Chapter 3
Amateur Musicians, Long-Term Engagement, and HCI

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Abstract Musical instruments have a property of long-term engagement: people frequently become so engaged with them that they practice and play them for years, despite receiving no compensation other than enjoyment. We examine this phenomenon by analysing how the intrinsic motives mastery, autonomy, and purpose are built into the design of musical instruments; because, according to the self-determination theory of motivation, these three motives impact whether an activity might be found enjoyable. This analysis resulted in the identification of seven abstract qualities, inherent to the activity of music making or to the design of musical instruments, which contribute to the three intrinsic motives. These seven qualities can be treated as heuristics for the design of human-computer interfaces that have long-term engagement. These heuristics can be used throughout the design process, from the preliminary stage of idea generation to the evaluation stage of finished prototypes. Interfaces with instrument-like long-term engagement would be useful in many applications, both inside and outside the realm of music: they seem particularly suited for applications based on the attainment of long-term goals, which can be found in fields such as physical fitness, rehabilitation, education, and many others. In this chapter, we discuss an interface prototype we created and its pending evaluation. This interface, a rehabilitative rhythm game, serves as a case study showing how the heuristics might be used during the design process.

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3.1 Introduction

Musical instruments draw a high level of engagement from musicians. Amateur musicians, in particular, exhibit a great deal of engagement with regard to practicing instruments. They are not paid for practicing, but many do so on a near-daily basis over the course of years. They are often self-taught, picking up knowledge and techniques from peers and Internet research. For them, practicing is a form of entertainment on par with television. The ability of musical instruments to draw this level of engagement from hobbyist musicians stands in contrast to many human-computer interfaces: as any interface developer can attest, it is challenging to create an interface which does not quickly grow tiresome to users.

Most literature from the intersection of music and HCI focuses on the development of new interfaces for making music. Some of this literature focuses on the application of HCI principles to instrument design (e.g. Wanderley 2002; Wessel and Wright 2001). Of that, some is authored by expert musicians, and seems focused on interfaces for other expert musicians (e.g. Trueman and Cook 2001). Here, we take a different approach: instead of using concepts from HCI to improve musical instrument design, we look for qualities of musical instruments that inspire long-term engagement as seen in amateur musicians. Then we generalise these qualities for application in the development of HCI.

If any qualities of instruments exist which inspire long-term engagement, and can apply to HCI, it follows that these qualities should be considered possible design elements when trying to make engaging interfaces. Using psychological literature as inspiration, we looked at the design of instruments and the activity of music performance in order to identify any qualities that satisfy these constraints. The seven qualities we identified are discussed in this chapter. These qualities can be thought of simultaneously as potential qualities of devices or interfaces (such as instruments), potential qualities of activities (such as music performance), and as design goals or heuristics when creating interfaces for long-term engagement.

3.2 The Motivation to Play Instruments

One theory explaining the behaviours of hobbyist musicians is the self-determination theory (SDT) of motivation (Ryan and Deci 2000). In SDT, behaviour results from intrinsic or extrinsic motives. Extrinsic motives are related to factors out of the individual's direct control, such as rewards or punishments (e.g. grades, remuneration). Intrinsic motives come from within the individual, and have more to do with the sense of enjoyment. People that are intrinsically motivated to perform an activity, do so without regard for extrinsic incentives. In empirical validations of SDT, it was found that intrinsically motivated participants tend to perform better and persist longer in a given activity than extrinsically motivated participants. It was also found that incentivising an activity with rewards or punishments serves to decrease the level of intrinsic motivation of activity participants. This highlights an important difference between SDT and other relevant theories of motivation such as Reiss's multifaceted theory of motivation (2004), Tinto's theories of student persistence (1975), or Maslow's hierarchy of needs (1970). These theories hold all motives to be similar in kind and additive; therefore an individual's motivation to do an activity is determined by adding up the impacts of a variety of physiological needs, outside incentives, sociocultural factors, and intrinsic motives. However, because of the way intrinsic and extrinsic motivation levels interact with one another, this paradigm does not hold in SDT. Overall motivation to do an activity can be less than the sum of intrinsic and extrinsic motivation for that activity.

