Strong Concepts: Intermediate-Level Knowledge in Interaction Design Research

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Design-oriented research practices create opportunities for constructing knowledge that is more abstracted than particular instances, without aspiring to be at the scope of generalized theories. We propose an intermediate design knowledge form that we name *strong concepts* that has the following properties: is generative and carries a core design idea, cutting across particular use situations and even application domains; concerned with interactive behavior, not static appearance; is a design element and a part of an artifact and, at the same time, speaks of a use practice and behavior over time; and finally, resides on an abstraction level above particular instances. We present two strong concepts—social navigation and seamfulness—and discuss how they fulfil criteria we might have on knowledge, such as being contestable, defensible, and substantive. Our aim is to foster an academic culture of discursive knowledge construction of intermediate-level knowledge and of how it can be produced and assessed in design-oriented HCI research.

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1. INTRODUCTION

Our work as interaction-design researchers, like that of any other researcher, entails the construction and communication of knowledge. When we say interaction design in this context, we refer to design-oriented practices within the academic field of human-computer interaction (HCI). In the HCI field, the dominant approach to knowledge construction is to design innovative interaction schemes and to evaluate them empirically through more or less rigorous use studies. Broadly speaking, this approach has two parallel aims in terms of knowledge construction: to present particular examples of innovative designs and to contribute to a more generalized understanding of human-computer interaction. For the purposes of this article, we would say that HCI research mainly produces knowledge on the levels of *instances* and *theories*, using a predominantly empirical approach.

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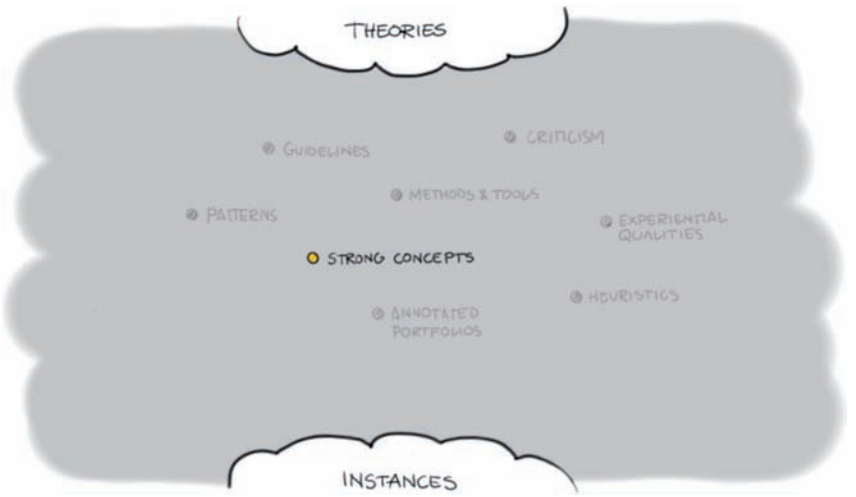

Fig. 1. Intermediate-level knowledge.

However, it has been our experience that design-oriented research practices create opportunities for constructing knowledge that is more abstracted than particular instances, yet does not aspire to the generality of a theory. We call this middle territory *intermediate-level knowledge*, and our purpose here is to elaborate on what it may consist of and how researchers may produce it. In order not to be misunderstood, we would like to emphasise that specific design instances are important elements of research in themselves—*ultimate particulars* as Stolterman describes them [2008]. In that sense, we concur with Gaver's position that "the role of theory should be to annotate [a string of design examples] rather than replace them" [Gaver 2012], even if we take strong concepts a bit further than to be only annotations.

More specifically, our focus in this article is on *generative* intermediate-level knowledge, that is, knowledge that plays a direct role in the creation of new designs. We shall propose and elaborate a particular form of generative intermediate-level knowledge called *strong concepts*, but we wish to make clear that this is only one of several possible intermediate-level knowledge forms that can emerge from design-oriented HCI research. Other examples in the generative category include patterns, guidelines, annotated portfolios, methods and tools. Examples of evaluative intermediate-level knowledge are experiential qualities, design heuristics, and criticism. In the interest of clarity, we will omit these and other examples of intermediate-level knowledge to focus strictly on strong concepts (see Figure 1).[1]

Our approach is to start by surveying what design-oriented HCI can learn from general design theory when it comes to intermediate-level knowledge. We then move on to present two detailed examples of strong concepts: social navigation and seamfulness. Based on those examples, we discuss what characterizes strong concepts, how they can be assessed, and how research processes can be structured when the aim is to construct strong concepts. The article as a whole should be seen as an exercise in epistemology

[1]The interested reader is referred to the following sources: Patterns are treated later; guidelines as operationalizations of general theory are epitomized in Lidwell et al. [2003]; annotated portfolios are introduced by Gaver [2012]; experiential qualities are surveyed in Löwgren [2009]; design heuristics date back to Nielsen's and Molich's work in usability engineering [1990]; and the possibility for interaction criticism as a source of intermediate-level knowledge is introduced in Bardzell et al. [2010].

rather than research sociology—the aim is to provide articulations that can serve the needs of the emerging academic community in design-oriented HCI and interaction design, and specifically to provide conceptual tools to further the knowledge-oriented discourse in that community.

2. INSIGHTS FROM DESIGN THEORY

Design theory is an academic field of some stature; even though it may be somewhat fuzzy around the edges, it still represents close to half a century of conceptualizing and theorizing on design. It aims to be pertinent to all design disciplines; the assumption is that there is a common core of practices, processes, and conceptualizations across, for example, architecture and product design. (See Jones [1970/1992]; Krippendorff [2006]; and Cross [2007] for an overview of the history and the most significant strands of design theory.)

There is increasing recognition that interaction design–including a design-oriented approach to HCI—can and should be seen as a design discipline. This is also our position. Given that, it follows that concepts from design theory might be relevant also to our field, and when examining the basics of design theory, it soon becomes clear that an intermediate-level knowledge is a primary epistemological category in their writings.

The first important distinction to observe in design theory is the one between *generative* and *evaluative* modes of working. In design-oriented HCI today, this distinction is perhaps best known in the guise of ideation versus synthesis [Kolko 2010], where ideation refers to creating new design ideas and possibilities, and synthesis is the act of focusing, selecting, and combining ideas to form a direction for further detailing, prototyping, or development work. In design theory, however, it is easily traced back at least to the divergence-convergence dichotomy of Jones's work in the 1970s [Jones 1970]. Other seminal contributions in design theory include Lawson's [1980] findings that designers ideate by exploring the solution space, whereas engineers work in a space of problems to be solved. Another important manifestation of generative and evaluative modes in design culture is the existence of fields of criticism for more or less any mature design discipline, and the healthy interplay between (evaluative) criticism and (generative) design practice in those disciplines.

