# Chapter 6
# Design Thinking as Principles for the Structure of Creative Cities

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**Abstract** Birds build nests, and bees build hives, and bowerbirds build bowers. Humans build villages, suburbs, urban metropolises, space stations, and virtual, online worlds we cannot actually live in but often spend more time in. We are not just the “wise” species—we are *homo designare*. We are the species that designs our world. We have a unique capability for design thinking, an open-ended capacity that enables us to create novel objects, environments, or situations by combining and recombining, and sometimes inventing, base elements into novel constellations. In this chapter, I present design principles for creative cities derived from a cognitive perspective on design thinking. To do so, I will build up a cognitive model of design thinking. I will then use this cognitive model to propose principles that we should apply to the design of creative cities.

## 6.1 Introduction

We are not the only animals who change the environment to suit ourselves. Beavers are a canonical example: they build dams because they require their burrows, or shelters, to have access points under water (Gurnell 1998). Intriguingly, beavers do not build only one type of dam, nor are dams built of any single type of material. As in humans, some animals work cooperatively to modify their environment. Termites as a collective build mounds of remarkable complexity and have been characterized as being “among the world’s most sophisticated animal architects” (Turner 2010, p. 20). J. Scott Turner (this volume) describes the swarm cognition displayed by termites when they cooperate to build and maintain complex mounds, which regulate heat and gas exchange and thereby maintain homeostatic nest conditions. When birds and gorillas build nests or beavers dams or termites mounds, they are actively adapting the environment to their specific needs.

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J. Portugali and E. Stolk (eds.), *Complexity, Cognition, Urban Planning and Design*, Springer Proceedings in Complexity,
DOI 10.1007/978-3-319-32653-5_6

Evolutionary biologists term the behavior of animals who actively modify their environment, and thereby influence the selection of genetic traits, *niche construction* (Day et al. 2003; Odling-Smee et al. 1996). In humans, we call this behavior design.

Unquestionably, humans have an exceptional capacity to design our world. Though there are some cognitive capacities that set humans apart from even our closest surviving animal relatives (see Suddendorf (2013) for a review) and we share many fundamental abilities with other animals, only humans have the necessary cognitive skills to design our world to suit our future needs (Suddendorf and Dong 2013). The most parsimonious answer to the question of why humans have an exceptional capacity to design our world is the relatively large size of our brains. It has also been put forth that there is a single, related answer to the question why it is that large cities seem to have a higher capability for knowledge creation and innovation: population size (Bettencourt et al. 2007a, b).

A question that evolutionary biologists continue to debate is *why* humans developed such a large brain. The *expensive tissue hypothesis* proposes that encephalization—the ratio of brain size to body mass—increased relative to the size of other metabolically expensive organs such as the liver, heart or kidneys as our diet improved in terms of food quality and ease of digestion (Aiello and Wheeler 1995). Since the dietary tract consumed less energy to digest food, more energy could be devoted to the growth of the most metabolically expensive organ: our brain. In contrast, the *social brain hypothesis* proposes that the need for large social groups drove the increase in encephalization (Dunbar 1998). When the groups became sufficiently large, increased brain capacity enabled language development (Aiello and Dunbar 1993). Whatever the ultimate cause may be, and there may be more than one, brain size is nonetheless a significant predictor of cognitive ability. It may turn out that it is not brain size per se that determines the cognitive abilities relevant to human achievement. Rather, our brain's internal structure, such as the number of neurons and neural pathways and the resulting relative sizes of important cognitive processing areas (Jensen 1998), or its internal functions, such as coordination functions (Kelso et al. 2013), determine cognitive abilities.

