AN INQUIRY INTO THEORY USE IN HCI RESEARCH

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Theory has been an object of interest for HCI researchers working on questions related to disciplinary identity and maturity. And recently there have been empirical studies of theory use in HCI research publications. These recent studies are crucial for enriching our understanding of how HCI researchers use theoretical knowledge objects like Activity Theory or the Trajectories Conceptual Framework. Moreover, they establish precedent for conducting textual-analytic empirical studies of theory use. However, there are limitations to these recent empirical studies.

In this dissertation, I discuss several formative studies conducted during my doctoral career. These formative studies contribute material to the conceptual and theoretical frameworks that I apply in a summative study of theory use in five years of CHI Best Paper winners (n=90). These studies motivate three primary contributions. First, I provide an empirically grounded description of the richness and diversity of theory use in HCI scholarship. Second, I show that there is a growing collection of nascent HCI theories being proposed and developed. Finally, I suggest an alternative way of framing the HCI research community – one that embraces the diversity and richness of theory use evidenced in its scholarly publications.

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Chapter 1. Introduction

The Research Problem

HCI as a research community has been grappling with questions about its identity for some time. These questions have focused on its legitimacy and cohesion as a research community (Carroll & Campbell, 1989; Carroll & Kellogg, 1989) and on the role of design as a knowledge-generating activity (Bardzell, Bardzell, & Koefoed Hansen, 2015; Gaver, 2012; Höök et al., 2015; Stolterman & Wiberg, 2010). There has been a recent influx in the number of researchers asking questions and raising concerns about the complex and potentially confusing nature of HCI as a research community (Hornbæk et al., 2015; Oulasvirta & Hornbæk, 2016; Reeves, 2015).

For example, Grudin explores the possibility that HCI can be understood in terms of three discrete research threads that have not coalesced into a single, unified whole (2005, p. 46). In addition, he argues that an emphasis on conference publications – instead of journal articles and books – has contributed to fragmented knowledge production (Grudin, 2006). Moreover, he suggests "HCI will for some time be in its early days," (Grudin, 2012, p. 34). A research community in its early days is by definition *developing*, and this might be one reason why contemporary HCI researchers ask questions about its constitution and the direction of its development (Hornbæk et al., 2015; Reeves, 2015; Rogers, 2012). What kind of community will it become? What knowledge will it claim as its own?

If, as Yvonne Rogers (2012) has suggested, HCI can be understood as in a state of adolescence, then perhaps it stands to reason that HCI consists of a variety of discrete research threads and divergent approaches. There are cognitive scientists examining how

the brain processes information and sociologists studying the different ways computers mediate relationships between professionals. There are designers building and deploying new artifacts and philosophers contemplating ethical questions about artificial intelligence. These and other research threads do not necessarily connect with one another, and, in a state of adolescence, they may not connect at all. But at some point HCI will presumably move into young adulthood. What will this new stage be like?

This question is open to speculation, but at least one answer foreshadows an ominous future. In her book *HCI Theory* (2012), Yvonne Rogers considers the possibility that HCI may be heading towards an identity crisis, which would result from an inability to achieve greater unity and cohesion. The idea of an identity crisis is an important part of the project I wish to undertake in this dissertation. However, my goal will *not* be to try and prevent the crisis. Instead, I wish to treat it as one of many possible ways to frame the HCI research community. It is also possible to take the qualities and characteristics that motivate Rogers to warn of an identity crisis and frame them in terms of richness and diversity, which are qualities in need of protection and cultivation.

I agree with characterizations of HCI that emphasize its complex mix of research paradigms, approaches, and methods (Rogers, 2012; Reeves, 2015, Hornbæk et al., 2015). Furthermore, I agree that it is challenging to say what is HCI as a research community (Rogers, 2012, p. 5). For example, are there common research themes or an accepted set of big questions or grand challenges? Is it possible and worthwhile to distinguish HCI theories from other kinds of theories?

Given HCI's novelty as a research community and the apparent mix of research approaches and methods (Harrison, Sengers, & Tatar, 2007), it seems reasonable to

invoke a metaphor of adolescence (Rogers, 2012, p. 12-14) to characterize the current state of the community. Adolescence could represent a rapid diversification of interests and experiences *and* the anxiety and uncertainty that comes with trying to find your place in the world. One of my key assumptions is that adolescence is an apt metaphor not only because it seems to be a relevant, useful way to characterize HCI research but also because it aligns with my interest in studying theory use. As some researchers have argued, "the use of theory in research is a hallmark of [a] discipline's academic maturity," (Pettigrew & McKechnie, 2001 p. 62).