Amateur musicians, and other hobbyists, do not receive or require extrinsic incentives in order to remain engaged with their activity. For this reason, SDT seems to be a very useful theory of motivation for study about long-term engagement as it regards music—it is also frequently cited in music education literature (e.g. Austin et al. 2006; Hallam 2002). SDT defines three intrinsic motives: mastery, autonomy, and purpose.[1] People tend to enjoy activities containing these intrinsic motives; for example, all hobbies seem to have at least one of them. Instrument playing has all three intrinsic motives, and the field of HCI can be informed by the way music and instruments facilitate these motives.

Although many non-musical activities have the property of long-term engagement, instrument playing is especially relevant to HCI, because there are some conceptual similarities between instruments and human-computer interfaces. Just as HCI is designed to simplify and enable a variety of complex tasks, instruments exist to simplify and enable the act of music generation. If defined broadly enough, the category of interfaces includes musical instruments, and one might say musicians use instruments to "interface" with sound, audiences, and each other. In addition to these conceptual similarities, there are aspects of instrument playing which could be incorporated into the field of HCI to great benefit, such as the following:

- Instrument practice is a way for musicians to gradually attain their long-term goals of musical expertise. Some interfaces are similarly based on the achievement of long-term goals.
- Instrumentalists practice in order to attain skill so they can perform complex music more easily. This is a useful paradigm in HCI when difficulty cannot be avoided: **practice-oriented HCI** can facilitate the attainment of skill thereby allowing users to manage higher levels of difficulty.
- Instrument learning results in nuanced and masterful bodily movement in instrumentalists. Tangible, gestural, or motion-based interfaces can also benefit from nuanced and masterful movement.

The following sections describe the relationship between instruments and the intrinsic motives in more detail. We treat the intrinsic motives as qualities of activities, interfaces, or interface designs; all of these can be characterised according to the degree they facilitate the intrinsic motives, and this allowed the use of analytical reasoning to examine why each intrinsic motive might exist in instruments.

[1] Per Ryan and Deci, the intrinsic motives are labelled competence, autonomy, and relatedness. We adopt nomenclature used by Pink (2009).

Table 3.1 Summarises design heuristics proposed in this chapter, and describes their impact on long-term engagement

Motive	Heuristic	Description	Impact
Mastery	Incrementality	Whether progression in difficulty from beginner to expert is gradual	Maximises flow state in users; impacts persistence within activity
	Complexity	Potential complexity of interaction; ceiling of expertise	Impacts longevity of long-term engagement
	Immediacy	Whether obstacles to participating in the activity are low	Impacts number of people initiating and persisting in the activity
Autonomy	Ownership	Whether users have options, configurability, or ways to express or invest themselves	Imparts sense that the interface is best suited for user
	Operational Freedom	Whether interaction seems driven by user or interface	Lack of free operation leads to boredom
Purpose	Demonstrability	Whether user can demo expertise to other	Incentivises mastery and draws new users
	Cooperation	Whether users can work together	Fosters community of sharing and motivating

Through this process, we inferred the existence of seven qualities contributing to the intrinsic motives in instruments. These qualities are conceptual and abstract, but each satisfies the conditions discussed in the introduction to this chapter: First, they each increase long-term engagement by contributing to the existence of mastery, autonomy, or purpose. Second, although they describe aspects of instruments or the act of playing instruments, they easily transfer to the field of HCI. Some users will always exhibit more engagement than others, but interfaces with these qualities should prompt more engagement in users over a long term. The qualities are discussed in the following subsections and summarised in Table 3.1.

3.2.1 Mastery

People are motivated by mastery if they feel they are good at, or capable of becoming good at, something difficult. In looking at instruments for conceptual qualities contributing to mastery, we found three that are applicable in HCI development: **incrementality** of increases in challenge; maximum potential **complexity** of interaction; and **immediacy**, meaning a lack of obstacles or delays in practicing the activity. These qualities are discussed in the following subsections.

