auditory display and general sound–based HCI contexts. In the field of auditory display, Flowers (2005) has highlighted the central importance of this problem with the observation that, in his experience, "meaningful information does not necessarily arise naturally when the contents of complex data sets are submitted to sonification". Framed in this way, the mapping problem asks how data can be mapped to sound in a way that presents the data to a listener in a meaningful manner. Worrall (2009) suggests that the mapping problem poses a significant challenge to the effective application of more orthodox parametric sonification approaches such as parameter mapping sonification (PMson). The present chapter considers the mapping problem in auditory display from two primary perspectives. The first is the question of how to design mapping strategies which can support the effective communication of data to a listener and the second, which is often referred to as dimensional entanglement (Worrall 2010, 2013), is concerned with the intermingling of auditory dimensions traditionally assumed to be separable within traditional sonic frameworks (such as PMson). For example while pitch, loudness, duration and timbre can be mapped to unique data these dimensions are not independent. Changes in one dimension can cause changes in another obscuring the intended data to sound mapping strategy and making it difficult for the listener to interpret a sonification

(see Grond and Berger 2011; Peres and Lane 2005; Flowers 2005; Worrall 2010; Peres 2012). It has been argued that this aspect of the mapping problem is a result of the way sound is parameterized by sonification designers (Roddy 2015). Dimensions adopted from conceptual paradigms discussed previously, in which a computationalist understanding of knowledge and meaning, wherein the listener is a computer of abstract perceptual symbols that reveal their meaning through computational processing on a mental level supposedly devoid of any real link to or grounding in embodied experience, cannot account for how humans make and assign meaning. While such dimensions are useful for describing and measuring sound in terms of the acoustic waveform, and its perceptual correlates, they are not necessarily useful dimensions for communicating information in a sonification context. Truax (1984) argues that the prevailing common sense understanding of sound in the West is built around a model of energy transfer. In this model the energy of physical excitations are transferred to physical waveforms that are in turn transferred to sonic experiences in the mind of the listener. He argues that this model is adequate for quantifying sound in terms of physical phenomena but is not sufficient for describing how sound communicates information to a listener. Wishart (1996) makes a similar argument about Western art music. He reasons that as Western art music evolved the focus of composers shifted from creating and organising musical performances to creating and organising written scores. This reduced the rich multi-dimensional spectra of musical discourse to just three primary dimensions: pitch, duration and timbre. These dimensions represent a small sub-set of the many possible dimensions of sonic experience. Worrall (2010) argues that this reductive approach to music is informed by the computationalist theory of mind and that modern music technologies employed to create sonifications are built around this same disembodied framework which fails to account for the role of the embodied performer and the perceptual and cognitive configuration of the embodied listener. The reduction of the rich spectra of sonic experience to non-orthogonal dimensions of pitch, duration, amplitude and timbre, the appropriation of these isolated dimensions as the primary channels for communicating information to a listener and a disregard for the embodied perceptual and cognitive faculties of the listener in interpreting a sonification have all contributed to the mapping problem. In this context, new models of the dimensions of sonic communication are required for an embodied approach to sonification that might address this problem. In the sonic information design paradigm, this need to find more communicative dimensions of sound for representing data becomes a practical design problem which must be solved whenever a designer designs a sonification. Similar principles from embodied cognition have already been successfully applied to help solve similar design problems in the context of HCI intuitive user centered visual interfaces (Imaz and Benyon 2007; Hurtienne and Blessing 2007) and tangible interfaces (Macaranas et al. 2012) and can also be used to similar effect in auditory displays (Antle et al. 2011).

A suggested framework for helping to design sonification solutions which address the mapping problem is the embodied sonification listening model (ESLM) (Roddy 2015), represented in Fig. 12.3. This model uses a conceptual metaphorical mapping to describe how listeners derive an understanding of the data from the

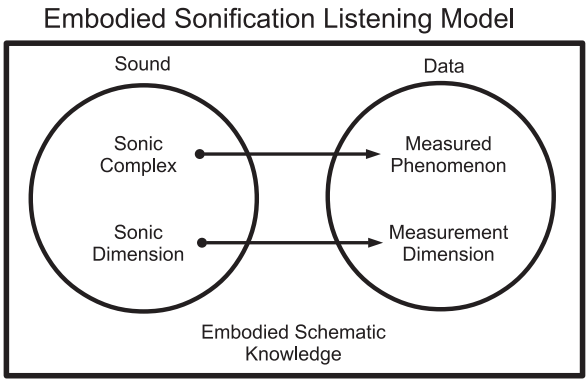

Fig. 12.3 The embodied sonification listening model from (Roddy 2015)

sounds presented in a sonification. It introduces the sonic complex as a sonic metaphor for the measured phenomenon, e.g. a specific animal, and the sonic dimension as the sonic metaphor of the dimension of measurement in the data source e.g. the weight profile of that animal over time. The mapping from sonic metaphor to imagined data is mediated by the listeners embodied schematic knowledge. The model and its application are described in greater detail by Roddy (2015). Designing sonification solutions on the basis of models of this nature might help the designer to develop solutions which account for some the embodied cognitive components of sonification listening.