In his book *The Artificial Ape: How Technology Changed the Course of Human Evolution*, Taylor (2010) offers an alternative hypothesis. He claims that technology produced modern humans, rather than the other way around. Taylor explains that the invention of the sling, a device he believes is only a short conceptual leap from chimpanzees carrying their young on their backs, prolonged the human gestation period by allowing the skull to enlarge outside the womb. In other words, it was the sling—an early adaptive technology—that enabled us to grow larger brains. Hence—because technology shaped and influenced the selection of genetic traits for a larger brain—we are 'artificial apes'. The invention of the sling itself would not have required more than secondary representation, a cognitive skill documented in all great ape genera (Nielsen et al. 2005; Suddendorf and Whiten 2001). Secondary representation is the basis for imitation—such as humans copying the carrying of infants on our backs from chimpanzees—and means-end reasoning. Both are necessary to make the connection between carrying an infant and crafting a simple sling from available materials to suit that purpose. Given that humans share the cognitive skill of secondary representation with all great ape genera, the evolutionary origins of a mind capable of inventing a sling dates back at least 14 million years, long before the appearance of cities or even language.

Today, we continue to live in artificial worlds that have shaped our evolution (Taylor 2010). Cities are perhaps the most important artificial world that humans have developed. We have evolved brains that can design cities of increasingly sophisticated forms. It may never be possible for us to know how the design of our cities will influence the evolution of our brains or even which inventions and designs already had the greatest impacts on the evolution of our brains. However, could knowledge about the structure and function of a brain enabled with the capability to design our world provide useful principles for the design of cities? More precisely, given what we know about design thinking—the cognitive strategies and skills and forms of mental representations associated with designing objects, environments and situations—how should we design our cities to make us more creative? Whilst it is a long arc to draw, I would like to suggest that the cognitive strategies and skills that enable design thinking and the structural regularities underlying knowledge creation and innovation in cities (Bettencourt et al. 2007a, b) positively influence one another. That is, our complex brain enables us to build complex cities. Increasingly complex cities are specialized niches that, in the short term, provide environments for brains to maximize their potentiality and, in the long term, increase the likelihood of the selection of a set of genetically endowed traits favoring complex brains. Further, it is not simply a complex brain that is of interest to this reciprocal relationship. Rather, it is the design thinking mind—the mind that can design the world to suit our needs—because the design thinking mind is essential to the innovation cycles that prevent the stagnation of cities (Bettencourt et al. 2007a, b). I propose a working definition of design, as I have outlined elsewhere (Dong 2010), as the capacity to envision a nonexistent material world to a level of complexity that is not obvious based on the local material environment and then to reify that nonexistent world in material or symbolic semiotic form. The latter part of this definition accords with the idea that artifacts "reflect projections of intent from a mind into the external world" (Gowlett 2009). In other words, this definition of design requires that we can do more than rely on the perceived affordance of an existing object to, say, test the depth of water before crossing it, a behavior which has been observed in orangutans (Russon et al. 2010). Rather, we would gather up sticks and vines to build a raft and cross the water on it, building on our observation that sticks float on water, even though we may not understand the physics of buoyancy.

To address this hypothesis, I will build up a cognitive model of design thinking. Since the number of cognitive strategies and skills associated with design thinking will be expansively large, I will focus attention toward those cognitive strategies that are associated with productivity and high-quality design outcomes. I will also focus on the cognitive skills that humans possess to imagine new objects, environments, and situations (Dong et al. In Press). After describing this model, I touch upon social institutions and practices that build upon our biological capability to design (Dong et al. 2013). I conclude by describing the advantages cities provide and the implications of this model on principles for creative cities.