Within the broader discourse on theory, *theory use* could be framed as a practical tool for assessing *both* maturity *and* identity – where identity refers to the clarity of the distinction that can be made between research communities. Thus, for Rogers, examining theory with an eye towards identifying proper HCI theories and the role/function they play in scholarship is a key component in her project to establish or facilitate the maturity and identity of HCI as a research community.

Theory has been a topic of study for HCI researchers working on questions related to disciplinary identity (Carroll, 2010; Oulasvirta & Hornbæk, 2016; Reeves, 2015), and more recently there have been empirical studies of theory use in HCI research publications (Clemmensen, Kaptelinin, & Nardi, 2016; Velt, Benford, & Reeves, 2017). These recent studies are crucial for advancing our understanding of how HCI researchers use particular theories like activity theory or the trajectories conceptual framework. Moreover, these studies establish precedent for conducting empirical studies of theory use via text analysis. However, there are also important limitations to these studies.

First, they do not take into account the diverse ways of thinking about what counts as theory in HCI research. Nor do they engage with the task of distinguishing HCI theories from other kinds. Moreover, each study limits their analysis to publications that use theory in substantive ways. This limitation may derive from studies of theory use in other disciplined where researchers exclude "subsidiary" or "circumstantial" instances of theory use (Hannay, Sjoberg, & Dyba, 2007, p. 92). But it is not always clear what distinguishes "substantive" use from "subsidiary" or "circumstantial" use. And if substantial use is judged to be "better" than subsidiary use, then understanding the distinction could be a useful step towards *more* substantial theory use.

Following a discussion of several formative studies, I present findings from a study of theory use in HCI research publications. I examine five years' worth of CHI best paper winners (n=90) using six models of theory use (Beck & Stolterman, 2016a) as an analytical framework. I show the number and variety of theories used in this set of best papers, I present possible candidates for proper HCI theories, and I argue that the features of the HCI research community that could be seen as causes for concern might be usefully reframed as indicators of HCI's diversity and richness. I argue that HCI research ought to embrace its adolescence as a time for examination and intellectual exploration.

Personal Interests in the Research

The germinal text for all of the work on theory that I've done as a doctoral student is Karl Popper's *Science: Conjectures and Refutations* (1963). Popper introduced me to the problem of demarcation by prompting me to thinking about how to distinguish scientific theories from other kinds of theories. It is a problem that I have explored throughout my doctoral career, and it could be a good illustration of the essence of my interest in

understanding the unique qualities of people and things. *Who am I? What is an HCI researcher? What kinds of knowledge claims do HCI researchers make? What are the generic characteristics of designing or those of the HCI research community?*

This interest in establishing boundaries between concepts manifests itself in papers I have written about scientific theories of designing (Beck & Stolterman, 2015), examining theory use (Beck & Stolterman, 2016a, 2016c), and citation function (Beck & Chiapello, 2016). It is especially prevalent in my exploration of cumulative versus additive knowledge growth (Beck & Stolterman, 2017b). Moreover, to ask whether big questions are an appropriate approach for HCI research (Beck & Stolterman, 2017a) is in some sense to ask what sort of identity the members of a research community wish to cultivate. Do they want to organize around a common set of questions or challenges? Or do they want to cultivate an identity emphasizing a diverse set of questions or challenges that do not necessarily build on or around one another?

While I find many different theories and kinds of theory use in CHI best papers, my goal is *not* to prescribe a particular interpretation or definition of theory or way of using theory in HCI research. This is one way I differ from Rogers' (2012) apparent interest in unifying approaches to theory use, and Carroll's (2010) characterization of HCI as a multidisciplinary science. However, in my attempt to be broad and comprehensive in my understanding of theory and theory use I may be limiting my ability to make strong empirical claims. By stretching the definition of theory use I undermine my ability to distinguish theory (or theories) from other kinds of knowledge objects.

Popper's text reveals the possibility of using theory as a tool for constructing disciplinary identity. For Popper, this involved distinguishing scientific theories from

other kinds and describing the logical relationship between scientific theories and the practice of scientific practice. Scientific theories are falsifiable, and the goal of scientific practice is to attempt to falsify them. For Popper, studying scientific theories yielded insights into how researchers think about the world, the kinds of questions they ask, the way they go about seeking answers, *and* the criteria used to evaluate the strength of their approach. I got a sense of wonder from that insight. That sense of wonder was what compelled me in the first place to examine scientific and design theories more deeply and to pursue that examination down several discrete-yet-related paths. These different paths constitute eight formative studies that I conducted over the last four years. These studies motivated me to focus this dissertation on three key research questions

Research Questions for this Dissertation

1. What are the limitations of studying publications in an effort to understand theory use in HCI research?
2. How might visual modeling enhance research on theory use in HCI and other scholarly communities?
3. Should HCI researchers take steps to clarify theory use in their scholarly writing?