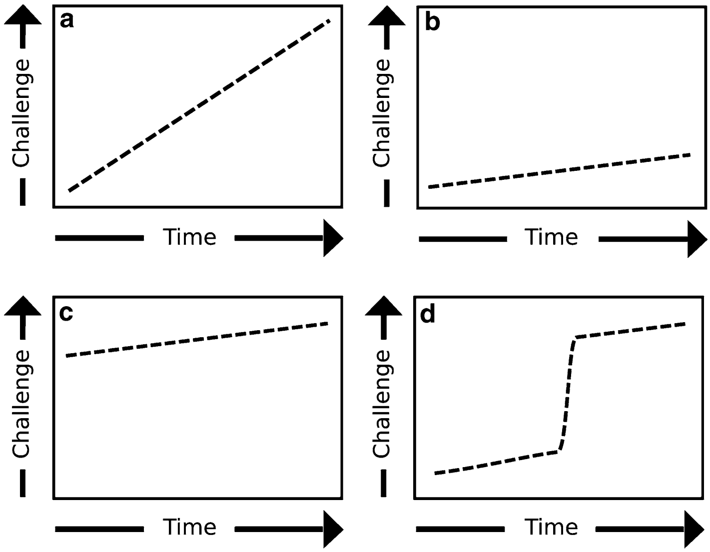

Fig. 3.1 Incrementality profiles. (**a**) Ideal profile for long-term engagement. (**b**) Users may grow bored in the short term. (**c**) Users may be overwhelmed at the outset. (**d**) Users may be engaged at first, but overwhelmed at the challenge jump

3.2.1.1 Incrementality

Incrementality describes the gradualness of the learning curve in an activity. The motive of mastery is due in part to the pursuit of flow (Csikszentmihalyi 1990). Flow is an enjoyable mental state attainable through performing activities that are complex but not overwhelming. Extrapolating from this, it follows that the challenge involved in any long-term activity inducing flow will likely conform to a specific profile over time: it will start small for beginners, then increase gradually as skill is attained (Fig. 3.1). If challenge increases too quickly, participants may become overwhelmed and quit, and if it increases too slowly, participants may become bored and lose interest. The way this challenge profile is manifested varies from activity to activity. Video games, for example, manage challenge through levels and scoring. Instrumentalists, on the other hand, manage their own challenge levels: there is such a diversity of music available to learn that musicians at all skill levels typically have an abundance of appropriately difficult music.

There are differences in incrementality between instruments, and these differences illustrate relationships between incrementality, the size of a user base, and the dedication of a user base. For example, it takes practice to play one's first notes on an oboe. There are fewer players of this type of instrument than instruments that are easy to play notes on, such as piano. However, dedication is probably higher among oboe players as they have invested significantly more effort from the outset. Other instruments, such as diatonic harmonica, are easy to take up, but have large challenge jumps corresponding with times when advanced techniques such as note bending are learned. These jumps in challenge are large enough that some people set the instrument aside instead of learning the advanced techniques.

3.2.1.2 Complexity

In many activities, the term “skill” is equivalent to “capability of accomplishing complex things.” This is the case in instrument playing, where there is such potential complexity that no individual can fully master any non-trivial instrument; some facet of playing the instrument could always be improved. This impacts long-term engagement because it means that the upward-trending challenge profile discussed in Sect. 3.2.1.1 extends into infinity, so hobby participants can theoretically remain engaged forever. Instruments that do not seem to afford much complexity, such as kazoo, are often perceived as toys and are usually not the source of long-term engagement (Jordà 2002). Despite its counterintuitive nature, the idea that interactive complexity is a positive design trait is not new to the field of HCI: for example, Norman (2010) provides an exhaustive argument in favour of design complexity.

The quality of complexity is related to other heuristic qualities discussed in this chapter: it can be thought of as the ceiling or end-point of the incrementality profile, and it is also a frequent by-product in systems containing high levels of ownership and operational freedom (these qualities are discussed in Sect. 3.2.2). Interaction complexity should not be forced on beginning users, and designers should avoid extraneous or confusing interface elements, but the potential for complex interactions should exist for users with sufficient skill levels. Systems should not, for example, demand endless repetition from users, nor present overly repetitive feedback. Once users encounter perceived limits to a system’s interactive complexity, their engagement may drop. Consider video gaming: once players have defeated a game, they will probably play it less frequently.

3.2.1.3 Immediacy

Some instruments are practiced as a daily hobby, in part, simply because they are easy to practice in this way. These instruments can be left on a stand in a convenient location, so picking them up and playing a few notes takes little effort. This is an example of immediacy. Activities with immediacy have minimal obstacles, where obstacles can come in logistic, temporal, or economic forms. Anything that serves to delay the practice of an activity constitutes a reduction in immediacy.

Differences in immediacy exist between instruments, and these differences illustrate a relationship between immediacy and instrument popularity. Traditional harps have less immediacy than harmonicas because they are not portable and much more expensive. Traditional organs have less immediacy than guitars because guitars are fairly ubiquitous while organs are rare and fixed to specific sites. Software instruments have less immediacy than flutes because of the delay involved in starting up the computer and launching the software.