12.4 Conclusion: HCI, Sonification, Multi-modal Aspects Grounded by Embodied Cognitive Frameworks

Whilst the wider field of HCI has benefited greatly from developments in embodied cognition research, auditory display and its related sub-disciplines are in a position to further benefit from adopting an embodied approach. Frameworks from embodied cognition can help to design auditory display solutions which rise to the challenges posed by the sonic representation of complex multivariate data sets, and exploit the communicative potential of sound and sound synthesis techniques. They can also help to capitalise on the opportunities offered by a new wave of gesture–based controllers and interaction modalities. This chapter explores a number of such frameworks which, the authors argue, might be of use to researchers and designers working with sound in a HCI and auditory display context. In making the case for applying an embodied cognition approach to these problems, we note that HCI research has the potential to engage still further with this rapidly developing field. The authors believe that a broad interdisciplinary approach, integrating methodologies and expertise from cognitive science, philosophy, electroacoustic music practice and design, will support innovations within auditory display and sound–based HCI research and praxis.

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Chapter 13
The Methodological Pivot

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Abstract This essay formalizes a mode of inquiry called 'transdiscursive material practice' based on the communication theory of Niklas Luhmann. Technologies are understood to be in the environment of discourse, and thus amenable to an indeterminate number of disciplinary investigations, which are articulated within the operational closure of communication systems. This mode of inquiry begins with material practices which are refracted through any number of discursive lenses that are brought to bear on the prototype through the process of the methodological pivot.

13.1 Sketching Transdiscursive Material Practice

Today the place of making in inquiry is becoming increasingly prominent, not only through the expansion of doctoral programs in art and design, but also in the growing trends of developing makerspaces as part of a general innovation network connecting makers to educational institutions and startup accelerators and incubators. New interdisciplinary programs, whether mobilizing existing or producing new knowledge, are integrating the skillsets of art, design, engineering and computation toward new kinds of research in the academy, or products for the marketplace. Increasingly, there is a need for a first principles approach that can orient making and inquiry across any possible disciplinary and technical configuration, as existing models such as reflective practice, design thinking or art-based research do not fully capture the epistemological and discursive dimensions of developing a robust R&D program around making. New developments in understanding interdisciplinary collaboration, such as proposed by the concepts of 'trading zones' and 'interactional expertise' do not explicitly foreground making as a component of exchange amongst experts, beyond noting that artifacts can function as 'boundary objects' between disciplines (Gorman 2010). In making, however, the artifact is not at the boundary

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but rather at the center of inquiry. It constellates its own multi-disciplinary character through the relevant methodological pivots.

This chapter will sketch a new variant of what might otherwise go under the headings of inter-, multi- or trans-disciplinary research and production, what will be called *transdiscursive material practice*. This mode of inquiry builds on Niklas Luhmann's concept of autopoietic communication systems, in which systems produce distinctions through operations of self- and other- reference in an environment to which they are structurally coupled. To remain a sketch, I will limit the discussion to a short summation of Luhmann's ideas.

In Luhmann's theory, technology is in the environment of communication. Distinctions, also understood as observations, are always produced by the autopoietic systems which produce forms of self/other reference, and which exist in various environments. For Luhmann there are three autopoietic systems that are the focus of his extensive oeuvre: social, psychic and biological. His 'supertheory' as he called it – by which he means a theory which includes itself in its own observations – proposed this triadic model as a solution and alternative to the traditional modern mind/body dichotomy. For Luhmann, only communication communicates, i.e. minds or bodies do not communicate. E.g. if a mind wishes to communicate, it would be through the structural coupling of language or gesture or some other form of meaning, since the operational closure of minds is demonstrated by the fact that we are not telepathic. Similarly, the body's processes are not open to either directives spoken in language or thoughts aimed at it, but has its own operational closure. If one becomes ill, positive thoughts directed at the illness tend to have little effect; rather medicine intervenes at the level of the body's own autopoietic and operationally closed processes. Mind, body and communication are systems that take each other as their local environment. The environment itself makes no distinctions, and it falls to the particular observing system to produce meaning through both its own operational closure and structural coupling to an environment.

> Observing systems...have *no contact with the environment* at the operational level. All observation of the environment must be carried out in the system as an internal activity with the aid of the system's own distinctions for which there is *no correspondence* in the environment. Otherwise, it would make no sense at all to speak of observing the *environment*. All observation of the environment presupposes the distinction between self-reference and other-reference, which can be made only in the system (where else?). (Luhmann 2012: 49)

> Communication systems do not know that communications contact nothing else but communications. Systems therefore operate under the illusion of having contact with the environment– at least so long as they only observe *what* they observe and not *how* they observe. (50)

> Technology...operates orthogonally to the operational closure of autopoietic systems. This is likely to explain why societal evolution takes recourse to technology in order to secure couplings between the societal system and its environment. (318)

> [C]ommunication has to presuppose technology and be able to rely on technology in all *present* operations (322)

Society is understood as an ecology of functionally differentiated communication systems, such as mass media, law, the economy, the political sphere, education,

art and science (or academic inquiry generally). In society, each of these communication systems is operationally closed with respect to the others, despite some relations between them of dependence, perturbation or structural coupling since they take each other as their environment in the ecology of society. While academic communication is functionally specialized and distinguished from other social communication systems, within academic discourse there is no operational closure between the disciplines, since in his terminology all academic knowledge is based on the same orienting code (to be discussed shortly). Communication systems, which are autopoietic (i.e. self-producing) are only operationally closed relative to each other when they change codes, programs and media. Such differences are not evident between different academic disciplines, since all of the academic disciplines are part of the same general communication system, and thus there are no operational boundaries between them. In everyday social contexts, academic disciplines might appear to have a kind of 'faux operational closure' between them that ultimately does not stand up to either analytic scrutiny or practical inquiry.