Ways of Exploring the Problem

I have completed nine studies during my time as a doctoral student and candidate. Here, I provide a chronological overview of these studies. These studies build on but are not defined by each other. This means that the insights and outcomes from each study contribute to my theoretical standpoint but they do not necessarily *explicitly* lead to new research questions. For example, following my study of four theories about designing, I did not end with the insight to study theory use in design research publications. I end this

summary section with a short reflection on how these studies have shaped the way I think about my chosen topics of interest.

- In *Can there be scientific theories of designing that do not scientize designing*, my ambition was demonstrate that (1) some theories about design can be construed as scientific in Popper's terms, and that (2) these theories do not "scientize" the design process; that is, they do not necessarily frame design as a systematic, objective, and rational process. I conducted an analysis of four classic design theories using Popper's criterion of falsification as an analytical framework.
- *Examining Practical, Everyday Theory Use in Design Research* is an examination of how theories as knowledge objects are used in articles published in *Design Studies*. I analyze 32 articles using an emergent coding approach, which I describe as a mix of content analytic and grounded theory techniques, and I develop six models of theory use based on my analysis.
- In *Practical, Everyday Theory Use in HCI Research,* I analyze 35 randomly sampled CHI full papers using the six models of theory use described in my previous study of design research publications, and I suggest that theory is most commonly used (1) as an object of study and (2) as a contextual tool.
- In *Schön's Legacy: Examining Contemporary Citation Practices in DRS Publications*, I conduct a content analysis of 63 texts published at the 2012 and 2014 DRS conferences. My goal was to understand the function of citations of Donald Schön's work. I found that scholars primarily cite Schön's work to support their own research topics, methods or methodologies, and arguments *and* to credit Schön for his concepts or ideas. I found few instances of citations that

engage critically or build on Schön's ideas.

- *Why aren't there more scientific theories about designing?* is an essay exploring (1) the possibility that there are fewer theories about the design process that aspire to achieve scientific status and (2) the consequences of this possibility for knowledge growth and disciplinary identity. I proposed three possible explanations for the possible lack of scientific theories: (1) They are not useful to practitioners, (2) design research is building its own intellectual culture, and (3) different ways of understanding scientific theories may yield different results.
- In *Examining The Types of Knowledge Claims Made in Design Research*, I conduct a content analysis of 30 texts – ten from natural science, ten from social science, and ten from design publications – in order to identify the types of knowledge claims made in each. I explore the possibility that knowledge claims might be an effective way to distinguish the design discipline from others. And I find that design publications often contain multiple knowledge claims of different kinds whereas natural and social science publications tend to make singular knowledge claims of similar kinds.
- In *Reviewing the Big Questions Literature; or, Should HCI Have Big Questions?* I conduct a literature review of 71 publications examining or proposing big questions. My twofold contribution is to provide the first review of big questions scholarship *and* to leverage this review as a means of examining the value and utility of big questions in HCI research.
- *The Theory-Practice Gap as Generative Metaphor* is an essay in which I examine the concept of the theory-practice gap in terms of what Donald Schön called a

generative metaphor. I explore the multiple, nuanced interpretations of the gap in HCI research literature. I show how different researchers have defined the gap differently and, thus, how these different definitions have led to different proposed solutions to the problem the gap characterizes.

- *Studying Theory Use in the Best Papers @CHI* is an application of the six models of theory use developed in a previous study to a corpus of 91 best papers spanning the last five CHI conferences. The outcome of this analysis is a comprehensive list of which theories were used and how they were used. I raise the possibility of distinguishing HCI theories on this list, and I reflect on some of the biases and limitations of my position and approach as an analyst.

Expected Contributions of this Dissertation

I aim to make three primary contributions with this dissertation. First, research examining theory use in HCI research publications has so far taken textual analytic approaches (Clemmensen, Kaptelinin, & Nardi, 2016; Velt, Benford, & Reeves, 2017) as the primary research methodology. **Contribution 1:** I describe the strengths and key limitations of textual analysis as a means for studying and understanding theory use in HCI research.