Since immediacy impacts the likelihood of someone taking up an activity and persisting within it, interface designers should note that a relationship will exist between immediacy and the size of the user base. Therefore, if other things are equal, one way of promoting an interface's success is ensuring it has the quality of immediacy. In many cases, this will entail careful selection of the HCI delivery vehicle, as this will impact many factors relating to immediacy, such as: latency and start-up times, ease of setup and use, portability or ubiquitousness, and how expensive an interface is to obtain. For example, immediacy is a common factor between many recent successful interfaces delivered via the iPhone, Nintendo Wii, or Macbook.

3.2.2 Autonomy

People are motivated by autonomy if they feel they freely choose to do an activity, and do it in their own way. Lack of autonomy seems to restrict motivation greatly even when there is a high degree of mastery and purpose. An everyday example of this lies in the many employees who dislike their jobs despite high levels of skill and teamwork involved. Incentivising activities that might otherwise be intrinsically motivating with reward or punishment is counterproductive, in terms of engagement, as this reduces feelings of autonomy (Ryan and Deci 2000). In looking at instruments for conceptual qualities contributing to autonomy, we found two that are applicable in interface design: **ownership** of activity, and **operational freedom** within the activity. These qualities are discussed in the following subsections.

3.2.2.1 Ownership

In musical instruments, mastery and autonomy are related. The diversity of music affords its incrementality and complexity, and also affords a completely individualised path of learning for instrumentalists. Ergo, each musician can consider their playing style to be unique, best suited for them, and therefore "owned" by them. Renowned masters of music provide case studies on stylistic ownership: for example, Franz Liszt and Art Tatum are both considered absolute masters of the piano, yet their styles and techniques were highly dissimilar. The sense of ownership is one factor allowing musicians to consider their music to be a form of self-expression. Since playing styles are developed with great effort over the course of long periods of time, ownership in instrumental performance also represents investment that may deter musicians from quitting.

One way to transfer the concept of ownership to HCI design is to integrate options and end-user configurability into the interface. Another way, used frequently in video games, consists of rewarding accomplishment of interface goals with access to new customisations, interactions, or advanced features. A less obvious tactic for transferring the concept of ownership to HCI, advocated by Sengers and Gaver (2005), is intentionally making interaction or feedback very abstract, so users must construct the meaning of the interface for themselves.

3.2.2.2 Operational Freedom

Musicians perceive few restrictions on their freedom to play an instrument in their own way, because they can draw from a large number of playing styles or techniques whenever they wish. When numerous ways to interact with an interface exist which can be applied at will, that interface can be said to have operational freedom. Interfaces containing operational freedom will tend to also have potential interactive complexity. Some users may not use their operational freedom to do very complex things, but potential complexity exists nonetheless, because users are capable of combining or sequencing interactions in innovative ways to create complex outcomes. When operational freedom is very limited users may lose engagement rapidly.

Sometimes in HCI, specific user interactions are desired, either because of the application or because of other factors such as constraints in the sensing technology. For example, movement rehabilitation systems often need to encourage beneficial movement habits while discouraging poor movement habits (e.g. Wallis et al. 2007). Designing for operational freedom can be challenging in these circumstances, but musical instruments provide an applicable model. As noted by Jordà (2002), instruments have affordances, and these affordances lead to stylistic similarities among the players of any given instrument. Expert musicians are sometimes capable of going beyond the natural affordances of an instrument, but in most cases playing techniques will converge to the most efficient and ergonomic possible. Transferring this concept to HCI development, when specific user interactions are needed, designers can integrate affordances into their interfaces so users will gravitate to desired interactions without perceiving restricted operational freedom. This insight is not new to the field of HCI: many theorists have expounded on the topic of designing affordances (e.g. Gaver 1991; Norman 2002).

3.2.3 Purpose

According to SDT, the motive of purpose is evoked by activities containing a social element or an element of relatedness with other people. Purpose seems to be important when people are deciding to take on new hobbies, or choosing between otherwise similar hobbies. For instance, there are few differences between guitar and ukulele in terms of mastery and autonomy, but ukulele players are much less common. Social factors may cause some of this difference in popularity.

In hobbies outside the realm of music, purpose varies widely: some hobbies are competitive, some hobbies are based on communities of like-minded people, some hobbies afford quality time with family, and so forth. In looking at instrumental music performance for conceptual qualities contributing to purpose, we found two that seem applicable in interface design: **demonstrability** of skill, and **cooperation** among users. These two qualities seem well suited for helping a hobby proliferate quickly through a populace. They are discussed in the following subsections.