All academic disciplines are susceptible to cross-pollinations between them since by default there is no difference in the guiding codes, which are always binary. Examples of codes in Luhmann are:

- Law: legal/illegal
- Economy: possession/non-possession
- Politics: conservative/progressive
- Science: true/false
- Mass Media: information/non-information

In addition to codes, communication systems have media – such as money, ballots or television– and programs "to implement the code" (Mattheis 2012). In mass media, for example, the main programs Luhmann distinguishes are news, advertising and entertainment. Academic disciplines would be analogous to different programs which all share the same code – true/false, arguments about what Dewey (2013) would call 'warranted assertions' (one might say alternately – warranted or unwarranted assertions)– and the same media (e.g. academic journals and conferences). Operational closure exists between autopoietic systems such as law, economy, politics, science or mass media, which together comprise the ecology of society. But within such a system, however, there is no closure, and thus, within the system of science (or inquiry), all academic disciplines are in principle operationally open to all others, since they are only different programs using the same codes and media.

I argue that *transdiscursivity* emerges from this general empirical situation of all academic disciplines differing only in their programs for implementing the same general code in the same media. Further, all technologies are outside of, or in the environment of, all discourses. A discourse in the context of HCI research is a communication system for making distinctions about technology as the environment for human systems, whether psychological, physiological or social. In the context of making-oriented research, one way this is manifest is that there is no limited set of discourses that can be brought to bear on any technology, and in fact technology is open to discursive observations from any if not all disciplinary positions.

This general state of transdiscursivity is herein joined to material practice as a mode of inquiry. Material practice, following the main line of Western thought on techne and labour– from Aristotle through Hegel and Marx which is synthesized in Lukács' social ontology (1980)– is the entraining of causal chains to teleological positing, i.e. human goals. Material practice, as techne-labour, can be broken down into various components, such as the positing of the goal, investigation of the means, consideration of alternatives, contingency of past decisions, material constraints, social needs, posited vs. actual causality, being and reflection, material production and so on.

In material practice, causal chains are entrained or harnessed by teleological goal and means positing acts in order to bring something new into reality that would not otherwise come about through mere causality alone. No new material novelties can come into existence without being thoroughly founded in causal chains, but causality alone will never turn iron deposits in the earth into into a metallic instrument, for example. In the history of Western thought, the primary intellectual background for material practice begins with the Greek concept of techne and is developed further by the Hegel-Marx-Engels concept of labour, in which teleology becomes separated from its classical rootedness in all natural processes and becomes a specific feature of human historical development. In other words, natural events in more recent thought are not understood to have goals or ends as originally proposed in Greek philosophy, but human behaviour unavoidably does, and Lukács develops this theme throughout his social ontology.

Having here sketched the concept of material practice in order to establish its general import, we can pose the question: Why is it that the technological artifact can have any number of discourses 'thrown' at it, as it were? What makes it at the same time escape any particular discipline, and yet invite so many to it?

An answer to this question can be found in Luhmann's 'supertheory.' Technology is in the environment of communication, as something to be distinguished by discourse. While by necessity only a finite set of methodological pivots can be accomplished by a single researcher, there is no final and limited set of discursive possibilities. Pivots of this kind are possible because methodologies are practices of distinction and observation. Technology is in the environment of such communication, and thus is not in any meaningful way contained or constrained within it.

Luhmann's theory itself is an example of porosity across disciplinary domains. He was nominally a sociologist, doing "social theory," but in his development of a supertheory aimed to sublate philosophy in the same way that Hegel tried to sublate religion– i.e. integrate and surpass it– and so placed himself in an intellectual lineage with Kant, Hegel and Husserl. He borrowed heavily from two applied fields– the phenomenology of biology (the concept of autopoiesis of Maturana and Varela) and second order cybernetics (the systems theory which includes the observation of observation). George Spencer Brown's calculus of form and distinction was also integrated to understand cognition as the production of distinctions in general. In the realm of sociology– his nominal profession– he took from Talcott Parsons the concept of functional differentiation of social systems– but did not really follow the discipline's founders, such as Weber and Durkheim, in his conception of sociology.

The artifact, in the mode of transdiscursive material practice, stands outside of any particular discursive lens, being in the environment of discourse. The prototype is not there because one has previously gathered together many disciplines and then forged an artifact out of it, as can sometimes be implied in discourses of interdisciplinarity. I.e. first there is nothing, then the disciplines come together, and then there is something, with each discipline is understood as a distinct, coherent, and unified entity. Perhaps something like this happens in the case of such massively complex technical systems as the Large Hadron Collider, and other examples well conceptualized by Galison's notion of 'trading zones' (1997) and Collins and Evans' 'interactional expertise' (2002) applicable to complex experimental design in the physical sciences, where the artifact is specifically designed to answer research questions and advance disciplinary frontiers.