## 6.2 Cognitive Strategies and Skills for Design Thinking

Historically, design research focused attention on activities considered unique or essential to designing in relation to other human activities. For instance, the 'object' of design and its form and aesthetics (Whitfield 2005) figured centrally in design research from the start. Simon (1969) started the cognitive turn in design research by emphasizing the "forms of reasoning" associated with designing. He claimed that these forms of reasoning differed from forms of reasoning associated with the natural sciences. Since then, the cognitive design research paradigm (Visser 2006, 2009) has viewed design as a cognitive activity as opposed to a set of specific practices relevant to the object being designed. Goel and Pirolli (1992, pp. 395–396) characterize designing as a "quintessential cognitive task" and state, unequivocally, that: "Design is, therefore, fundamentally mental, representational, and a signature of human intelligence: Features that surely make it an important subject of study in cognitive science" (1992, pp. 395–396). Since this research paradigm considers that the thinking processes associated with design are independent of the object being designed, scholars in this area produce generic schemas (Gero 1990) and descriptions of the cognitive activities taking place during design. In addition, they claim a causal relation between particular cognitive strategies and forms of mental representations of designs and the productivity of the designer (Goldschmidt 1992). That is, while a number of cognitive strategies (e.g., brainstorming, trial-and-error, depth-first search) can be applied toward designing, only a subset of these is associated with high productivity and high-quality design outcomes. These cognitive strategies are observed across successful design cases and in a form that differs between highly experienced practitioners of design and novices. For example, in a study of mechanical engineering design, researchers found that expert design engineers used analogies to reason about the function and predicted behavior of a component, but this strategy was absent in novice engineers (Ahmed and Christensen 2009). *To date, cognitive design research has identified four key cognitive strategies associated with designing*: framing (Dorst 2011); abductive reasoning (Kolko 2010; Roozenburg 1993); analogical reasoning (Ball et al. 2004; Visser 1996); and mental simulation (Ball and Christensen 2009; Christensen and Schunn 2009). Identifying productive cognitive strategies forms the research basis of design thinking[1] as well as my cognitive perspective on it.

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[1] Some authors use the term 'designerly ways of knowing' (Cross 2006) or 'designerly thinking' (Johansson-Sköldberg et al. 2013) to distinguish between this cognitive perspective on design thinking and the more practice-based or processual view on design thinking which is primarily used in the literature on management (Brown 2008). For the purposes of this article, I will use the term design thinking with reference to the cognitive design research paradigm.

In turn, the cognitive strategies of design thinking rest on a set of fundamental cognitive skills that are part of the general texture of cognition. These may have been adapted (or evolved specifically) to support our ability to shape our environment to suit us; having the ability to shape the world to suit our survival needs would have maximized humans' chances for reproduction in comparison to other species.

Whereas research on the key cognitive strategies in design thinking is both rich and convergent, the foundational cognitive skills associated with design thinking remain less understood. One approach to identify the fundamental cognitive skills that underlie human design thinking is to look to other species because we are not the only great ape, or even species, to behave creatively and innovate (Reader and Laland 2003). The production of novel and useful artifacts has been recorded for our closest relatives, the great apes: tool making by chimpanzees (McGrew and Collins 1985; Schick et al. 1999); novel methods to obtain food, make nests for sleeping and resting, and appropriate and modify objects for comfort and protection (such as leaf umbrellas) by orangutans (van Schaik et al. 2006); and, dating back at least 4,300 years, the use of stone products of thrusting percussion to crack open nuts by chimpanzees (Mercader et al. 2007). Imaginative capacities which we share with closely related species are likely to be homologous: that is, inherited from a common ancestor (Suddendorf and Dong 2013). Thus, it is more parsimonious to assume that this capacity evolved only once—in our common ancestor—than to assume that it evolved on independent occasions. The cognitive (and neurological) mechanisms underlying homologous capacities in related species are likely to be very similar.

Creative outcomes can arise through a variety of activities. Not all of these activities require a mental representation of either the external world or of processes acting on the world to achieve a desired outcome, which are distinguishing cognitive elements of design thinking. Nonetheless, there is sufficient evidence of animals behaving creatively and producing innovations in ways not attributable to mimicry or accidental discovery to suggest incipient design thinking cognitive skills in the great apes.

Based upon an analysis of recent literature in comparative psychology and early childhood cognition, Dong, Collier-Baker, and Suddendorf (In Press) identify three candidate cognitive skills: *recursion*, *representation*, and *curiosity* as fundamental to the conceptual system of design thinking, that is, the system that gives us the mental ability to produce a knowledge structure about an object, environment or situation. Recursion allows us to combine and recombine basic elements into novel mental scenarios. As such, it plays a direct role in design by providing us with the capacity to generate an infinite range of artifacts from a finite set of physical elements and construction operations. Recursion also enables nearly unlimited flexibility and conceptual possibilities in design processes. One characterization of the design process is that designers respond to a design situation by proposing 'primary generators' (Darke 1979). These primary generators are not design concepts; rather, they are a small set of objectives used to give rise to an expansion or projection of conceptual possibilities. Generating new conceptual possibilities from primary generators requires the cognitive skill of recursion to derive additional propositions based on the initial proposition in a process that is "spiral and iterative" (Darke 1979). To date, recursion has not been definitively observed in any nonhuman species, and the current consensus is that it is unique to humans (Corballis 2007; van Heijningen et al. 2009).