Now, it should be made clear that the notion of generative and evaluative modes is an analytical distinction, and as always, the boundaries are blurred in practice. For instance, sometimes the qualities against which we evaluate a particular design can be used to stimulate ideas and guide a design process [Hagen 2011], but the distinction serves an important purpose in design theory in the sense of spanning a field and naming the two key aspects of the discipline.

Our mission in this article is to focus on the generative aspect of design. To explore design theory further in this direction, we find a significant amount of literature on the nature of generative design work and the knowledge involved in such work. Lawson's findings on design as exploration of the solution space, as just mentioned, were echoed in the influential work by Schön [1987] in which design is conceptualized as reflective practice. In Schön's view of design, generative work draws on what he calls the designer's "repertoire" of partial solutions, configurations, and approaches. Unfortunately, Schön is not very explicit on what exactly constitutes the repertoire, but it seems clear that a broad and rich repertoire enables more agile and proficient generative work. Lundequist and Ullmark [1993], among others, build on Schön's work to propose a so-called matching model of generative design, where the designer matches repertoire elements to the design situation at hand until a good enough fit is found to deserve further detailing, thus driving the design process forward. In general, the notion of a "library" of partial, solution-oriented elements is strongly supported not only through empirical studies of professional design (a seminal contribution here is Darke

[1979] but also through observing the great importance placed traditionally on studies of canonical examples in design education, as well as the traditional significance of a designer's portfolio when judging her skills and suitability for a particular design assignment.

Going back to Schön for a moment, his notion of design as reflective practice is also strongly tied to the notion of design learning as a reflective practicum, where practical knowing is developed in a master-apprentice relationship. There is no denying the effectiveness and transformative power of this traditional model, but at the same time, it restricts the possibilities for a growing community of knowledge production, that is, a research community in the conventional academic sense of the word. Collaborative production of knowledge requires mediated communication, which in turn requires articulation of what is, in Schön's perspective, essentially tacit, that is, practical knowing. Scaling up the knowledge processes of generative design from the studio to a worldwide community of peers corresponds to what Krippendorff [2006] has amply labeled the "languaging" of design.

Historically, one of the most influential attempts at language generative design was Alexander et al.'s. [1977] work on patterns aimed at articulating and communicating solution elements in architecture and urban planning. Even though this work was originally intended to form the basis for a democratizing language of design and thus enable stakeholders to be more active in design processes, ultimately having an impact on their own living conditions, it turned out that the semi-formal structure and partial-solution orientation of patterns above all made them suitable for capturing, disseminating, and coordinating best-practice knowledge—oftentimes with aims that tended towards standardization and rationalization. In this capacity, patterns have cemented their role and function in professional design practice ranging from architecture to software engineering [Gamma et al. 1995], user-interface design [Borchers 2001; Van Duyne et al. 2002], and games [Björk and Holopainen 2005].

Moving on from design theory in general, there is a small but growing academic body of literature in which scholars regard interaction design as a design discipline and base their conceptual underpinnings on design theory. Some of it explicitly addresses the HCI community with the intention of shaping a design-oriented approach; important examples include the prescient work by Carroll and Rosson [1992] and Winograd et al. [1996] as well as work such as that of Gaver and Martin [2000], Fallman [2003], Löwgren and Stolterman [2004], Hallnäs and Redström [2006], and Wolf et al. [2006]. In recent years, the focus in design-oriented HCI has explicitly turned to research and specifically to design-oriented forms of scholarly knowledge production, following similar developments in the general design theory community where design research has been the primary challenge for the last decade. Influential examples with a HCI orientation include Zimmerman et al. [2007], Koskinen et al. [2011], and Gaver [2012]. This development defines the context for our present work.

Specifically, we want to approach the question of how the academic HCI community can engage in the collaborative construction of generative design knowledge. In particular, we are inspired by the work by Stolterman and Wiberg [2010] on the possibility of a concept-driven approach to interaction design research. To them, a concept design represents the manifestation of a more general theoretical notion in a more concrete design, focusing on overall organizing principles of the design as a whole and generally aimed at portraying future designs. A key example of a concept design for Stolterman and Wiberg is the Dynabook, which was proposed by Alan Kay and his colleagues at Xerox PARC in the early 1970s as a vision of future personal computing in the context of children's learning. The Dynabook was never implemented—indeed, the concept assumed technological sophistication well beyond what was available at the time—and yet it turned out to be very influential on subsequent research and development in

design-oriented HCI and computer science. In a sense, what the Dynabook concept design did was to embody theoretical notions of constructivist learning in a concrete design and thus contribute to the research community a form of knowledge that did not originate with user studies and would not let itself be categorized as either instance or theory.

Stolterman and Wiberg are mainly concerned with exploring alternatives to predominant research paradigms focusing on use situations. What they also address, however, is the issue of abstraction levels of knowledge and the possible existence of an intermediate level of knowledge between theories and instances that represents abstractions of concept designs. They postulate the existence of what they call conceptual constructs as knowledge entities on the intermediate level loosely characterized as a "midway" between instances and theories that brings together earlier findings from new concepts and artifacts. Our contribution here is an elaboration of this insight, offering a more concrete suggestion of what such conceptual constructs might be. We call this intermediate-level form of generative knowledge strong concepts.

3. STRONG CONCEPTS

Strong concepts are design elements abstracted beyond particular instances which have the potential to be appropriated by designers and researchers to extend their repertoires and enable new particulars instantiations. We connect the notion of abstraction to scope of applicability. A specific artifact is fully concrete, that is, not abstracted at all, and as such, it is (primarily) applicable only in the situation for which it was designed. Elements of that particular artifact, or instance, can be isolated and abstracted to the level that they are applicable in a whole class of applications, a whole range of use situations, or a whole genre of designs. To take a trivial example, the Angry Birds app as such is applicable only in situations where people want to play Angry Birds. The slingshot touch interaction idiom, which is an essential part of Angry Birds' interface design, can be isolated from the Angry Birds app and abstracted to the level that it becomes useful in a wide range of touch-interface design situations, including not only casual games but perhaps also more productivity-oriented applications, such as transmitting selected information to Bluetooth-paired devices. Thus, the slingshot interaction idiom resides on a more abstract level than the Angry Birds app when compared as two pieces of knowledge.

At the same time, strong concepts are more specific than theories; there is no claim of universality. To continue with the same trivial example, slingshot input is obviously relevant only for certain types of interaction tasks where variability and imprecision are tolerated and even encouraged in return for the playfulness and visceral pleasure of the quasi-physical feedback that the idiom represents. It is not a universally appropriate technique for input of direction and speed; for instance, having to locate specific information in a long list of data using slingshot input would quickly become frustrating.