Typologies or taxonomies describing different kinds of theory use are common outcomes of research on theory use. Some researchers point to speak to their interest in the location in which theory appears in a given publication, no attempts have been made to somehow account for the significance of *the location of theory in a publication* **Contribution 2:** I argue that there is value in visual models representing how theory interacts with other core elements of a scholarly publication.

Rogers (2012) has expressed concerns over "weakening theoretical adequacy"

facing the HCI research community. **Contribution 3:** Although I critique the notion of weakening theoretical adequacy I question whether HCI researchers ought to be more intentional in their use of theory in scholarly research and writing.

Structure of the Dissertation

In Chapter Two I review research published in HCI and design about theory. This review takes an inclusive approach in surveying scholarship on theory. This means that I did not start collecting literature with a particular meaning of theory in mind. I examine texts that frame theory as a family of thought, a scientific explanation of some phenomena, an abstract idea, among others. I did not include or exclude publications that discuss particular kinds of theory, which means I collected texts on/about information theory, scientific theory, behavioral theory, economic theory, HCI theory, and design theory. I used "theory" as a keyword to search three scholarly databases (e.g. Thomson-Reuters Web of Science, Google Scholar, and the ACM Digital Library) for conference papers, journal articles, and book chapters and books. I also snowball sampled additional readings from the bibliographies of texts found in the initial round of database searching.

Following my summary of related work, in Chapter Three I discuss the research approaches I have taken to studying theory and theory use. This chronological narrative summarizes the eight formative studies I completed during my time as a PhD student. I made the decision to present this story chronologically in an attempt to capture the evolution of my thinking. Where did I start? What path did I take? Where am I now?

In Chapter Four I dive deeper into each formative study. In particular, I detail the approach I took to answer each question, and the outcome of my approach. At the end of

this chapter, I reflect on these formative studies, and I describe how and why I made the decision to conduct a final study of theory use in CHI Best Papers.

In Chapter Five I present findings and a discussion of my examination of theory use in 90 CHI best paper winners. I discuss the presence of possible HCI theories, and I compare and contrast my findings with other studies of theory use in HCI research publications. In addition, I discuss the challenge and opportunity of studying *implicit* theory use in publications and I reflect on the strengths and limitations of my approach.

In Chapter Six, my ambition is to synthesize three key insights in response to my research questions. First, I suggest that studying theory use by studying scholarly publications is useful but that researchers should explore other approaches. Next, I reflect on the utility and value of models of theory use as tools for studying theory use in a research community. Finally, I discuss steps HCI researchers might take to strengthen intentional theory use in their research and writing.

In Chapter Seven I suggest possible ways to reframe HCI research.

Chapter 2. Literature Review

Introduction and Context

Many scholars in HCI have written about theory, including its role and function in the field as well as its relationship with designing. There are publications exploring the different ways theory has informed HCI research (Erickson & McDonald, 2008; Olson & Kellogg, 2014; Rogers, 2004, 2012), on the historical importation and development of theories from other disciplines in HCI (Grudin, 2008; Rogers, 2004), and on the relationship between theory and practice (Dalsgaard & Dindler, 2014; Rogers, 2012).

There have been inquiries into the current "state of the discipline" by taking stock of the current state of its theory (Rogers, 2012). The "current state of theory" may be assessed by examining the extent to which scholars use theory in their research and writing or assessing the presence and development of theory *from within* a given research community. These inquiries appear to take up the idea that theory can be used to gauge disciplinary health (Camic & Gross, 1998; Pettigrew & McKechnie, 2001). More recently, there have been efforts to ascertain whether research through design (RtD) is a useful approach for developing theory in HCI and design research (Zimmerman & Forlizzi, 2008; Zimmerman, Stolterman, & Forlizzi, 2010). And finally, HCI researchers explore ways to develop theory that is relevant and useful to practitioners.

Given the variety of questions and approaches to studying theory in HCI research it seems reasonable to reflect on its utility and value. In this dissertation, my interest has to do with theory as an object of study. How do HCI researchers study and write about theory and theory use? What are the strengths and limitations of the various approaches that could be undertaken to study theory? How can researchers in the community more effectively study theory? How do researchers in other fields study theory empirically?