The second skill is representation. Following the model of Perner (1991), the cognitive strategy of framing relies on a capacity to represent design situations in ways that have a direct semantic relation to the world (primary representation), in ways that model the world through a particular abstraction such as function (secondary representation), and then interpreting and evaluating the way of representing —a reflection which requires an understanding that the representation itself can be represented in turn (meta-representation). Of these three representational skills, only meta-representation has not been observed in non-humans, likely to due to its reliance on the cognitive skill of recursion. Meta-representation is at the heart of design because it allows us to compare alternatives and to consider the validity of various representational relations such as, for example, whether to frame the design solution to our interaction with computers as 'menus' or 'windows'. Mental simulation rests on recursion and representation; recursion enables us to string together different scenarios into causal sequences (narratives) and, when combined with meta-representation, entertain multiple explanations of that narrative.

Finally, curiosity provides the "thirst" that drives us to produce artifacts with an exuberant range of variation. It has been argued that cultural preference for novelty can drive variation (Martindale 1990). Since culture is often defined by variations in patterns of behavior in the absence of plausible environmental explanations, an innate capability for representational variation must logically precede culture. Others have argued that sexual selection would have led to a reproductive advantage for those with 'creative' skills that could make things that were both novel and useful (Kohn and Mithen 1999; Miller 2001). Their explanation implies that females are the 'choosy' sex, and that males must display behaviors that females prefer, giving creative males a reproductive advantage. This advantage generated a selection for brain functions that facilitate creativity, leading to runaway selection for creativity and hence increasing variety in cultural artifacts and practices over time. Thus, while social factors are recognized as an important extrinsic factor for novelty production, designing requires a cognitive capacity for novelty that cannot be pre-determined by social or environmental factors alone.

Curiosity may be a predisposition of the mind owing to the architecture of the brain. One of the most important architectural (anatomical) differences between the human and primate brains and those of many other species is that, in our brain, conception is not directly connected to sensation. Our cerebral cortex lacks interconnections linking the unimodal areas that serve our different senses. Sensory information undergoes extensive associative elaboration. The large number of alternative trajectories and transmodal pathways through the brain activated as sensation is transformed into cognition means that the same sensory stimulus can potentially elicit numerous alternative representations (Mesulam 1998). The consequence of this behavior permeates all aspects of cognition and underlies the

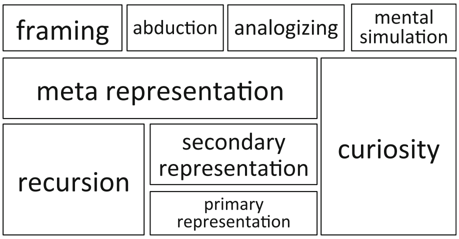

**Fig. 6.1** Cognitive skills enabling design thinking

uniquely human aptitude for discovering multiple solutions to similar problems. Combined with our unique ability for episodic foresight (Hudson et al. 2011) or mental time travel (Suddendorf et al. 2009; Suddendorf and Corballis 2007, Portugali, this volume), curiosity galvanizes us to propose alternative possible futures. It is worth our while to seek synthetic knowledge about what the future might be like, so that we can design with the future in mind. Designers then employ the cognitive strategy of abduction to propose a hypothesis or best explanation for the most convincing versions of the future. Abduction is a cognitive strategy employed while designing to make sense of complex data about the world; it is necessary to prune and filter new alternatives spurred through curiosity (Kolko 2010). Curiosity, the cognitive capacity for novelty, would have been crucial as a primary motivator in the mental activation of alternative representations that gave novelty and utility some selective advantage.

Figure 6.1 summarizes the cognitive perspective on design thinking presented above. The key cognitive strategies—framing, abduction, analogizing and mental simulation—are supported by the cognitive skills of recursion, representation and curiosity. Building on this model, I return to the issue of creative cities in light of our aim of building design thinking minds.