Are we saying that slingshot input is a strong concept, then? Not exactly; it was used as a way to illustrate the notion of abstraction and the level of generative knowledge residing between instances and theories. Specifically, we propose that a strong concept in interaction design is distinguished by the following characteristics.

—It concerns the dynamic gestalt of an interaction design, that is, its interactive behavior rather than its static appearance.
—It resides at the interface between technology and people. It is a design element, a potential part of an artifact, and at the same time, it speaks of a use practice and behavior unfolding over time.
—It carries a core design idea which has the potential to cut across particular use situations and perhaps even application domains.

—It resides on an abstraction level above particular instances, which means that it can be realized in many different ways when it comes to interface detailing (cf. concept design vs. detailed design).

The slingshot idiom, considered as a piece of knowledge, clearly fits the first, second, and fourth items on the list. However, it would be premature to conclude that is has the potential of cutting across use situations or application domains. Social navigation and seamfulness, which are the two examples of strong concepts we present next, do fulfil all the criteria.

Strong concepts are generative pieces of knowledge in the sense that they help generate new solutions for a particular design situation. When an interaction designer or researcher has appropriated a particular strong concept, it comes into play during ideation by suggesting specific directions and by guiding the design towards particular operative images [Löwgren and Stolterman 2004] that can be further elaborated upon and detailed. Applying a strong concept involves skills and a deep understanding of the particulars of a specific design situation—it is not guaranteed to predict certain outcomes or successful designs. Rather, it is pointing to a likely combination of use behavior and dynamic gestalt.

The remainder of this article is devoted to extensive discussion of two strong concepts—social navigation and seamfulness—and then a more general discussion of what strong concepts mean in a research context and how interaction-design research can be envisioned to produce strong concepts as knowledge contributions. Before going into that, though, it will be necessary to address the question of why we are proposing a new construct. Is it not the case that what we call strong concepts is very similar to patterns?

Strong concepts, just like patterns, are solution-oriented pieces of generative knowledge residing on a level of abstraction between instances and theories. However, we find that the notion of patterns has matured, and perhaps even frozen, over the years into a widely known construct that mainly addresses best practice in professional design, with overtones of standardization and rationalization: many pattern libraries are motivated in terms of making interactions familiar to the user and making production more effective [Gamma et al. 1995; Borchers 2001; Van Duyne 2002]. To us, this is not a fruitful starting point for a knowledge-oriented academic discourse. (In fact, the attempt by one of the authors to introduce the notion of inspirational patterns [Löwgren 2007b] to the academic interaction design research community failed miserably in terms of communal interest and uptake.)

To us, the key values of the academic knowledge culture is the ongoing assessment, questioning, and elaboration of knowledge contributions that take place as a sustained conversation among scholars, including activities such as analyzing the research-oriented design work of others and abstracting it into intermediate-level knowledge. We would like to point out that a strong concept has to be described, discussed, and understood as provisional (cf. Gaver [2012]). Sometimes they last only for a short time period, following the fashion of the designs at that time. We present examples of strong concepts and discuss research practices for their construction and dissemination in the hope that we can inspire other researchers to join in on the knowledge-oriented discourse. It is our sense that this aspiration requires a new label in order to escape the established connotations and practices of design patterns.

4. EXAMPLE: SOCIAL NAVIGATION

Social navigation refers to the notion of making decisions based on the decisions of others [Dourish and Chalmers 1994; Munro et al. 1999; Svensson et al. 2001]. It is an example of a strong concept, that is, an intermediate-level piece of interaction design

knowledge that has proven to be highly generative. Social navigation as a strong concept has been appropriated in a variety of interaction design situations. Variations have developed, including anonymous recommender systems [Resnick and Varian 1997] in which the sociality of the social navigation is reduced to the faceless notion of how other people have acted in similar situations (i.e., "People who bought X also bought Y"). Other examples include footprints in virtual information spaces [Wexelblat and Maes 1999] and lately also in the physical space of our everyday world (in, e.g., Google Latitude), where the user is presented with other identified people's paths or whereabouts and tribal navigation of audiovisual media, where the altruistic trait of small, tightly knit social groups is leveraged to overcome the difficulties of navigating large bodies of time-consuming information with inadequate metadata [Lindstedt et al. 2009]. In this sense, social navigation is definitely interactive, that is, not a static property of the design. Social navigation only makes sense when we are navigating a space using the social cues as navigational aids and where those same social cues change with use (our own as well as that of others) over time.

The social navigation concept has been used in numerous designs, and traces can be found in most commercial products where users have to navigate large information spaces (such as `scholar.google.com`, `www.imdb.com`, `www.amazon.com`, and many others). Starting with mobile applications like GeoNotes from 2001, which allowed users to leave traces in the real world for others to follow or interact with [Espinoza et al. 2001], all the way to the numerous mobile apps making use of the choices of others (such as choosing a restaurant in Google Maps), we can see how social navigation has had a major impact on navigation outside the digital libraries and product catalogues on the Web. This strong design concept cuts across many use situations and domains.

Social navigation can take on many forms, both in terms of how it is portrayed in the interface but also in terms of how the social trails are collected, processed, and turned into relevant cues vis-a-vis the particular domain. Sometimes it makes sense to simply provide a click-count, thereby finding the most popular item; at other times, we want to follow the advice of those similar to us, of those at the same location, etc.; or in some domains, we only want to follow those who are experts in the field. Sometimes we first need to limit the set of possible options relative to where the user is currently (in the information space, in the system, relative to others, etc.) and then calculate which option is most relevant. It should be noted that people are sometimes most interested in a personal account from one or two persons recommending an item, thereby ignoring the collective advice of thousands. For example, in `www.imdb.com`, the calculation of the stars is based on many users, but many still want to look at the personal accounts of the movie experience.

People are social beings, and it is not surprising that we are influenced by others' choices, be it when choosing books, movies, how to decorate our homes, or whether to buy shares in a company. In fact, there is no "grand theory" of human cognition that does not encompass some account of how people influence one another—through norms, watching each other, recommending or discussing choices. What is interesting is, of course, how we translate that into interaction design and how we can make those processes thrive on the properties of digital media. Access to the trails of many—millions or billions of users—becomes an important asset for social navigation techniques.