3.2.3.1 Demonstrability

People often learn instruments in order to attain skill and play for others. They may initially choose to take up an instrument because they have heard impressively performed music on that instrument (Manturzewska 1990). Demonstrability is related to mastery, because it is the payoff for attaining expertise in an activity. Demonstrability is also related to autonomy: music is thought of as a form of self-expression precisely due to its autonomous qualities. If interfaces are designed such that users produce something that can be displayed, performed, or shared in some way, this will encourage users to attain greater levels of skill, and these users may impress and attract more new users.

3.2.3.2 Cooperation

Music making can be done in solo or ensemble settings. The option to play in ensembles contributes to the motive of purpose, as musicians are often motivated to practice by the prospect of jam sessions, drum circles, duets, and so forth. These represent social opportunities, allowing players to spend time with peers and make new friends. As noted by Swift in this volume (2013), musicians often describe a shared feeling of euphoria, immersion, and engagement when playing or improvising music well together. Cooperation also allows musicians to teach one another, inspire one another, and motivate one another. If interfaces are designed to be used in group settings, and efforts are made to increase community among users (for example, through online forums and wikis) this will help increase overall engagement within the user base. It will also help attract new users and speed the attainment of skill in the user community as a non-competitive environment of knowledge sharing and group discovery develops. According to Tinto's theories of student persistence (1997), social integration will also reduce an individual's likelihood of quitting.

3.3 Application to HCI Development

Since the seven qualities discussed in Sect. 3.2 contribute to the intrinsic motivation of instrument playing, we propose to use them as a set of heuristics for designing interfaces that are intrinsically motivating. The resulting heuristic design framework is summarised in Table 3.1. Whenever HCI developers design systems that could benefit from long-term engagement, these heuristics can be used as catalysts for thought. Developers should ask themselves questions like: "Is this system demonstrable?" or "Would different sensing technology make this system more immediate?" The qualities underlying these heuristics are not the only ones possibly inspiring long-term engagement: for example, many engaging hobbies are more competitive than cooperative. The popularity of the instrument-playing hobby indicates, however, that this set of qualities is compelling.

The heuristics can be considered at any stage of design; this includes preliminary idea generation and analysis of finished prototypes. The most utility might be drawn from the heuristic framework if it is applied at the very outset of the design process, when the designer has done nothing except identify a human-centred problem to be addressed with an interface (where the problem could benefit from long-term engagement in users). This will help avoid premising the interface on some application or type of interaction that is not conducive to long-term engagement. Designers using these strategies will tend to create interfaces that have creative elements, game-like elements, or elements of knowledge or skill building. Not coincidentally, one or more of these elements are found in essentially all hobbies. However, if for some reason the interface cannot contain any of these elements, this framework may prove to be of little assistance.

When using the heuristics to inform the preliminary idea of an interface, it may be useful for designers to address the human-centred problem from the perspective of creating engaging activities, rather than engaging interfaces. In other words, the interface being developed should be thought of as a portal or facilitator to an engaging activity. This is helpful in part because there are numerous existing hobbies and activities that people find engaging over long time periods. These can be mined for ideas: if a compelling activity already exists that can be facilitated with interfaces (e.g. word puzzles), designers may be able to create a slightly modified interface for that activity which also addresses the human-centred problem (e.g. an interface using word puzzles to help users learn foreign languages).

Some HCI theories are focused on strategies for designing interfaces that deliver fun, enjoyable, positive user experiences (e.g. Blythe et al. 2003; Hassenzahl and Tractinsky 2006; Malone 1984). The ideas in this chapter represent one possible approach for accomplishing this; in fact, they are readily applicable to the design of interfaces in which there is no human-centred problem being addressed beyond that of entertainment or self-expression. However, numerous human-centred problems exist in more utilitarian realms such as education, fitness, or rehabilitation, which could benefit greatly from interfaces facilitating long-term engagement. Interfaces addressing these problems must be engaging, because unless users adopt and use these interfaces frequently over a long period of time, these systems will not succeed in their human-centred goals.