However, in a making process such as prototyping, it will often be the case that one has a sudden insight or intuition and just proceeds to build something more in the mode of Deweyan practical inquiry, and perhaps accompanied by Schönian reflective practice. The artifact is at the center, not the boundary, of inquiry. Once built, the artifact, which is the result of a process of teleological positing that gathers up the causal chains, occupies a part of the local environment and can then be the subject of multiple research trajectories, each one of which produces forms of observation and distinction. The unity and coherence of this process is what is meant by the notion of transdiscursive material practice.

13.2 Critique of Reflective Practice

Transdiscursive material practice is distinct from the notion of 'reflective practice' common in art and design research discourses. Reflective practice entails refinement in the ability to articulate and understand one's professional practice, which is often obscured by an individual's intuitive or 'tacit knowledge' (Polanyi 1966). It is typically confined to the sphere of a particular professional activity– such as architecture, nursing, or psychotherapy– and does not aspire to a wider range of discursive application, conceptual abstraction, or epistemic engagement, but has as its goal both better practice of the professional activity, and a more conscious, communicative and reflective explication of that activity.

The concept of reflective practice received its founding elaboration by Donald Schön (2008). Schön's aim was to establish a general "epistemology of practice" (Loc 60 & 63) to define and legitimate the often tacit knowledge and expertise of professional practitioners. However, what this epistemology actually looks like– e.g. as a stable set of principles or methods, in the manner of other widely used epistemologies– is not synthesized by Schön. One likely explanation for this lack of synthesis is Schön's unclear use of the term "research" in this canonical work, *The Reflective Practitioner.* One might wish to argue that professional reflection rises to the status of research when there are pathways established that allow one to traverse back and forth between general concepts and particular contexts. However, the dif-

ficulty encountered in this text is that while Schön tries to affirm or posit practitioners as researchers, all of his case studies show reflective thinking occurring only within particular professional contexts, without that thinking being worked up into a level of generality– by the practitioners themselves– that would satisfy the kind of meanings one would normally associate with the term "research," e.g. as expressed in publications of peer reviewed journals, which is a normative standard in the use of the term.

Schön's concept of research becomes a kind of desired status symbol to attach to the thinking of professional practitioners, and perhaps because of this only Schön himself, as a researcher, comes into possession of something like an episteme of practice, whereas the practitioners themselves, whose thinking he would seem to want to validate and affirm, do not quite become researchers into practice as Schön's epistemology would attempt to argue.

Schön's writing on research and epistemology is under-developed on several levels. For instance he writes, "universities...are institutions committed, for the most part, to a particular epistemology, a view of knowledge that fosters selective inattention to practical competence and professional artistry" (Loc 49) However it is too much a stretch to claim that universities affirm only one kind of epistemology, given the wide spectrum of disciplines and methodologies that constitute the contemporary university. Schön often appears to advocate that professionals should have different notions of rigor from the academy, which on more careful reflection cannot be the case – e.g. architects rely on the same physics as academic engineers, just as doctors do not have an alternative vision of science just because they are not teaching in medical schools.

Schön depicts universities as fostering only a single epistemology, which is defined in the negative as 'other than professional' (!) which mixes tautology and reduction with a counter professional or anti-establishment sentiment. Schön doesn't define what he means by "epistemology" other than to say that universities do it one way, and practitioners do it another way, and what isn't mentioned in this construct of defining something by what it is not are all the professional programs that have long since made their way into the academy anyway, e.g. business, law, medicine, architecture etc.

But Schön also finds fault in professionals, who are often inarticulate with regards to the ways in which they know things:

> It is as though the practitioner says to his academic colleague, 'While I do not accept your view of knowledge, I cannot describe my own.' Sometimes, indeed, the practitioner appears to say, 'My kind of knowledge is indescribable,' or even, 'I will not attempt to describe it lest I paralyze myself.' These attitudes have contributed to a widening rift between the universities and the professions, research and practice, thought and action. (Loc 53)

Thus there is a fundamental social rivalry set up, between the prestige of the academy and the social status of practitioners, and between the theoretical and the practical that at times seems to result in either ambiguous conceptual binaries or a straightforward competition for social legitimacy and esteem.

Schön does however assemble a formidable set of descriptions, elements and propositions that could perhaps form a coherent epistemology of practice, but if we wish to have one we will have to assemble it ourselves out of all the tantalizing and promising components that emerge from his case studies – like Nigel Cross (2011), his concepts emerge out of case studies of specific practices. Unlike Cross, Schön doesn't attempt formal modeling of his emergent concepts but perhaps this is an intended part of his discursive strategy, to not academicize the episteme of professional practice, but rather let it hover close to its empirical case context.