Theoretically, social navigation has its closest links to theories of embodiment [Dourish 2001], drawing in turn on phenomenology. Playing a central role in phenomenology, embodiment offers a way of explaining how we create meaning from our interactions with the everyday world we inhabit. The way we perceive the world does not reside purely interiorly in our minds nor purely exteriorly to ourselves. Instead, we are "in" the world, interacting and creating meaning through our fundamental, bodily ways

of being in the world together with others, building meaning from practices, social encounters, and tools available in our culture. Social navigation captures aspects of how we orient around social practices, the choices made by others, and their ways of navigating through information spaces or complex tools.

At the same time, through the social navigation tools we place into the world, we are interfering with, extending on, and adding to users' practices. Our ways of understanding what we can do based on what we see others doing shape us, that is, the tools become *embodied*.

Social navigation, therefore, has strong ties to ideas of constructivism and social communication theory. We are not passive receivers of social cues, influencing our decisions in some stimulus-response cycle following a cognitivist stance. We are actively giving form and sense to ourselves, the practices, objects, and tools in our environment. We actively perceive and choose what to perceive [Merleau-Ponty 1962]. A constructivist stance can be contrasted with the prevailing information channel-model in human-computer interaction [Boehner et al. 2005]. In the latter, communication between people through ICT is looked upon as a bandwidth problem, that is, we are sending and receiving messages from one another, and the richer and broader we can make the channel, the better. But if we instead view people as social beings that construct meaning in *interaction*, the bandwidth metaphor becomes meaningless. We do not send messages that others interpret out of context as nicely parcelled pieces of information. Instead, we actively seek meaning, interactively building an image of ourselves and others. In social navigation, small cues, like stars next to a list of movies (as in the preceding example), can become immensely meaningful tools for people to not only make choices of which movie to see, but also to construct their judgements of who they are and who they want to be and to detect norms of others and figure out the underlying reasons why we have certain movie productions on the market. This minimal communication, in every sense lacking bandwidth, becomes a cue we rely on to make our judgements.

In short, social navigation behaviors can be linked to grand theory, in particular, to theoretical concepts such as embodiment and constructivism. This, in turn, helps explain why this strong concept can be successful (when applied correctly, in the right context). Obviously, we can then have a discussion between scholars on the choice of theoretical concepts and whether others would better capture the details of all these different behaviors we group under the heading *social navigation*. This property of strong concepts being amenable to multiple theoretical perspectives is a general one which underlines the distinction between intermediate-level knowledge and general theories.

Social navigation is also communicated through the rich array of instances that we can find nowadays. It has, in every way, become accessible to design practitioners as a generative concept.

5. EXAMPLE: SEAMFULNESS

The idea of designing for *seamfulness* started as a counterreaction to the prevailing strive for seamlessness as the golden standard for all kinds of connectivity, network coverage, positioning information, and suchlike. In a seamful design, moving between different networks, glitches in the coverage of the positioning system, or moving from one media tool to another will not be seamlessly hidden from users' view, but, instead, openly exposed so that users could not only understand what is going on but even take advantage and make use of the seams in their activities. For example, by offering a representation of a seam, such as the signal strength indicator on your mobile, you could start making sense of the service and understand why phoning in a tunnel might not always work. This visualization is not strictly necessary—the user will be aware of signal strength anyway, since it affects the quality of the connection. However, without

much explanation, it becomes a tool that allows users to search for locations with better signal strength in areas with low coverage.

The representation of the seams may be through simply exposing it in some form in the interface or through a choice of functionality allowing users to participate in the construction or naming of the seam, such as naming places in Facebook for "check-ins".

But the concept goes beyond the telco domain. Already, Weiser talked about exposing and taking advantage of the seams between all sorts of surfaces [1991]. The new technology and the seams where it joins to other media are, as Weiser put it, "literally visible, effectively invisible." He challenged us to make "seamful systems, with beautiful seams" [Weiser 1994]. His idea was that if you copy a photo from, say, Powerpoint to Word, you should be made aware that you are crossing the boundary between the two tools and therefore changing the properties of the photo and the possible ways it can be edited. His challenge to designers was to make that copy-and-paste act itself beautiful and graceful.

The design approach for seamfulness advocated by, amongst others, Chalmers et al. [2003, 2004] and Chalmers and Galani [2004] is to regard seams as something that can be socially constructed and shared between users. Users should be actively involved in forming and supplying the content of the digital social medium, thus treating seams as features or phenomena that are created in and through social interaction.

Such interactions are interesting, as they allow for more dynamicity and co-construction of the digital space by end users. This may better capture the dynamic nature of how the space changes over time.

As we have entered the mobile age, we see more combinations of physical spaces with digital spaces and, thereby, seams between the two. The physical medium builds a space that is filled with nature, roads, buildings, walls, doors, and objects. Digital space is sometimes viewed as a model of physical space, where every piece of digital information can and should be tied to a specific physical location. Tangible interaction, for example, is often seen as a matter of matching physical objects to digital information. Such a view is unnecessarily restricted for many reasons [Fernaeus and Tholander 2006]. The digital medium allows for the construction of parallel digital spaces, for time travel and personal views, and sometimes for entirely different activities than those that are possible in the physical space: the digital model of the social space may change faster or slower than the actual social activities in the space; messages may be left at certain locations for others to read much later; physical and digital encounters may also be mismatched—all of which we can now see as smartphones have become widespread and as tools like social media and various positioning technologies are integrated in the mobile interactions.

There are many examples of seamful design elements in most applications we can think of, even if the designer might not necessarily refer to them as such. Obvious examples are the signal strength indicator of your WLAN, Bluetooth, or mobile network connectivity. Facebook's place labels is a good example of how users can actively name positions and help adjust the GPS location.

There are also attempts to explicitly address seamfulness as a core functionality in an application. Bell et al. designed FeedingYoshi, (see Figure 2), in which they make use of WLAN networks as a resource in the game [2006]: Users plant fruit for Yoshi in the WLAN hotspot they are at; that fruit then grows and can be harvested at a later point in time, which requires that you revisit the same hotspot. Similar ideas are implemented in the game "Can you see me now?" [Benford et al. 2006], in which the designers experiment with rules that could be bent to the player's advantage if the player figures out where to hide from connectivity (e.g., close to a large building) or where to enhance connectivity (e.g., using the fence rails to create a huge antenna).

Fig. 2. Screendump of FeedingYoshi (permission of Matthew Chalmers).

Similar to social navigation, seamfulness relies on active users creating meaning beyond what the interface is showing to make sense of what those seams are revealing, and in the cases where users are asked to help define or name the seams, seamfulness is a form of crowdsourcing. A social constructivist position rhymes well with the idea of seamfulness.

6. IMPLICATIONS FOR RESEARCH PRACTICE

So far, we have argued that there is an intermediate level of knowledge between theories and instances in design-oriented HCI research and that the construction of knowledge on that intermediate level is a defensible and worthwhile activity for interaction design researchers. Here, we would like to address how such knowledge construction can be undertaken and how the constructed knowledge can be assessed and validated.