## 6.3 Cities and Design Capabilities

Whether researchers use the term design, innovation or creativity, they all hark back to a common reference: the successful creation and exploitation of ideas. In economics and development studies, the focus is on economic and social policy promoting innovation. Economists and policy-makers tend to agree that innovation is the fundamental outcome of a creative economy, and that the creative economy is, in turn, a core generator of economic activity. Underlying this recognition is an assumed capacity to deliver innovation but also a popular appreciation, demand for and consumption of innovative products and services. Spurred by discourse on the relation between design, innovation and economic policy (Florida 2002; Landry 2000), local governments in Europe, North America, and Australia have been formulating policy to encourage centers of creative activities to underpin design industries (Malecki 2007). According to the empirical analysis of the economies of several North American cities by Florida (2002), policy makers simply need to invest in the right mix of technology, tolerance and talent. Various cities around the world have taken heed of the creative cities policy recommendations made by Florida (2002) and Landry (2000). Cities in the UK such as Liverpool, Sheffield, Birmingham, Newcastle and Belfast have ‘creative quarters’. In inner suburban Brisbane, Australia we find a conceptually similar ‘creative industries precinct’. Developing countries also see design as part of and a precursor to human development; design and development policies are often based on an ethic of inclusiveness, making them part of an endeavor of social justice and, in the words of Gui Bonsiepe (2006), not a “tool for domination”. In developing countries, however, development is not always democratic (Drydyk 2005) and foreign direct investment in skills, like those promoted by Florida and Landry, tend to favor highly skilled countries (Velde and Xenogiani 2007); the question of what type of policies favor creativity in cities—worldwide—while promoting human development is far from resolved.

*I propose the model shown in* Fig. 6.1 *as a starting point for thinking about* structural regularities underlying knowledge creation and innovation in cities. This provisional framework formulates the core human cognitive skills and strategies that allow a person to design. Given the framework, one pathway to enhancing design-oriented minds is through social and political institutions. I have proposed a Design Capability Set (Dong 2008; Dong et al. 2013) to assess the extent to which social policy and institutions contribute to—or, conversely, detract from—the expression and enjoyment of the cognitive capabilities that underlie design. The six dimensions of the design capability set and their examples are:

- **Abstraction**—the capability to build up and sustain valuable cultural resources that provide the raw material for creative activities such as design; examples include social institutions and practices that document and preserve culture such as the Smithsonian, and public and private financial support to the arts and other cultural initiatives.
- **Authority**—the capability to exert a positive or negative obligation on government to design a world that they value; an example is the California voter initiative process, which has been applied to compel governments to provide particular forms of public infrastructure and amenities.
- **Evaluation**—the capability to validate design solutions put forward, both during the design process and when the design work has been completed; one example is citizen juries that judge submissions to design competitions for public buildings, another is community consultation in urban planning.
- **Information**—the public entitlement to information that is authoritative, complete and truthful; examples include the *Ralph M. Brown Act* in the state of California—commonly known as Sunshine Laws—which mandate public agency meetings be made open to the public—and freedom of information acts
- **Knowledge**—the capability to have general knowledge of the practice of design; examples of knowledge capability enhancing institutions include museums of design, tool-lending libraries and ‘do-it-yourself’ workshops such as the Maker Faire.

- **Participation**—the capability to set conditions for meaningful citizen participation; an example is "21st Century Town Meetings" wherein many thousands of citizens collaboratively frame complex problems and produce working principles—or recommendations—for action (Lukensmeyer and Brigham 2002).

The design capability set is one way to link the socio-political environment with cognitive strategies and skills associated with design thinking. How could urban design itself contribute to and influence more capable design thinking minds? As a first step toward addressing this question, I describe three ways that cities could amplify the development of design thinking: establish a broad basis for analogical reasoning; display complex situations for inhabitants to frame into meaning; and maintain a repository of cumulative cultural knowledge that induces mental simulation to reason about the past and future design iterations. This discussion leads to a set of design principles for the structure of creative cities.