Should we wish to construct the epistemology of practice that Schön does not synthesize out of his many "vignettes of practice" (Loc 64) as he calls them, we would have to gather together the following elements, which exist only as brief textual elements, into a coherent scheme:

- It would move beyond "knowing-in-practice, most of which is tacit" (Loc 66).
- Professional knowledge would be discovered through "protocols of actual performance" (Loc 67).
- What one is looking for, and hoping to inspire, is "reflection-in-action" (Loc. 888 and elsewhere).
- Scientific application fails when it encounters "messy," ambiguous, and uncertain reality, or in dealing with conflicting goals and values (Loc 529–550).
- Problem setting is more important than problem solving. "Problem setting is a process in which, interactively, we name the things to which we will attend and frame the context in which we will attend to them" (Loc 656).
- The process of a successful solution emerges from Naming and Framing, or the gathering together of the main elements of the problem (naming) and becoming aware that one's solution is based on the ways in which one frames what one has pooled together in the naming phase.
- Theories are clean, reality is a mess: "In the varied topography of professional practice, there is a high, hard ground where practitioners can make effective use of research-based theory and technique, and there is a swampy lowland where situations are confusing 'messes' incapable of technical solution" (Loc 678).
- Abandoning Comte-esque "Technical Rationality" does not imply abandoning what is sometimes called "instrumental reason" in the humanities: "instrumental problems are not given but must be constructed from messy problematic situations" (Loc 760).
- We have to accept "experience, trial and error, intuition, and muddling through" (Loc 691).
- An epistemology of practice makes implicit processes explicit.
- We have to account for and acknowledge the importance of knowing-doing, or doing-knowing (the interactive feedback loops between thinking while enacting in situated contexts).
- Research is equivalent to reflection. "When someone reflects-in-action, he becomes a researcher in the practice context (Loc 1095).
- The reflection of the practitioner often results from the "back-talk" of the overall situation. Reflection is in essence "a conversation with the situation" (Loc 1408).

- The reflective practitioner attends to a "web of moves" and cycles across the global implications of local moves which change the global situation and create new possibilities and constraints for the allowed local moves (Loc 1401, 1475, 1498, 1513, 1517 and others).
- Schön's concept of material practice is found in his notion of the back-talk of the material: "In the designer's conversation with the materials of his design, he can never make a move which has only the effects intended for it. His materials are continually talking back to him, causing him to apprehend unanticipated problems and potentials" (Loc 1492).
- Reflection-in-action can often involve metaphoric processes, a "seeing-as" in which analogies are traced across dimensions of the situation.
- Research of practitioners is "triggered by features of the practice situation, undertaken on the spot, and immediately linked to action" (Loc 4567).
- There are four kinds of reflective research: ""Reflective research," as I shall call it, may be of four types, each of which already exists at least in embryo. Frame analysis, the study of the ways in which practitioners frame problems and roles, can help practitioners to become aware of and criticize their tacit frames. Description and analysis of images, category schemes, cases, precedents, and exemplars can help to build the repertoires which practitioners bring to unique situations. A most important kind of research has to do with the methods of inquiry and the overarching theories of phenomena, from which practitioners may develop on-the-spot variations. And practitioners can benefit from research on the process of reflection-in-action itself" (Loc 4572).
- Practitioners do repertoire building out of their situations, establishing a background of possible action patterns that can be used to frame new situations. This repertoire is matched against and is in dialogue with the abstract theoretical models of the profession.

As should be apparent, Schön's theory doesn't seem to gel into the kind of conceptual form or model that one might typically desire of a set of concepts that claim to be a new epistemology. Rather, the writing style seems closest to a phenomenological analysis of professional practice, in its eschewing of formal abstract models for reflection-in-action, and preferring to stay thematically close to the vignettes of practice that Schön assembles. Schön's epistemology of practice is never presented directly in an all-at-once frame or formalized into a set of principles, but rather is a loose set of emergent themes closely tied to particular contexts. He ultimately seems to present a kind of phenomenology of professional knowing in action, rather than an epistemology that elevates professional reflection to the (somewhat coveted) status of research.

This critique of Schön's 'epistemology' of practice highlights it's insufficiency with respect to its own claims and aspirations to become research. It is not clear how professional knowledge, if it were to name itself 'research,' would differ in either media or code from the other established disciplines, at which point it would be understood as yet another program of general inquiry. Reflective practice articulates a valuable core of experience but ultimately needs to be accompanied by methods

elsewhere in use by other disciplines in order to realizes its own goals that it has set for itself to be a form of research.

There is a particular importance for reflection on practice underscored not by Schön but rather by Dewey, namely that experience is the main safeguard against forms of dogmatic orthodoxy:

> What is the reason for using the term [experience] at all in philosophy? The history of philosophy supplies, I think, the answer. No matter how subjective a turn was given to the word by Hume and Kant, we have only to go to an earlier period to see that the appeal to experience in philosophy was coincident with the emancipation of science from occult essences and causes, and with the substitution of methods of observation, controlled by experimentation and employing mathematical considerations, for methods of mere dialectic definition and classification. (Loc 36336)

What today we distinguish as 'art' versus 'design' has its origin in exactly such a 'dialectic definition and classification,' namely that of the Encyclopedists of the eighteenth Century who gave us the distinction of the fine (or 'final') arts relative to the useful arts. They were in turn preceded by the Scholastics who, in the medieval era, had divided the liberal from the mechanical arts. Behind both these dialectical classification schemas was the ancient Greek distinction of means versus ends. Today, every 'art and design' institution, or institutions in which there are 'art' units in one faculty division, and 'design' units in another, reflect in their organization exactly these non-experienced-based but rather conceptually and dialectically derived classification schemes.