6.1. Academic Quality Criteria

First, let us note that design work—in the deep sense of actual design work, including the exploration of design spaces through ideation and making as well as fieldwork—is part of the knowledge construction work. This notion of constructive design research is a key message of Koskinen et al. [2011], and it goes back at least to conceptualizations of design research from the early 1990s, such as the famous trichotomy of research about, for, and through design [Frayling 1993]. Design work in the context of research leads to what Zimmerman et al. [2007] call "research artifacts", corresponding to our notion of instances.

Whether instances coming out of design research represent academic knowledge in themselves is a contested issue (see, e.g., Seago and Dunne [1999]; Cross [2007]; and Galey and Ruecker [2010]). Irrespective of the conclusion on that matter, it can be noted that instances as knowledge contributions leave all the appropriation work to the designer-researcher who partakes of the results. Viewed from this perspective, the

approach advocated by Zimmerman et al. [2007] really is not much different from the tradition in design education of studying canonical examples. The knowledge contributions we are interested in here reside on an abstraction level above particular instances. Beyond bringing out novel design instances and mapping out new territories or novel experiences, a designer-researcher can also engage in the reflection, articulation, and abstraction necessary to tease out strong concepts, rather than stopping at performing the design work and presenting the resulting instance.

We will shortly elaborate on what it might mean to engage in reflection, articulation, and abstraction in order to arrive at intermediate-level knowledge contributions, but before that, it is necessary to address the question of what distinguishes an academically valuable intermediate-level knowledge contribution. In other words, what *academic quality criteria* should be applied? Every academic discipline has its own quality criteria, but on a suitably general level, they bear strong similarities. A typical formulation of general academic criteria is that an academic knowledge contribution must be contestable, defensible, and substantive [Booth et al. 2008].

Contestable means that the contribution proposes a position that not everyone in the academic community already believes. *Defensible* means that members of the community can accept the new position given the arguments or evidence given. Finally, a *substantive* contribution is one that is worth the time and effort of the researcher making it and the community members engaging with it. Contemporary positions on academic quality criteria in design-oriented HCI research [Zimmerman et al. 2007; Löwgren 2007a] conform quite well to this generic formulation, and thus we propose to use it as follows for assessing intermediate-level knowledge contributions in interaction design research.

—*Contestable.* Is the contribution inventive and novel for the academic community in question?
—*Defensible.* Is the contribution grounded empirically, analytically, and theoretically? Is the research process and the reasoning rigorous and criticizable?
—*Substantive.* Is the contribution relevant to the community in question? Does it contribute to the goals of the community, for example, better interaction design? (For strong concepts in particular, this includes the expected *generativity* of the contribution, i.e., its potential to be used in designing new instances.)

6.2. Constructing a Strong Concept

If these are the criteria that academic intermediate-level knowledge contributions in interaction design research must fulfil, how can we go about constructing such contributions?

Strong concepts are situated in the design space (refer to Botero et al. [2010] for a useful introduction to the history of the notion of design spaces). The strong concepts are design elements or principles that are generative, that is, that can be used by other designer-researchers to create instances in different design situations. Construction entails the following.

(1) The source of a strong concept could, for example, be an instance designed to respond to a particular existing use situation. It could also be an instance designed to explore a possible use situation, including examples of explorative design that do not aim at addressing any existing problem per se. Another possibility is represented by instances designed to concretize or instantiate a specific theory of human behavior (cf. Stolterman and Wiberg's notion of concept-driven research [2010]). Whatever the genesis, finding candidates for strong concepts in a particular instance amounts to identifying the elements or principles in the instance that could be of value in other design situations within the same genre or domain as

the original instance, or transgressing genre/domain boundaries, depending on the abstraction level of the strong concept identified.

The strong concept of social navigation previously presented will be used an illustration here, since it was developed quite some time ago and has gone through substantial maturation. At the time when the concept was developed (around the mid-90s), researchers had started to address the problem of information overflow. Internet and email were growing fast, and the prevailing design solutions did not suffice. The designs at the time were all based on spatial thinking, with files organized in folders and with hierarchical hypertext structures. Designers were experimenting with clickable maps and complex menu structures to help users grasp the structure, but on the whole, the users were struggling. In a fieldwork study of information search in a huge online manual at a large company, running up and down the long corridors, one of the present authors [Höök 1996] was repeatedly told that her informants would rather "talk to someone." Nobody was really interested in reading through the online manual. Instead, they wanted to talk to one of the guys who had written the manual or to someone who had acted on the manual from whom they could glean ideas on how to get on with their work. Today, the combination of powerful search mechanisms and access to millions of users on the net enables entirely different views on information search. Nobody would design a huge online manual without any possibility of seeing what others have done in that space in a similar situation or without the possibility of asking questions and getting answers from the community. It seems hard to imagine today, but in order to construct what we would now call the strong concept of social navigation, we had to try out a range of solutions in which some worked and some didn't, depending on domain characteristics. The concept was ultimately abstracted from a number of existing proof-of-concept prototypes, including Edit Wear and Read Wear [Hill et al. 1992], Tapestry [Goldberg et al. 1992], GroupLens [Konstan et al. 1997], and Kalas [Svensson et al. 2001]. These design instances form the body of our understanding of what social navigation is. They embody the strong concept.

(2) The next step towards making a strong concept into an academic knowledge contribution is to relate it to similar concepts, focusing on similarities and differences that can help to understand the range of applicability of the strong concept. This step might be called *horizontal grounding*, and within academia, it also serves a secondary purpose of assessing the novelty of the potential knowledge contribution. A useful analogy here might be to think about the purpose of the "Related Work" section customarily required in academic writing.

To continue with the illustration of social navigation, the first publications entailed a discussion of the new concept in relation to at-the-time known techniques for supporting online information retrieval. For instance, Hill et al. [1992] experimented with augmenting the scroll bar with an account of how much editing had taken place in different parts of a document (cf. `www.apparent-wind.com/navigation`, where their original work from the early 90s is still preserved). Chalmers et al. [2004] tried putting various markers next to Web links to show how many had visited the link, including a dinosaur when the link was more or less dead. Svensson et al. [2001] attached chat rooms to collections of food recipes. Today, social navigation and various recommender functions are totally integrated with social media, to such an extent that we do not really notice them anymore. In a sense, social media has turned the design upside down: the social is the foundation upon which information search is built.