If interfaces have long-term engagement, users will freely opt to use them, and the interfaces will draw these users repeatedly back over time. This suggests that the ideas in this paper might be used in the design of practice-oriented HCI: interfaces helping users practice and perform tasks that are unavoidably difficult. For example, in some applications, complex and rapid-paced interactions are required from users. These situations are like music in that practice is required. Interfaces can be designed to facilitate that practice and make it enjoyable. Similarly, sometimes large-scale complex deliverables are needed from users. Clearly, engaging interfaces might help users stay on task; but perhaps less obviously, practice-oriented interfaces might also help users attain skill at producing the deliverables more quickly and easily. An analogy illustrating this lies in the difference between composers and improvisers of music. Whereas a composer might painstakingly score musical events over the course of hours or days, a practiced improviser might create music of the same complexity with little effort, taking only the requisite time to produce the notes on the instrument.

Practice-oriented HCI may prove to be an important concept as new tangible, gestural, and motion analysis-based interfaces emerge in the marketplace. Such interfaces often afford a greater degree of nuance and technical skill than traditional keyboard-and-mouse interfaces, but nuance and technical skill are attained with practice. If people practiced these interfaces in the way amateur musicians practice instruments, they might eventually be capable of efficient, nuanced, and technically skilled interface control. This also suggests that interfaces could be designed for the sole purpose of getting users to focus more awareness on their own bodily movements. Movement awareness is beneficial in itself—ergonomic movement techniques such as the Alexander Technique are built around it (Jones 1997).

3.3.1 HCI Evaluation for Long-Term Engagement

Although there is no single optimal method for evaluating various interfaces for long-term engagement, long-term engagement user studies will tend to have certain commonalities. For instance, participant recruitment should be based solely on interest, and continuing participation should also be based on interest. Payments, incentives, or rewards for participation should be avoided. These will distort the data because long-term engagement is related to intrinsic motivation, which is depressed and eclipsed by extrinsic incentives. Therefore, one potential challenge when evaluating interfaces for long-term engagement is attracting study participants.

Most evaluations of long-term engagement will require accurate tracking of the time each participant spends on the interface. The sum total of the time spent can then be compared to the amount of time available to participants. This results in a frequency-of-use ratio loosely correlating with engagement levels.

This frequency-of-use ratio is an indirect metric (engagement cannot be quantified directly) and may be considered misleading in cases where participants are actually engaged with some activity coinciding with interface usage. For example, collage artists may frequently use photo-editing software, but this does not prove engagement with the interface: if the software did not exist the artists would work with scissors. In many cases, however, the reason long-term engagement is desired is because it maximises frequency-of-use, in which case this caveat may not apply.

Interface designers may wish to evaluate interfaces with regard to the seven heuristics. Such evaluations could prove very informative. Using quantitative evaluation techniques to measure the heuristics would be difficult and fraught with problems, however. First, the qualities the heuristics are based on are abstract constructs and cannot be measured directly, so any metrics used will be indirect metrics and may have misleading properties. Second, each quality is highly variable in its manifestation within an interface: for example, operational freedom means something different in video games, where users freely control animated characters, than it does in virtual musical instruments, where users freely control sounds. It would be challenging to construct a measurement of operational freedom equally applicable in both types of interfaces. Quantitative evaluations of the heuristics may be most useful when comparing heuristic levels between different versions of singular interfaces; it is more likely the versions will manifest the qualities in comparable ways.

Although the heuristic qualities cannot be easily evaluated with quantitative methods, they can be evaluated using standard qualitative methods. Heuristic evaluation is typically done through having a small sample of users rate the interface according to each heuristic, making note of any issues found that result in poor ratings. This should lead to the discovery of any major design problems, as these will be noted by all users, and also result in the identification of a number of areas of possible improvement discovered by smaller subsets of users (Nielsen and Molich 1990). In addition to the standard heuristic evaluation, surveys or interviews can be performed in order to glean heuristic-specific information, using both broad-scope questions (e.g. “What do or don’t you like about this system?”) and heuristic-specific questions (e.g. “Do you find this system too easy or hard? Do you find it gives you enough freedom?”). Observation of user interaction with the interface will also prove informative: if it is observed that participants have gained the ability to improvise and be creative with a complex interface, for example, this could indicate a degree of familiarity that comes with engagement and frequent practice.

Efforts should be made to gather the impressions of participants and researchers at every stage of system usage. Participants at the beginning and end stages of engaging with the system will provide especially important insights. Understanding the quality of complexity in an interface, for example, may require data from participants who are beginning to lose interest. This points to an obvious challenge when evaluating interfaces for long-term engagement: the length of time required. Engagement with a well-designed interface could conceivably last a lifetime, but full understanding of interface deficiencies or possible improvements requires data from a sample of users who became engaged with, and subsequently lost interest in, the interface. The ideal evaluation would not end until all participants quit using the interface of their own volition, but that could take a prohibitively long period of time.