One obvious way that cities can support design thinking is by providing stimuli for creative thought, stimuli that become sources for analogies. In analogical reasoning, designers apply similar properties or features of a prior object to the current design problem. Analogies have figured prominently as inspirations for design, not only in an anthropometric sense wherein a building is designed to 'look like' a natural object, but also to exert a framework over subsequent sequences of problem formulation, interpretation and solution assessment (Rowe 1982). The problem with using analogies for creative design is that the relevant reference knowledge base is not necessarily available. That is, the sources of analogies are not necessarily shared or equally available for one reason or another; one might not have had the opportunity to be exposed to a rich array of examples. A study by Strickfaden and colleagues described the effect of students' opportunities for social and cultural activities prior to their tertiary architecture education on their design performance. They claim that design students acquire a cultural medium consisting of places, objects, events, and architecture through their experiences, such as by traveling to various cities around the world or through everyday experiences. Students who had the opportunity to acquire a broader and richer cultural medium could draw upon it as the material for the production of new design concepts whereas those with a limited cultural medium tended to struggle. Design educators could assist students to "search within themselves and in their environment to learn about the things they are designing" (Strickfaden et al. 2006, p. 98), but students must already possess or have access to the development of a cultural medium for the educators to be effective. Cities that amplify the opportunities for individuals to acquire a rich cultural medium through its design thereby give an advantage to individuals within these cities.

The effects of this advantage are broadly reported. The robustness of creative industries is a key indicator of the design culture of a broad community and has been strongly correlated with economic vitality (Jayne 2005). Likewise, arts and culture vitality is correlated with the resurgence of economic vitality and cultural identity (Aksoy and Robins 1997). In the United States, the Urban Institute's study of cultural vitality (Jackson et al. 2006) and the Social Impact of the Arts Project

(SIAP) at the University of Pennsylvania School of Social Policy and Practice are unequivocal in their findings that the provision of public arts institutions and urban cultural vitality are strongly correlated to social cohesion and quality of life. Further, the Urban Institute recognizes the importance of both the formal arts and culture sector—such as museums, operas and commercial creative activities—and the informal sector of amateur and opportunistic creative activities that result in the creation of skills for the conceptualization, realization, and diffusion of cultural artifacts and events. These informal cultural activities can progress onto established programs, such as the Edinburgh Festival Fringe growing from a group of theaters performing on the sidelines of the Edinburgh International Festival into a cultural event in its own right. The development of skills for cultural invention makes artistic cultural vitality a capability-building dimension for design.

The importance of out-of-domain analogical reasoning as the basis for creative problem formulation and solving (Christensen and Schunn 2007; Kalogerakis et al. 2010; Tseng et al. 2008) suggests two principles for creative cities. The first is that mixed-use schemes should be preferred. Precincts concentrating a specific industry would be eschewed in favor of more diverse industries, as in biotechnology next to digital media or aerospace manufacturing next to architectural design, to permit cross-fertilization of ideas. Second, it suggests that urban designers and planners should design schemes that allow for coincidental or ambiguously defined mixtures to emerge within otherwise structured physical, socio-economic encounters. Such schemes would provide opportunities to stimulate new creative ideas by analogical transfer of ideas from another domain. The curious, novelty-seeking brain—enabled by transmodal pathways in the brain—further suggests a need for multi-scale, multi-modal transport options that can, literally, transport people through the city following more than one path. Not only could multiple paths through a city promote redundancy in the transport network, it also enables inhabitants to encounter random conceptual links, or, in other words, random analogical stimuli. This creative city principle is consonant with Bill Hiller's suggestion that the city-creating process is based on multi-scale connections (Hillier this volume). Hiller argues that there is a social advantage associated with bigger, more spatially dispersed and hybrid networks. Multi-scale interconnections throughout this network make it possible to grow various conceptual groups and for someone to meet someone else with a random conceptual link. Such is the basis of familiar strangers (Sun et al. 2013), unintentional, passive encounters with other individuals through regular, everyday activities that can be the precursor to the development of social communities.