I have found a number of publications studying theory use by conducting content analyses (Clemmensen, Kaptelinin, & Nardi 2016; Pettigrew & McKechnie, 2001; Weerakkody, Dwivedi, & Irani, 2009). One of my assumptions in this dissertation is that examining the role or function theory plays in research publications will yield insights into what Rogers called "the theoretical adequacy" (2012, p. 18) of the field, which describes the degree to which HCI theory accounts for its core objects of study. Theoretical adequacy becomes quite an important concept then – one that is central to my project. So, it is important to build out a deeper understanding of just what theoretical adequacy can mean. Toward this end, I summarize a collection of texts about theory culled primarily from HCI research literature. I organize the review according to five research questions:

- How does theory frame and fuel the HCI research agenda?
- What if technological artifacts were interpreted as embodying theories?
- What role should theory play in HCI design research?
- What kinds of theory are useful to HCI practitioners?
- How are theories used in HCI research publications?

Reading and organizing the literature for this dissertation has yielded the following personal insights about theory and theory use in HCI research. First, there is a diversity of thinking about what constitutes theory and what its role/function in research ought to be. *There are no generally accepted positions on what theory means or on how it ought to be used in HCI research. However, there are dominant positions on both of these questions.* For example, a classic perspective on technological artifacts as embodiments of theory assumes a scientific perspective on the meaning of theory and its role in research.

Moreover, *adopting a particular understanding of theory constrains the way it might relate to different research approaches*. For example, a scientific perspective on theory could be seen to relegate design research to take up a supporting role in the HCI community – wherein its purpose is not to generate knowledge on its own terms but rather to serve as a testing ground for the applicability of scientific theories in the design and development of technological artifacts. In addition, while some theories and theoretical concepts have proven more useful to practitioners than others, *there is a lack of consensus about what makes theory practically useful, and there is little effort geared towards evaluating proposed solutions to the problem of practical utility*.

Gathering the Literature

The texts that serve as the foundation for this review were collected using a keyword approach summarized in (Hart, 1999). I searched the ACM digital library, Google Scholar, and the Web of Science using "theory," "theory building *or* development," "theorizing," and "theory use" or "use of theory" as primary keywords. I manually examined the search results in each database and identified texts that seemed to engage with theory as a primary topic of study. My aim was to curate a corpus in which the publications focused on the concepts of theory or theory use or theory building.

Next, I engaged in a round of bibliography mining. I examined reference lists in each text in the initial corpus for additional readings that seemed relevant. I judged a reading to be relevant on the basis of its title, abstract, and citation count. For example, the question of what constitutes a scientific theory continues to be well studied in the philosophy of science (Azzouni, 2014; Chakravartty, 2001; Contessa, 2006; Van Fraassen, 1987). One common feature of this discourse is persistent citations of classic texts on scientific theories and their function in research. These include texts by Karl

Popper (1963, 2002), Thomas Kuhn (1970, 2012) and Imre Lakatos (1970). Using citation count to evaluate a text for inclusion/exclusion risks skewing the corpus towards older, established texts. I tried to protect against this by filtering search results to emphasize publications from the last five years (2013-2017).

Philosophy of Science as a Foundation for Making Sense of Theory

The philosophy of science is a broad research community that asks questions about the nature of science. These questions address the nature of scientific activity, scientific knowledge, and even the place of scientific knowledge in society. In his text *Theory and Reality*, Peter Godfrey-Smith glosses of some of the central questions in the field, which include "what science is, how it works, and what makes science different from other ways of investigating the world" (Godfrey-Smith, 2009).

One approach to distinguish science from other ways of investigating the world is in terms of its theories. Karl Popper grappled with this issue, which he described as "the problem of demarcation." He was interested in establishing what distinguishes scientific theories from other types. In this section, when I use the word "theory," I use it to mean a scientific explanation or description of some phenomenon and not, for example, a family of thought.

In his famous book, *The Logic of Scientific Discovery* ([1959] 2002), Popper argued for "falsifiability" as a possible solution to the problem of demarcation. Falsifiability refers to a theory's capacity to be tested and disproved. In the most basic sense, if a theory can be disproved then it is a scientific theory. If it cannot be disproved, then it is not a scientific theory. For example, Popper pointed to Freud's theory of psychoanalysis, Marx's theory of history, and Alfred Adler's theory of individual psychology as non-scientific theories.

In Popper's view, Freud, Marx, and Adler all proposed *un*falsifiable theories—ones that could never be disproved. "Once your eyes were thus opened [to these theories] you saw [only] confirming instances everywhere… whatever happened always confirmed them" (Popper, 1962, p. 35) Nothing seemed to contradict them or undermine their explanatory power. Popper presented Einstein's theory of general relativity, by contrast, as an exemplar falsifiable theory. From Einstein's theory, one could deduce logical, empirically observable consequences of the theory's truth and test those deductions as a means of testing the theory.