3.3.2 Case Study: A Rehabilitative Game for Parkinson's Patients

This section describes a case study that is currently underway. At this stage, the heuristics have been used to design an interface, and a prototype exists, but evaluation of long-term engagement is pending. This section is meant only to provide an example of heuristic usage in the design process.

Research shows early-stage Parkinson's disease patients can slow deterioration in some symptoms by performing wide-amplitude movement exercises as part of their physical therapy. There are a variety of exercises for this purpose, but the wide-amplitude nature of the movements is the key common factor (Farley and Koshland 2005). Physical therapists may guide patients through these exercises in one-on-one sessions or in groups. With the latter, the therapist leads the group from the front of the room in an arrangement similar to that seen in aerobics classes. Unfortunately, some Parkinson's patients may not find the exercises engaging, due to their repetitious nature. Or, with the group classes, patients may feel self-conscious when performing movement exercises in front of others.

If an interface were developed requiring users to perform wide-amplitude movements in order to do an engaging activity, this could benefit many Parkinson's patients. In looking at relevant existing activities, rhythm games seem suited to this human-centred problem. Existing rhythm games have similarities with aerobics classes: *Wii Step*,[2] for example, is modelled directly on step-aerobics. Recent studies suggest that movement-based video games may be an effective means of engaging and rehabilitating patients of all ages (Sugarman et al. 2009; Clark and Kraemer 2009). Therefore, in this case study we created a rhythm game early-stage Parkinson's patients might use, designed to encourage wide-amplitude arm movements.

3.3.2.1 Standard Rhythm Games

Rhythm games, as exemplified by popular video games such as *Wii Step*, *Guitar Hero* (Harmonix 2005), and *Dance Dance Revolution* (Konami 1998), challenge players to closely synchronise with a complex sequence of actions. This sequence of actions is given by the game, and action timing is usually related to a background song in some way. For this reason, it is useful to think of each sequence-song

[2] *Wii Step* is in Nintendo's *Wii Fit* (2008) suite of games.

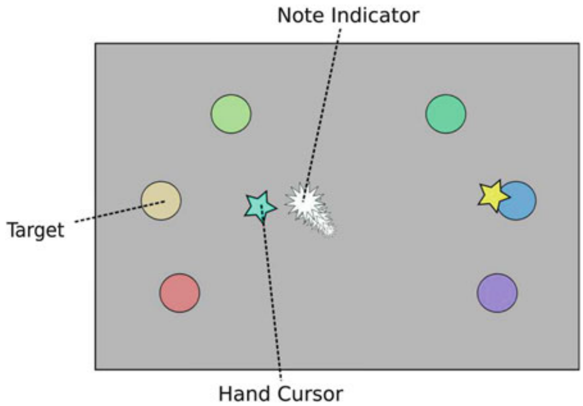

Fig. 3.2 This is a diagram of visual layout in the case study rehabilitative game

combination as a game session, or a song-game. Most rhythm games contain large libraries of song-games. Existing rhythm games are fairly well designed in terms of the heuristics related to mastery. They have incrementality, because their song-game libraries are large and diverse enough that players at all levels will find song-games of an appropriate difficulty. They also have a measure of immediacy, as they are relatively low-cost and easy to set up. They are somewhat limited in potential complexity: once the most difficult song-games can be defeated with ease, players are unlikely to continue being engaged.

The case study system uses a visual interface layout similar to that seen in Fig. 3.2. This interface contains three interactive elements: (1) *Hand Cursors* are visual indicators, the locations of which are driven by motion tracking on the player's hands—we use Microsoft's Kinect sensor to perform this hand tracking. (2) *Targets* are areas of the virtual space that the player must touch in accordance with the game's sequence of actions. Each target is attached to a musical pitch. (3) *Note Indicators* make up the sequence of actions; these radiate out from the centre toward individual targets. Whenever a note indicator reaches a target, a hand cursor must simultaneously touch that target. If this happens, the target's musical tone, which is a melodic tone designed to accompany the background track, will play. If not, a less pleasant "flubbed" sound will occur.