The second type of stimuli that cities provide exercises the cognitive strategies of framing and abduction. These are the complex stimuli that force us to make sense of unfamiliar situations. Krippendorff (1989, p. 12) explains this type of stimulus in the following way: "Seeing something in a store as a chair requires imagining its use at home or in an office, a context that may or may not be realized in practice." In other words, we frame stimuli to extract patterns and meaning. We might then introduce a hypothesis through abductive reasoning to logically explain the validity of the frame. We might use metaphors to interpret an object or situation by reference to another object or situation, such as in describing an object as ‘warm’ in the sense of being comfortable, inviting, and cozy. Empirical research has identified that designers routinely use metaphors to frame (Hey et al. 2008) and structure (Casakin 2007) ill-defined problems in a more familiar way. As cities become increasingly complex and varied, we will seek statistical regularities (commonalities between chairs, stools, benches, and other forms of seating or houses, office blocks, skyscrapers and other types of buildings) and produce models (what chairs look like; what modernist office buildings look like), storing them in our memory. The number and information content of the categories of buildings we conceptualize increases as we perceive more examples, until we eventually produce mental models of buildings (Haken and Portugali 2003). The logical consequence of these observations is the principle that cities should provide more typological examples and more possibilities for design thinking minds to generate frames of increasing diversity and richness of information content. A diversity of unique stimuli affords the creation of many plausible alternative framings of observed reality.

Finally, cities store large repositories of cumulative cultural knowledge. The contemporary city is, as Mumford (1961) described, a “container of culture”. Cumulative cultural evolution refers to the transmission and accumulation of ideas, skills, traditions and other cultural artifacts such that each subsequent generation benefits from the advances made in the prior generations. This accumulation results in cultural artifacts of increasing complexity and sophistication. Having access to information from various designed artifacts through history constitutes knowledge in context. This contextualized understanding of the design inherent in everyday objects allows designers to make use of past experiences that have become embedded in everyday material culture (Demian and Fruchter 2006). For instance, we make enhancements to objects to suit the exigencies of the current situation and over time these objects may become increasingly useful, as their original design is updated by current contextual design interventions on them; designed artifacts accumulate modifications from generation to generation with each subsequent generation benefiting from the “ratchet effect” of cumulative cultural evolution (Tomasello 1999). Cumulative cultural evolution depends upon innovation, itself relying on imagination, and transmission via either imitation or instruction. Social—rather than genetic—transmission of adaptive information has enabled us to more rapidly change and control our environment. This cumulative ratcheting effect both relies upon and demands an ability for mental simulation: to make use of it, we must mentally construct the series of social and technical inputs that led to the introduction of a designed artifact and to plan the series of steps that allow us to create an object that will serve an anticipated future purpose. Design always entails imagining a future object and a future world that does not yet exist. The problem is figuring out possible future worlds. One of the most productive uses of mental simulations is to imagine cities that do not currently exist and how they might benefit (or injure) us. The *preservation* and *reuse of buildings would therefore be preferred over their demolition, as historic buildings not only preserve the history of place (and as such past contexts); they also embody cumulative cultural knowledge that can inform and enhance future design iterations*.

## 6.4 Concluding Remarks

In this chapter, I proposed a set of principles for the design of cities. The structure of cities should:

1. Facilitate opportunities for opportunistic encounters to encourage out-of-domain analogical transfer of ideas
2. Cultivate complexity in form to induce the generation of frames of increasing number and novelty about the meaning of city forms
3. Embody cumulative cultural knowledge to inform and enhance future design iterations

The principles are based on a cognitive perspective on design thinking. The organization of cities has followed numerous theories with focus as disparate as economy, geometry, technology, and finance (Hall 1988). Cognitive design research may offer new ways of conceptualizing the organizing principles for the spatial organization of cities. Just as urban planning has started to respond to issues surrounding public health as a set of organizing principles for the spatial layout of cities (Saelens et al. 2003), perhaps cities can promote smarter and creative minds by responding to concepts from design thinking.

The neural resources of the human brain and the intellectual resources of cities may share more mechanisms for creativity and innovation than scale—a common factor of both urban agglomerations and computing power. Cities are specialized niches that we have created; they can promote our creativity by design rather than hinder it. Our creative brains have been wired to design increasingly sophisticated cities. Perhaps we should wire our cities to produce increasingly creative minds.

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