From Einstein's theory one could deduce that stars near the sun would appear to have moved *away from* the sun and each other. Such a deduction is "incompatible with certain possible [empirical] results—in fact [it is incompatible] with results that everyone before Einstein would have expected" (Popper, 1962, p. 36). Einstein's theory and its predictions diverge from well-established scientific theory, and the consequences, if correct, would be profound. Popper also argued that Einstein's theory is falsifiable both logically and empirically, that is, both when it came to its practical, empirical predictions as well as its internal logical consistency.

Popper's work on falsification as a demarcation criterion for scientific theories has been critiqued and developed by others (Kuhn 1970; Lakatos 1970). In one of the most notable critiques of Popper's work, Thomas Kuhn, while acknowledging that Popper is not a naive falsificationist, suggested that Popper could be treated as one (Kuhn, 1970). Kuhn's claim for treating Popper as a naive falsificationist rests on two grounds: (1) there is no such thing as conclusive disproof of a theory and (2) because of (1) only logical falsification is left as the demarcating criterion of a scientific theory. If

there is no such thing as conclusive disproof, can we treat Popper as a naive falsificationist? And what might this mean for the validity of falsifiability?

Popper agreed to the impossibility of conclusive disproof. In *Logic of Scientific Discovery* he wrote, "In point of fact, no conclusive disproof of a theory can ever be produced" ([1959] 2002). This has to do with what he described elsewhere as the problems of the 'empirical basis,' which include unreliable research design and errors of observation. Such problems challenge the integrity of results that would otherwise seem to falsify a theory.

As powerful as science might be, its practices and procedures remain subject to human error. But acknowledging the lack of conclusive disproof does not establish Popper as a naive falsificationist nor do I believe it merits his treatment as one. In the absence of conclusive disproof, there is more than just logical falsification as the demarcating criterion of scientific theories. There is also the 'empirical basis.' Hence, I suggest that the empirical basis is a useful and valid tool for determining the scientific*ness* of a particular theory about designing.

In the discourse on falsification several concepts have been developed. For instance, Lakatos made a nuanced distinction between naive falsification, methodological falsification, and sophisticated falsification (1970). Even though these more precise definitions of falsification are important, what matters for my purposes is whether these different kinds of falsification imply different demarcation criteria for the scientific status of a theory.

In my view, naïve and methodological falsification express a common perspective on assessing the *falsifiability* of a theory. A theory may be designated scientific if it is

falsifiable. To be falsifiable means that a theory is capable of producing basic statements, which are "statements asserting that an observable event is occurring in a certain individual region of space and time" (Popper, [1959] 2002). These could be basic statements that are incompatible with preexisting ones *or* basic statements about a new phenomenon. An example of a basic statement would be the proposition that, during the day, stars close to the sun would look as though they had moved away from the sun and from each other. This is an observable event occurring in a certain individual region of space and time.

Falsifiability has been criticized, and others, perhaps most notably Thomas Kuhn (1970), have argued that falsifiability cannot be the demarcating feature of scientific theories. I do not make any claims about the truth of falsifiability as the demarcating feature of scientific theories. Nor do I claim that falsifiability is a better way to demarcate scientific theories from other kinds. My decision to use it in my prior work as a framework for studying theories about the design process should instead be seen as a pragmatic decision. One reason to use falsification as an analytical tool could be that it is a simple, intelligible concept. It could be understood in terms of what Mario Bunge (1961) calls "pragmatical simplicity."

Bunge wrote about pragmatical simplicity as it pertains to scientists faced with a choice between theories that are empirically equivalent yet conceptually *in*equivalent. For example, choosing between two theories that account for the same observable phenomena (empirical equivalence) but involve different philosophical views (conceptual inequivalence). Bunge lists different theories of gravitation, different interpretations of quantum mechanics, and different cosmological theories to illustrate empirical

equivalence coupled with conceptual *in*equivalence. For example, Einstein and Whitehead proposed competing theories of gravitation. How does a scientist choose between these different theories? I might pose a similar question about choosing between different demarcating criteria of scientific theories.

Bunge describes simplicity as one among several "metascientific criteria" that scientists use to choose between theories. But he characterizes simplicity as a complex compound and suggests achieving a deeper understanding of simplicity itself may yield insights about its function as a selection criterion. He introduces the notion of pragmatical simplicity, which

> *"may be analyzed into (1) psychological simplicity (intelligibility), (2) notational simplicity (economy and suggestive power of symbols), (3) algorithmic simplicity (ease of computation), (4) experimental simplicity (feasibility of design and interpretation of experimental results), and (5) technical simplicity (ease of application to practical problems"* (1961, pgs. 121-122)

Although there are other approaches to demarcating scientific theories, falsifiability can be interpreted as a simple, intelligible concept. It is widely known, and it is generative of a straightforward way of assessing the scientific*ness* of a theory, which involves "spotting the logical consequences" (Bunge, 1961, p. 125) of its axioms. Spotting the logical consequences may be a challenging task, but the task itself is clear enough. In my own work, I have attempted to follow this procedure when I examined four theories of the design process in order to determine whether they could be interpreted as scientific (Beck & Stolterman, 2015).