3.3.2.2 Applying the Heuristic Framework: A Creative Mode

The object of rhythm games, synchronising with song-game action sequences, is not conducive to the motive of autonomy. Therefore, in order to increase long-term engagement, a creative mode is added to this system. This creative mode allows players to create their own song-games. In the creative mode, there are no note indicators telling players where and when to reach for targets, and targets play melodic tones whenever touched by the hand cursors (instead of when touched simultaneously by hand cursors and note indicators). This effectively turns the interface into a virtual musical instrument. A background track still plays, but is chosen by the player and uploaded from among the player's own audio files. To create a song-game, players improvise along with their selected background track using the interface. The notes they play are saved as an action sequence into a centralised location. Then others can play that action sequence as a song-game: generated note indicators will direct users to play the saved improvisation.

This creative mode simultaneously solves many problems. It adds ownership because it lets players select their own background tracks. It adds free operation through letting players improvise. It adds demonstrability through the production of new song-games that are sharable (this is also a rehabilitative feature allowing physical therapists to create song-games attuned to their patients). It even adds complexity, because it results in an ever-expanding song-game library. Cooperation is the only heuristic quality not explicitly improved by the creative mode; however, that could be improved through the creation of online forums, wikis, and videos pertaining to the game. It could be improved further if a two-person creative mode were implemented, affording musical concepts like call-and-response.

3.3.2.3 Evaluating the Rhythm Game for Long-Term Engagement

This evaluation of the case study interface is pending. The system will be installed, as if it were an arcade game, in a public area of a university building where classes are held. This ensures that a significant number of possible users will frequently pass by due to their class schedules. Anyone who wishes may register for a login and password, after which they may play the rhythm game for free as much as they like. Users need not provide their real names upon registration; however, we will request their email addresses so that we can resupply forgotten passwords and follow up with players once they have lost interest with the game. The study will run for 3 months. This time period is based in part upon the length of a university semester, as the majority of our participants will be students with classes scheduled near the evaluation installation.

The login accounts will be used to track how often people return to play the game, and to calculate frequency-of-use over the population of account-holders. Between song-games, survey questions will appear. These questions will be designed to: (1) ascertain levels of player engagement; (2) obtain overall player impressions on the game's design, (3) gain an understanding of the interface with regard to the heuristics, and (4) determine the extent to which individual users have been engaged by musical performance or video games in the past, so we can control for that.

Since this game is partially intended to serve as proof-of-concept for the theories in this chapter, blocks of users will have different levels of access to game features. For example, some users will not have access to easy song-games, and others will not have access to difficult ones; this should give us a better understanding of incrementality in our interface. Some users will have no access to the creative mode; this should allow us to better understand the impact of those qualities enhanced by the creative mode. Like many theoretical frameworks based in psychology, the ideas presented in this chapter may never be proven in any definitive sense. However, if the heuristics are shown to result in a more engaging interface design in our case, this suggests they may be used to increase long-term engagement in other interfaces.

3.4 Conclusion

In this chapter, we began the process of creating a theory of design for interfaces containing the quality of long-term engagement. According to the self-determination theory of motivation, engaging activities are intrinsically motivated by the qualities of mastery, autonomy, and purpose. We examined why these motives are elicited in amateur musicians, extrapolating seven properties of instruments and music contributing to the three intrinsic motives. These seven properties—incrementality, complexity, immediacy, ownership, operational freedom, demonstrability, and cooperation—are transferrable to the field of HCI as heuristics for the design of interfaces which are engaging over longer time periods. These heuristics can be used in every stage of interface design, from generation of ideas through evaluation of finished prototypes.

An example system was designed, as a case study, using these heuristics. This system is a rehabilitative rhythm game, differing from other rhythm games in the addition of a creative mode enhancing the heuristic qualities related to autonomy and purpose. This system has been prototyped, and an evaluation of this system with regard to long-term engagement is among our next steps. This evaluation will help validate and refine elements of the heuristic framework.

In summary, we believe that if the intrinsic motives of mastery, autonomy, and purpose are explicitly designed into HCI, long-term engagement will be increased. Instruments provide these motives through the seven qualities discussed in this chapter. Therefore, integrating these qualities into interfaces is one way to make them more engaging over the long term. Interfaces with long-term engagement would be useful in various applications, including applications based on long-term goals, applications benefitting from practiced users, and applications for enjoyment and self-expression. Lastly, the ideas in this chapter can be used to maximise the impact and success of any human-computer interface, because engaging interfaces are likely to become popular interfaces.

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