The actual experience of prototyping yields no necessity for these categories, which are found not in practical experience but in ancient dialectical tropes, based on "divorcing means from ends" (Dewey's Moral Philosophy 2005). What becomes evident in prototyping with computational media is that there are no practical or meaningful boundaries between art, design, engineering, cognition, computing, workplace, a research project or aesthetic presentation within the artifact 'itself'– rather, these distinctions appear later as discursive and contextual additions that are useful only for scoping practical programs of research or creation.

13.3 The Methodological Pivot

The foregoing theoretical summary will now be grounded in a particular artifact to illustrate how the methodological pivot unfolds and why it is needed. Pixelphonics (PS) is a prototype system for the colocation of audio sources with their associated visual objects in screen-based media, a technology first described in *Apparatus, Method and System for Co-locating Visual Images and Associated Sound* (U.S. Provisional Patent No. 62/482725, 2017). The prototype produces a new form of multichannel audiovisual display in which the associated sound emanates from the specific screen areas of the moving image, allowing for colocated audio and visuals. The technology adds a new perceptual and experiential layer to the technology of synchronized sound, which has existed now for over a century, by adding its

spatial complement, so that sound can now be in place with its image, in addition to being in time with it. In contrast to surround sound arrays, which envelop listeners in an ambient sound field, Pixelphonics draws attention to areas of screen-based imagery, so that sounds are attached to their visual sources within the display just as they are in natural perception.

The application and user contexts for this new format of multimodal representation cut across many domains, briefly outlined below. The areas that have been identified for transdiscursive research have been organized below under the following headings: Home, Workplace, Industry, Education and Public Exhibition.

(1) Home

- Home Gaming
- Home Video
- Multi-stream video interface
- General Sonic Display

(2) Workplace

- Communications, Command and Control
- Work-based Telepresence
- Process Control
- Remote air traffic control

(3) Industry

- Pro Audio Hardware
- Audio and Video Editing Software

(4) Education

- Simulation-based Training

(5) Public Exhibition

- Large Scale Immersive Environments and Interactive Displays
- Art and Performance
- Virtual Arcades and Escape Rooms

Transdiscursive material practice proceeds by way of the methodological pivot, which builds upon established ideas of conducting interdisciplinary or multi-methodological research. What is perhaps new in this idea of the pivot, as applied to research, is a kind of agnosticism or multi-perspectivalism with regards truth paradigms, disciplinary boundaries, ensembles of methods, epistemes and theories of validity. As will be discussed below, the pivot differs in many respects from the similar concept of bricolage research. Moreover, the pivot is not quite equivalent to research ‘eclecticism’ as there is a clear anchor or ground that centers and focuses the inquiry, namely the prototype, which is a built thing, present nearby, concrete, and a catalyst for refracting any form of inquiry that may seem appropriate in the process of, and reflection on, its making.

Table 13.1 Investigation layers

Investigation Layers	Concerns
Physical	Acoustic & materials performance
Psychophysics	Perceptual organization
Cognition	Higher level cognitive processes
Cultural practices	Music, art, games, films
Social practices	Workplace environments

The term 'pivot' here is appropriated from the discourse on startups, economic disruption and technological innovation, its status in the popular lexicon captured well by a *New Yorker* cartoon caption of a man and a woman sitting at a cafe table: "I'm not leaving you. I'm pivoting to another man" (Art.com). The methodological pivot is an apt figure for the general method of transdiscursive material practice, since the technology, being outside of discourse, is available to any discourse and its related methods. The assemblage of methods are motivated by the requirements of developing a new technology of mediation which colocates sounds with the associated moving image. The selected discursive and methodological moves are summarized below (Table 13.1):

All of these layers can be integrated in order to fully investigate and develop a new representational format of multimodal display in which sound is colocated to visual sources in the video media, ranging from engineering considerations to human cognitive capacities to sociocultural forms and practices, all directed at a single prototype built in a 'cottage industry' manner in a basement studio. As might be clear from these tables, the total sum research potential exceeds what would typically be found in a single book-length volume, both in terms of potential length (word count and pages) but also strain at all genre boundaries as to what could constitute even an edited volume, since the audience diversity and disciplinary variation could literally make such a compendium unmarketable. Alternately, perhaps new genres of writing are called for, in which the artifact, as the phenomena at the center of discursive variation, constellates its disciplines and audiences irrespective of traditional academic conceptions. Parallel to this, transdiscursive inquiry through material practice would generally entail that the maker-researcher develop what Collins et al. (2010) call "interactional and contributory expertises" in other disciplines by publishing in the respective journals of other fields or collaboration with researchers in different disciplines.