(3) Another step is *vertical grounding*, that is, asking questions such as the following. Is the strong concept present in other known instances? Can we use those other instances as a broadened empirical base upon which to learn more indirectly about

the strong concept in use and thus be able to predict more reliably how it can or will affect use? What theories is the strong concept an illustration or concretization of? What could the relevant theories say about the strong concept that would help us provide an even more substantial knowledge contribution to other designer-researchers? And can the intermediate-level contribution represented by the strong concept inform theoretical development on a more general level?

Social navigation was adopted rather widely over time and used in a broad range of application domains and in many variations, as previously suggested. Thus, the concept accumulated substantial vertical grounding downwards from intermediate level to particular instances. Conversely, social navigation was initially analyzed from a cognitivistic theoretical standpoint and has later been reframed in theoretical terms, such as embodiment, social communication, and constructivism [Dourish 1999], thus adding to the upwards vertical grounding of the strong concept.

(4) Finally, the preceding steps illustrate that the work of reflection, articulation, and abstraction entails a triangulation of empirical, analytical, and theoretical domains. What is more, validation in the domain of design research is contingent not only on empirical experiments and theoretical grounding but also on the nature of the research process.

To return to the proposed quality criteria, the final step in constructing a strong concept involves validating whether it is contestable, defensible, and substantive. In a little more detail, a strong concept is *contestable* if it is novel to the interaction-design research community (as determined through a comparison with existing knowledge and the literature). It is *defensible* if it is grounded empirically, analytically, and theoretically and if the research process—including the chain of reasoning leading up to the strong concept—is rigorous and criticizable. The latter means, among other things, that procedures and key decisions are reported with enough care to enable a knowledgeable reader to judge the strength of the strong concept and possibly reach other conclusions on the most suitable abstractions. Validation through criticizability may also include, as pointed out by Krippendorff [2006], an examination of other possible abstractions together with an explanation of why they were found inferior. Finally, a strong concept is *substantive* if it is deemed relevant to the interaction-design research community, if it can be argued to contribute to better interaction design, and specifically if it is generative in the sense that it can be used to create new instances.

At the time when social navigation was introduced, it was novel and contestable, even if trails of the idea could be seen in the work by Hill et al. [1992] and others way before the actual name and delimitation of the concept was done (mainly through a book in 1999 [Munro et al. 1999]). As previously discussed, after some years of research, it became increasingly grounded empirically—both through the design of numerous instances embodying the design knowledge and by user studies confirming that this did indeed tap into practices that users easily made sense of—as well as theoretically. And as it has spread outside the academic community into designs of many different kinds spanning many domains, we argue that it is substantive.

In a slightly wider perspective, a research process in which new intermediate-level knowledge is constructed might involve several iterations between levels. For example, a typical approach may be to identify a tentative strong concept from one or several design experiments (in effect abstracting from the instances, pointing out what connects them) and then try the strong concept in new design experiments to assess its generativity, scope, and validity. If the aim is to reach a strong concept that has a relatively wide scope, the experiments can be made to intentionally address different genres or application domains.

To return to our example, we can see how the researchers experimented with building social navigation systems for several different application domains in order to strengthen the intermediate-level knowledge contribution as well as to further dissemination. The example also illustrated how the strong concept of social navigation was grounded upwards by searching for foundational theories of human behavior that would explain why and how social navigation worked and possibly even predict successful applications in use situations beyond those tested in design experiments. It can be concluded that the kind of research process we are considering here is not a deductive one, but rather an interpretive one. In some ways, it is closely related to the practice of criticism in whch the erudition and scholarship of the individual critic determines the outcomes, and yet the results are valuable for professional design practice as well as for further academic knowledge construction [Bardzell et al. 2010].

7. A STRONG CONCEPT IN FORMATION: BARE-SKIN CONNECTION BETWEEN STRANGERS

Right now, we are seeing many contending strong concepts in formation for the field of full-body interactions. With the proliferation of sensors and actuators and increased computing capacity in our mobiles and other artifacts, bodily gestures and interactions are enabled. However, it is not yet clear which gestures, movements, or other forms of interactions that elicit interesting dynamic gestalts, engaging users in particular behaviors, and that can generate more than one specific instance.

To illustrate the process of going from a concrete design instance to forming a strong concept, we introduce Mediated Body [Hobye]. It is an experience-oriented interaction design project, a particular instance consisting of a suit that translates bare-skin touch between a performer and a participant (both wearing headphones) into a relatively complex and captivating soundscape which they explore together in an act of social play in public view.

The particular research approach was dubbed research-through-explorative-design, combining synthetic and analytical elements, and the proposed knowledge contributions amounted to six pieces of intermediate-level interaction-design knowledge [Hobye and Löwgren 2011]. Out of the six, we will look into one here: bare-skin connection between strangers.

The touch-sensing technique used was intentionally designed to require bare-skin contact between the performer and participant. Moreover, the way Mediated Body is "played" by the performer is that a stranger is approached and invited to explore the experience (see Figure 3). These two elements in combination lead to a situation in which the boundaries of social norms are transgressed, and the performer and participant enter a zone of "social play", performing actions in public view that would normally constitute unacceptable behavior for a first encounter between strangers (akin to the oft-cited concept of the magic circle in games [Huizinga 1944/2003]). In other words, the Mediated Body and the way it is framed performatively makes it possible for two strangers in a public place to stand within personal and even intimate space [Hall 1966], touch and stroke each other's bare skin, and maintain prolonged eye contact—all the while being engaged in exploring a haptic soundscape that they share but that the bystanders cannot hear.

This turned out to be a very strong, sensual experience for the two parties involved. Given how the two participants became entirely absorbed in the interaction, we knew that the Mediated Body was a successful design instance, but is it a strong concept?

It would seem pertinent to point out that this finding originated in the context of the annual Burning Man festival, a performing arts event that is in its entirety a tribute to social play of various kinds. Thus, the generativity of bare-skin connection between strangers in terms of transfer to other kinds of use situations could, and should, be called into question. However, subsequent experiments with Mediated Body

Fig. 3. Mediated Body in action: Initial touch between the participant (on the left), and the performer (© Mads Hobye).

(unpublished) have shown that people of all kinds are surprisingly willing to engage in play with the performer in a variety of contexts, including subway trains and city streets and at more or less at any time of day and week. We consider this unexpected success at least in part to indicate the strength of the concept of the bare-skin connection between strangers.

In order for the work to proceed towards a strong concept, horizontal and vertical grounding are now called for. Horizontal grounding would amount to designing applications that involve bare-skin interaction for other domains and settings or studying existing applications of that kind. Vertical grounding entails developing connections to theory. For example, the relations between our work and general theories, such as embodied interaction [Dourish 1999], embodiment [Johnson 2007], and performance studies [Schechner 2002] are under investigation at the time of writing. Theories such as somaesthetics by Shusterman [2008] may also take us some steps closer to anchoring this strong concept candidate.