Working with Popper's publications provided me with a framework for thinking about theory and its role and function in research. For instance, in my early work, I tended to conceive of theory as a falsifiable explanation or description of a phenomenon.

Moreover, I considered the primary purpose of scientific research to be, as Popper stated, the attempted falsification of different theories. This means that my early theoretical framework was based partly on an understanding of theory as a scientific explanation rather than, say, a family of thought or a lens through which to make sense of things. This had implications for the way I contemplated the role and function of theory in HCI research, and it continues to influence my current thinking.

What role does theory play in framing the HCI research agenda?

Theory has been called an essential component of any academic discipline (Gregor, 2014). Theory is what makes it possible for researchers to move into the realm of shareable, applicable knowledge. And it provides researchers with the means to construct, structure, evaluate, and assess knowledge (Hannay, Sjoberg, & Dyba, 2007). It has been described as a model (Friedman, 2003), likened to a map (Ziman, 2002), and defined as a way of looking at a phenomenon "with explanatory or predictive implications" (Blackburn, 2008, p. 361).

Yvonne Rogers has provided the HCI community with summaries of the uses and meanings of theory in HCI (Rogers, 2004, 2012). It should be acknowledged that these summaries have the potential to constrain thinking. It could be argued, for example, that Rogers' work, and, in fact, other scholarship on theory in general (Weick, 1989, 1995), impedes different ways of thinking about theory since it adheres to relatively stable notions of what constitutes a theory and/or a theoretical contribution. For example, while Rogers acknowledges what I would call the theoretical diversity of the HCI research – there are many theories from *different* research communities being imported and worked with in interesting ways – a scientific perspective undergirds the core of her argument that HCI may be at risk of weakening theoretical adequacy.

Rogers offers a rich perspective on the role and contribution of theory in HCI. She acknowledges that an ever-broadening array of theory continues to be imported into HCI from other reference disciplines including the natural sciences, social sciences, humanities, and philosophy. These theories have been used to "analyze and predict the performance of users… identify factors relevant to the design and evaluation of interactive products… narrow down an area into concerns and research questions… [and provide] the rationale for selecting a variable or set of variables" (2012, p. 15-16) to address in one's research or design work. The roles that she emphasizes could be described as traditional roles for theory, such as: explanatory, predictive, prescriptive, or generative. These roles resonate with other scholarship on the role of theory in research (Popper, [1959] 2002; Ziman, 2002).

Importantly, Rogers claims that the "role of theory in HCI has been stretched, from how it was originally used as part of the scientific method to being interpreted broadly at different levels to describe, explain, predict, and argue with" (2012, p. 17). A key assumption in this claim seems to be that theory use in HCI may differ from other research contexts. Is there something unique about the way researchers in HCI use theory? How and why do HCI researchers *use* theory in their research and more specifically how do they *present* this use? In many cases, theory is used in ways that resonate with established definitions. We need not look too hard to find examples of theory as an explanatory, predictive, or prescriptive tool (e.g. Baskerville & Pries-Heje, 2010; Hollan, Hutchins, & Kirsh, 2000; MacKenzie, 1992). But as Rogers suggests, theory perhaps has other uses.

Rogers also speculates about the role theory plays, and *will* play, "in framing and moving the HCI research agenda forward" (2012, p. 81) as well as what is perhaps the most common topic of discussion when it comes to theory in HCI research: the theory-practice gap (Buie, Hooper, & Houssian, 2013; Dalsgaard & Dindler, 2014; Goodman, Stolterman, & Wakkary, 2011; Obrist et al., 2013).

Understanding the role and function of theory in framing and moving the HCI research agenda forward is an interesting, relevant project for the field. And it is one that can be (and has been) approached from different perspectives. Researchers who frame HCI as a scientific field *or* as a field with scientific aspirations (Liu et al., 2014; Reeves, 2015) may argue for scientific conceptions of theory and its of the role and function in research (Kuhn, 2012; Popper, 2002). Researchers who practice Humanistic HCI (Bardzell & Bardzell, 2015) may argue for theory as an interpretive lens, and they may critique and eschew scientific notions. Finally, researchers interested in research through design may explore both alternative roles for theory in research (Bowers, 2012; Gaver, 2012) and more traditional roles (Stolterman & Wiberg, 2010; Zimmerman et al., 2010).