> The difference between explicit, interactional, and contributory expertise can be summed up by reworking the distinction between "talking the talk" and "walking the walk." If "talking the talk" corresponds to primary source knowledge (knowing what has been said), and "walking the walk" corresponds to contributory expertise (actually being able to perform the task), then interactional expertise corresponds to "walking the talk"– that is, being able to use the language in novel settings in much the same way as a contributory expert might. (loc 832)

The methodological pivot is a strategy for developing new kinds of expertise, interactional and contributory, in the development of new computational media and design artifacts.

While the notion of a pivot is used in many contexts – for example, in foreign policy, the United States might be said to pivot toward Asia in contrast to its traditional focus on Europe and Russia, similar to the way a basketball player may pivot on the competitive court, who in turn pivots like a kind of mechanical connection– its use has been popularized by Eric Ries's *The Lean Startup* (2011) – and the considerable media content developed around the best selling book. Ries refashions concepts around 'lean manufacturing' developed in Japan by researchers such as Taiicho Ohno and Shigeo Shingo who pioneered new methods for working with small batches in large scale production lines. A pivot, as a research methodology, undergoes some transformations and analogies. The prototype, for example, is a material analog of the small batch since it offers the benefits of learning quickly while not consuming vast resources. There is the interplay of human intuition and imagination and rigorous research methods, and a rejection of persevering in a single method when there are clear indications that other methods may bring fresh perspectives. The concept also promotes a 'plucky entrepreneurial' spirit which is always useful for motivation in a making context. The prototype developed here can serve the purposes of useful artifact– with potential commercial potential– or artistic exhibition, and can work either as the setting for lab-like experimentation or creative expression. There is no need to foreclose commercial application when developing new technologies of multimodal display – designs exploring practical application may well have artistic outcomes and vice versa.

This fluidity between artistic and commercial activities is exemplified in this interview excerpt with Dimitri Nieuwenhuizen (Filimowicz and Tzankova 2017):

> You know the way it works here, there's LUST, which is formally a company, and there's also LUSTlab, and those are two entities and they're actually in two separate buildings, but pretty close to each other. And the purpose of the lab is that we need to do these ongoing continuous experiments. Trying both new theories, new methodologies, also new technologies that come out. We're not just trying to play with these things but conduct experiments with them. And usually that work ends up as autonomous installations which end up in museums all over the world, and we can put all our skills into that, all our thoughts, etc. And then, of course, as you can imagine, that delivers a lot of knowledge, and a lot of ideas, so that we actively try to look for interesting institutes or companies or whatever, that we can use these ideas and technologies for. And by doing so, we often manage to find the clients that we want to work for, so then the teams that form themselves when starting such projects, it's a very organic process. (302)

This distinction between LUST and LUSTlab, and the output of research as either museum exhibitions or client companies, is indicative of a pivot-rich material practice and research environment, in which "new theories, new methodologies" are applied in "continuous experiments" that produce "new technologies." In this context, the idea of "persevering" in a single research methodology (to borrow Ries's term) makes no practical or intellectual sense, or rather, one perseveres only so long as is required. Nieuwenhuizen gives a description of the extent to which one does in fact persevere in the process he describes:

> You know, if you do such an extensive research, and you dive so deep into the topic that there's nothing you can mix anymore, that you know so much about it, and parallel to that you start experimenting, you start making things, you start visualizing things, then at a certain moment those two things cross. And when they cross then you know you're on the right track and you've created something that you couldn't have thought of before. So you need this process. (309)

Thus the methodological pivot, as presented here, does not exactly do without methodological perseverance– or to use a more common word, 'rigor'– but that persevering rigor is far from an end in itself, and is taken up within a more overarching process of making which relativizes not just research methods, but implicitly all of the epistemic 'baggage' that comes with them (positivism, constructivism, activism, etc.). It could perhaps be argued that this idea of pivoting is encapsulated within what Creswell (2007) calls the 'pragmatic' paradigm: "consequences of actions, problem centered, pluralistic, real-world practice oriented"(23). Some have argued that the pragmatic (Feilizer 2010) and realist (Hall 2013) epistemes allow for the coherent complementarity of quantitative and qualitative methods, and these paradigms also happen to inhere in the position of grounding transdiscursive inquiry in a material practice. However, the artifact at the center of prototyping does not always need to be at the center of theoretical reflection, but rather can act as a general theoretical spur which prompts transdiscursive inquiry in lines of development that may not immediately serve real-world application and problems. This is because the process of making itself can also be at the center of reflection, and it is an easy shift from thinking about the physical prototype to consider the human making of it.

The methodological pivot, then, is a kind of 'meta-methodology' which uses the process of making a particular artifact as the 'pivot point' to frame inquiry as a discursive ensemble that the maker brings to bear in a manner akin to bricolage research but different from it as well, since bricolage inquiry has a particular association with qualitative research in the humanities and humanities-inflected social science, and nothing restricts the prototype to remaining strictly within a qualitative domain of inquiry.

While there is some conceptual similarity between the methodological pivot and what is more widely known as bricolage research, the latter term is not quite adequate for application in material practice as defined here. As mentioned already, with bricolage there is a particular connection to qualitative humanist discourses that the pivot moves well beyond in its 'catholicity' of inquiry. Here I will rely on Rogers (2012) historical survey of bricolage research to distinguish it from the pivot.