8. CONCLUSIONS

We have presented three examples of strong concepts ranging from the broad and mature to the tentative and experimental. Two of them emanate from our own design-oriented research, which is perhaps only natural since the articulation of intermediate-level knowledge requires relatively hard work and deep familiarity with the original instances and their properties. However, we also included the strong concept of seamfulness (upon which we have only done limited work) to show that there are other examples of intermediate-level knowledge in the interaction design literature. There are, of course, many other strong concepts we could have discussed. For example, the notion of *trajectories* in mixed-reality performances [Benford and Giannachi 2011] is another example of what could comfortably be called a strong concept. It is, in fact, our sense that several more strong concepts are waiting to be identified, articulated, and communicated as part of interaction-design research.

To summarize, we have proposed the following.

—There is an intermediate level of knowledge between general theories and specific instances.
—Interaction design research can be devoted to constructing that intermediate-level knowledge.
—Specifically, the intermediate-level knowledge includes generative strong concepts.
—Strong concepts are partial ideas, that is elements of potential design solutions, that can be appropriated by designers and researchers and used in the creation of new instances.
—Strong concepts concern the dynamic gestalts of design solutions, that is, interactive behavior rather than static appearance.
—Moreover, strong concepts reside at the interface between technology and people: they are potential parts of artifacts, and at the same time, they speak of use practices over time.
—Social navigation, seamfulness, and trajectories are some examples of strong concepts.

In conclusion, the work we present here is grounded in a view of design-oriented HCI research as an ongoing conversation—a process of discursive knowledge construction in which contributions are offered, assessed, synthesized, elaborated upon, and sometimes rejected through the channels of scholarly communication. More than anything else, such collaborative knowledge processes need a language. We believe that strong concepts and other intermediate-level knowledge forms are potentially useful constructs to these ends.

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REFERENCES

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., and Angel, S. 1977. *A Pattern Language: Towns, Buildings, Construction.* Oxford University Press, Oxford.

Bardzell, J., Bolter, J., and Löwgren, J. 2010. Interaction criticism: Three readings of an interaction design, and what they get us. *Interactions 17,* 2, 32–37.

Bell, M., Chalmers, M., Barkhuus, L., Hall, M., Sherwood, S., Tennent, P., Brown, B., Rowland, D., Benford, S., Capra, M., and Hampshire, A. 2006. Interweaving mobile games with everyday life. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'06)*. 417–426.

Benford, S. and Giannachi, G. 2011. *Performing Mixed Reality*. MIT Press, Cambridge, MA.

Benford, S., Crabtree, A., Flintham, M., Drozd, A., Anastasi, R., Paxton, M., Tandavanitj, N., Adams, M., and Row-Farr, J. 2006. Can you see me now? *ACM Trans. Comput. Hum. Interac. 13*, 1, 100–133.

Björk, S. and Holopainen, J. 2005. *Patterns in Game Design.* Charles River Media, Hingham, MA.

Boehner, K., Depaula, R., Dourish, P., and Sengers, P. 2005. Affect: From information to interaction. In *Proceedings of the 4th Decennial Aarhus Conference on Critical Computing.*

Botero, A., Kommonen, K.-H., and Marttila, S. 2010. Expanding design space: Design-in-use activities and strategies. In *Proceedings of the DRS Conference on Design and Complexity.*

Booth, W., Colomb, G., and Williams, J. 2008. *The Craft of Research 3rd Edition.* Chicago University Press, Chicago, IL.

Borchers, J. 2001. *A Pattern Approach to Interaction Design*. John Wiley, Chichesterm, West Sussex.

Carroll, J. and Rosson, M. B. 1992. Getting around the task-artefact cycle: How to make claims and design by scenario. *ACM Trans. Inform. Syst. 10*, 2, 181–212.

Chalmers, M., Dieberger, A., Höök, K., and Rudström, A. 2004. Social navigation and seamful design. *Cognit. Stud. Bull. Japan. Cognit. Sci. Soc. 11*, 3, 171–181.

CHALMERS, M., MACCOLL, I., AND BELL, M. 2003. Seamful design: Showing the seams in wearable computing. In *Proceedings of the IEEE Eurowearable Conference.* 11–17.

CHALMERS, M. AND GALANI, A. 2004. Seamful interweaving: Heterogeneity in the theory and design of interactive systems. In *Proceedings of the ACM Conference on Designing Interactive Systems (DIS'04)*. 243–252.

CROSS, N. 2007. Forty years of design research. *Design Stud. 28*, 1–4.

DARKE, J. 1979. The primary generator and the design process. *Design Stud. 1*, 36–44.

DOURISH, P. 1999. Following where the footprints lead: Tracking down new roles for social navigation. In *Social Navigation of Information Space*. Springer, London, U.K., 15–34.

DOURISH, P. AND CHALMERS, M. 1994. Running out of space: Models of information navigation. In *Proceedings of the HCI '94 Conference*.

DAURISH, P. 2001. *Where the Action is: The foundations of Embodied Interaction*. MIT Press, Cambridge, MA.

ESPINOZA, F., PERSSON, P., SANDIN, A., NYSTROM, H., CACCIATORE, E., AND BYLUND, M. 2001. GeoNotes: Social and navigational aspects of location-based information systems. In *Proceedings of the 3rd International Conference on Ubiquitous Computing.* 2–17.

FALLMAN, D. 2003. Design-oriented human-computer interaction. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'03)*. 225–232.

FERNAEUS, Y. AND THOLANDER, J. 2006. Finding design qualities in a tangible programming space. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'06)*. 447–456.

FRAYLING, C. 1993. Research in art and design. *Royal College Art Res. Pap. 1*, 1.

GALEY, A. AND RUECKER, S. 2010. How a prototype argues. *Lit. Ling. Comput. 25*, 4, 405–424.

GAMMA, E., HELM, R., JOHNSON, R., AND VLISSIDES, J. 1995. *Design Patterns: Elements of Reusable Object-Oriented Software*. Addison-Wesley, Reading, MA.

GAVER, W. 2012. What should we expect from research through design? To appear in *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'12)*.

GAVER, W. AND MARTIN, H. 2000. Alternatives: Exploring information appliances through conceptual design proposals. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'00)*. 209–216.

GOLDBERG, D., NICHOLS, D., OKI, B., AND TERRY, D. 1992. Using Collaborative filtering to weare an information tapestry. *Commun. ACM. 35*, 12, 61–70.

HAGEN, U. 2011. Designing for player experience: How professional game developers communicate design visions. *J. Gaming Virtual World 3*, 3, 259–275.

HALL, E. 1966. *The Hidden Dimension*. Anchor Books, New York, NY.

HALLNÄS, L., AND REDSTRÖM, J. 2006. *Interaction Design: Foundations, Experiments*. The Swedish School of Textiles, Borås.

HILL, W. C., HOLLAN, J. D., WROBLEWSKI, D., AND MCCANDLESS, T. 1992. Edit Wear and Read Wear. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'92)*. 3–9.

HILL, W., STEAD, L., ROSENSTEIN, M., AND FURNAS, G. 1995. Recommending and evaluating choices in a virtual community of use. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'95)*. 194–201.

HOBYE, M. Mediated Body: Designing for embodied experience. *ACM Comput. Entertain.* To appear.

HOBYE, M. AND LÖWGREN, J. 2011. Touching a stranger: Designing for engaging experience in embodied interaction. *Int. J. Design 5*, 3, 31–48.

HUIZINGA, J. 1944/2003. *Homo Ludens: A Study of the Play-Element in Culture*. Routledge, London, U.K.

HÖÖK, K. 1996. A glass box approach to adaptive hypermedia. Unpublished Ph.D. dissertation Department of Computer and Systems Sciences, Stockholm University.

JOHNSON, M. 2007. *The Meaning of the Body: Aesthetics of Human Understanding*. Chicago University Press, Chicago, IL.

JONES, J. C. 1970/1992. *Design Methods: Seeds of Human Futures*. Van Nostrand Reinhold, New York, NY.

KOLKO, J. 2010. *Exposing the Magic of Design: A Practitioner's Guide to the Methods and Theory of Synthesis.* Oxford University Press, Oxford, U.K.

KONSTAN, J. A., MILLER, B. N., MALTZ, D., HERLOCKER, J. L., GORDON, L. R., AND RIEDL, J. 1997. GroupLens: Applying collaborative filtering to Usenet News. *Commun. ACM 40*, 3, 77–87.

KOSKINEN, I., ZIMMERMAN, J., BINDER, T., REDSTRÖM, J., AND WENSVEEN, S. 2011. *Design Research Through Practice: From the Lab, Field and Showroom.* Morgan Kaufmann, Waltham, MA.

KRIPPENDORFF, K. 2006. *The Semantic Turn: A New Foundation for Design*. CRC Press, Boca Raton, FL.

LAWSON, B. 1980. *How Designers Think*. Architectural Press, London, U.K.

LIDWELL, W., HOLDEN, K., AND BUTLER, J. 2003. *Universal Principles of Design*. Rockport, Beverly, MA.

LINDSTEDT, I., LÖWGREN, J., REIMER, B., AND TOPGAARD, R. 2009. Nonlinear news production and consumption: A collaborative approach. *ACM Comput. Entertain. 7*, 3, 42.

LUNDEQUIST, J. AND ULLMARK, P. 1993. Conceptual, constituent and consolidatory phases: New concepts for the design of industrial buildings. In *Appropriate architecture: Workplace Design in Post-Industrial Society*, A. Törnqvist and P. Ullmark, Eds. Chalmers University of Technology, Gothenburg, Sweden, 85–90.

LÖWGREN, J. 2007a. Forskning kring digitala material. In *Under Ytan: Om Designforskning*. S. Ilsted Hjelm, Ed. Raster Förlag, Stockholm, 150–163. Available in English at http://webzone.k3.mah.se/k3jolo/Material/idResearchEssay.pdf with the consent of the publisher.

LÖWGREN, J. 2007b. Inspirational patterns for embodied interaction. *J. Knowl. Technol. Policy 20*, 3, 165–177.

LÖWGREN, J. 2009. Toward an articulation of interaction esthetics. *New Rev. Hypermedia Multimedia 15*, 2, 129–146.

LÖWGREN, J. AND STOLTERMAN, E. 2004. *Throughful Interaction Design.* MIT Press, Cambrige, MA.

MERLEAU-PONTY, M. 1962. *Phenomenology of Perception*. C. Smith (translator). Routledge & Kegan Paul, London, U.K.

MUNRON, A., HÖÖK, K., AND BENYON D., EDS. 1999. *Social Navigation of Information Space.* Springer, London, U.K.

NIELSEN, J. AND MOLICH, R. 1990. Heuristic evaluation of user interfaces. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'90)*. 249–256.

RESNICK, P. AND VARIAN, H. R. 1997. Recommender systems. *Commun. ACM 40*, 56–58.

SCHECHNER, R. 2002. *Performance Studies: An introduction. Routledge*. London, U.K.

SCHÖN, D. 1987. *Educating the Reflective Practitioner*. Jossey-Bass, San Francisco, CA.

SHUSTERMAN, R. 2008. *Body Consciousness: A Philosophy of Mindfulness and Somaesthetics*. Cambridge University Press, Cambridge, U.K.

SEAGO, A. AND DUNNE, A. 1999. New methodologies in art and design research: The object as discourse. *Design Issues 15*, 2, 11–17.

STOLTERMAN, E. 2008. The nature of design practice and implications for interaction design research. *Int. J. Design 2*, 1, 55–65.

STOLTERMAN, E. AND WIBERG, M. 2010. Concept-driven interaction design research. *Hum. Comput. Interact. 25*, 2, 95–118.

SVENSSON, M., HÖÖK, K., LAAKSOLAHTI, J., AND WAERN, A. 2001. Social navigation of food recipes. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'01)*. 341–348.

VAN DUYNE, D., LANDAY, J., AND HONG, J. 2002. *The Design of Sites: Patterns, Principles and Processes for Crafting a Customer-Centered Web Experience*. Addison-Wesley, Boston, MA.

WEISER, M. 1991. The computer for the twenty-first century. *Sci. Amer.* September, 94–110.

WEISER, M. 1994. Creating the invisible interface. In *Proceedings of the ACM SIGCHI Conference on User Interface Software and Technology (UIST'94)*. 1.

WEXELBLAT, A. AND MAES, P. 1999. Footprints: History-rich tools for information foraging. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'99)*. 270–277.

WINOGRAD, T., BENNETT, J., DE YOUNG, L., AND HARTFIELD, B., EDS. 1996. *Bringing Design to Software*. Addison-Wesley, Boston, MA.

WOLF, T., RODE, J., SUSSMAN, J., AND KELLOGG, M. 2006. Dispelling "design" as the black art of CHI. In *Proceeding of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'06)*. 521–530.

ZIMMERMAN, J., FORLIZZI, J., AND EVENSON, S. 2007. Research through design as a method for interaction design research in HCI. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'07)*. 493–502.

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