> Bricolage research...can be considered a critical, multi-perspectival, multi-theoretical and multi-methodological approach to inquiry. However, the theories that underlie bricolage make it far more complex than a simple eclectic approach. (1)

The notion of bricolage research takes its initial spur from Levi-Strauss's *The Savage Mind*, in which the anthropologist made a contrasting distinction between a method of meaning-making that makes "use [of] the tools and materials 'at-hand'" versus "the work of engineers, who follow set procedures and have a list of specific

tools to carry out their work." With respect to the notion of the methodological pivot, the bricolage research concept becomes immediately limited in this at-hand vs. engineering binary construct, since engineering method can actually be one of the pivots. In fact, in the PS prototype there is a custom-made hardware component, a 32-channel audio amplifier which was built by two electrical engineers. The methods of engineering are not beyond the scope of what can be pivoted to.

It is primarily in the area of multiplicity of approaches that the pivot overlaps with bricolage research. As Kellner argues, "the more perspectives one can bring to their analysis and critique, the better grasp of the phenomena one will have and the better one will be at developing alternative readings and oppositional practices." (cited in Rogers: 2). Again, however, the pivot differs from this conception. The methodological pivot is not only about producing "readings," but in the context of making, is about producing functioning artifacts. Bricolage research, as qualitative humanities methodology, is primarily oriented to texts and readings, or phenomena read as texts. Also, many of the authors associated with bricolage research (Kellner, Kincheloe, McLaren, Steinberg, Berry and Watt) impart strongly political and anti-empirical strains to bricolage research that are not essential and even contrary to the methodological pivot.

First, it will be clear that prototyping a new design for multimodal display is not the most politically contested field of inquiry and not a particularly ideal site for activism or what Creswell (2007) calls the transformative paradigm. Secondly, and far more importantly, the anti-positivist strain in bricolage research, or what some of its theorists call "the monological" is actually unwelcome and counterproductive. In Creswell's model, bricolage researchers in the main adhere to what he calls the constructivist paradigm, or in some cases mix the constructivist with the transformative, such as McLaren and Kincheloe who "[extend] bricolage to activist levels" (Rogers 2012: 13) since simply "developing an awareness of power and embracing subjugated knowledges might not be enough for bricolage to be considered a political research praxis."

The anti-empirical strain, however, is most problematic for material practice, since artifacts are capable of assembling causal orders that crucially pose challenges to imagined theories.

> The epistemological basis of positivism suggests that knowledge of the world is obtainable only through the objective scientific examination of empirical facts. Positivism proceeds on an assumption that scientific research will lead to the development of an understanding of world, and human interaction in "concrete and universal terms" (8)

Berry argued that "positivistic and other traditional research designs tend to work with the singular, linear, step-by-step structure."

> These strict positivist methods, like those of a metaphorical meaning-making "engineer" in Levi-Strauss's *Savage Mind* (1966), uncover "truths" about the social universe that exist independently of humans. (8)

The methodological pivot can embrace these positivist, strict, linear, 'monological' and 'formal' methods, and can accept– in some cases or with some kinds of phenomena– the empirical position that states of affairs in the world can be what

they are independent of what we know about them or how we model them. Material practice embroils one in causal chains, properties of materials, functions of mechanisms, real things, entropy and so on that are the discursive stuff of technoscience. The pivot is not saturated by any single truth paradigm or episteme, and can as happily embrace the social constructivist dimension when needed– for example, when it comes to aesthetic matters– and 'switch gears' to consider our 'hardwired' cognitive capacities if multisensory processes subsequently come under consideration.

While bricolage research can claim to assemble a wide array of methodologies– Rogers names "discourse analysis, deconstruction, Foucauldian genealogy"(4) and "ethnography, content analysis, historiography, cultural studies analysis, rhetorical analysis, semiotics, and critical hermeneutics" (10) as examples, from a prototyping perspective this is a small corner of the overall methods that are indeed 'at hand' in the original sense of bricolage as appropriated by Levi-Strauss. However, what this 'at-hand' means today is not clear, since it could be said that the internet makes nigh everything at hand! This at-hand quality is not an essential feature of the methodological pivot, since one can always go out of one's way to seek out that which is not at-hand, whether that means learning a new skill, hiring an external firm, or finding collaborators.

Nonetheless, there are some fruitful convergences with bricolage research to note, such as the connection Denzin and Lincoln make to "emergent design" (cited in Rogers: 5):

> The solution (bricolage) which is the result of the bricoleur's method is based on an [emergent] construction...that changes and takes new forms as the bricoleur adds different tools, methods, and techniques of representation and interpretation to the puzzle." (5)

Material practice, however, arrays not just representations and interpretations, but also causal chains, an appreciation and understanding of which requires empirical epistemic commitments, which in general are eschewed by bricolage research. Presumably, a transdiscursive material practice would never become a discipline in its own right, unless the technology developed for some reason evolves into a major field.

The prototype reveals what Ihde (2012) might call its "multistability" as it is investigated through a series of discourse variations which run the prototype through the wringer of multiple epistemologies, methods and their discursive frameworks, in order to capture as fully as possible the potentialities of the system, whether those potentials are in realms of meaning, experience, or function.

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