In the next section, I discuss two classic publications (Carroll & Campbell, 1989; Carroll & Kellogg, 1989) that examine the potentially complementary roles design and science play in HCI research and the implications of this relationship for theory in the field. My decision to examine classic texts in depth does not mean that the relationship between technological artifacts and theories has not been examined in depth. There is quite a lot of research in HCI and neighboring disciplines aiming to forge a stronger connection between theories and artifacts. Some examples include: (Barnard, 1991;

Baskerville & Pries-Heje, 2010; Carroll & Swatman, 2000; Gregor, 2009; Pries-Heje & Baskerville, 2008; Zimmerman & Forlizzi, 2008).

What if technological artifacts were interpreted as embodying theories?

John M. Carroll, a leading HCI scholar, along with Wendy Kellogg and Robert Campbell, authored two interesting and influential papers on the relationship between technological artifacts and theories in the late eighties (Carroll & Campbell, 1989; Carroll & Kellogg, 1989). The first paper, *Artifact as theory-nexus,* was published at the 1989 CHI conference. The second paper, *Artifacts as Psychological Theories,* seems to be less well known in HCI research, but it was (and still is) equally relevant. Both papers were written at a time when HCI was grappling with issues related to its disciplinary identity. Carroll and Campbell framed their work in part as an attempt to resolve concerns over both the legitimacy and composition of the field. Carroll and Kellogg took a similar approach—but they were a bit more precise in their framing. They sought to resolve a conflict between "theory-based design" and "hermeneutic approaches" to conducting HCI research. Both papers framed HCI as a *design* science, and both sought to understand the complementary roles of design and science in HCI research.

What does it mean to frame HCI as a design science? In Carroll and Campbell's terms it means that HCI "does not just study designs, in the way that archaeology studies arrowheads—it *does* design [work]" (1989, p. 253). The idea of design science could have been a source of anxiety over the legitimacy of the field. Cognitive science, human factors engineering, and psychology were dominant in HCI in the late eighties. Perhaps design was seen as a threat to the rigor with which other approaches conduct and evaluate research. Or perhaps the role and contribution of design was simply unclear. It may be useful and interesting to read Carroll and Campbell *and* Carroll and Kellogg's papers as

attempts to clarify the role and contribution of design work by proposing designed artifacts as embodiments of psychological theories.

What does it mean for an artifact to embody psychological theories? Carroll and Kellogg use an analytical framework of their own design to examine HyperCard. They suggest that HyperCard embodies multiple claims about learning and information processing, such as: (1) concrete, meaningful objects suggest goals, (2) modifying is easier than creating from scratch, and (3) learning by doing is superior to being told. These claims could in turn be used to develop more specific, testable claims about user behavior such as: (1) [user x] will develop [actionable goal y] in response to [meaningful object z] in the HyperCard tool or (2) [user x] will [retain y knowledge longer] by directly manipulating the HyperCard tool than [user z] will [retain y knowledge] by attending a brief presentation on the HyperCard tool.

Carroll and Kellogg acknowledge that the process of extracting such claims from an artifact is a process of interpretation and that such interpretive processes are valuable to a scientific field "insofar as they produce systematic and falsifiable results" (1989, p. 13). HyperCard, for example, may turn out to have features that impede rather than promote learning. An HCI researcher could therefore attempt to generate a list of its embodied claims and then subject them to falsification in the interest of testing the more abstract, general theories of learning and/or information processing on which they are based. When Carroll and Campbell refer to designs like HyperCard as "theory-like," they may be invoking Popper's conception of theory in scientific research. That is, HyperCard can be generative of falsifiable basic statements, and it could assume a theory-like role

if/when HCI researchers utilize it to generate testable basic statements about artifacts and users. But why is framing artifacts as theory-like useful to the field?

Carroll and Kellogg argue that framing artifacts as theories (1) cultivates effective theory building in HCI research, (2) reconciles a conflict between theory-based design and hermeneutics, and (3) clarifies the apparent paradox of HCI practice *leading* HCI theory. In addition, Carroll and Campbell argue that framing artifacts as theories "resolves the current methodological perplexity about the legitimacy and composition of the field" (1989, p. 247). Two of these claims in particular strike me as interesting and relevant to the current theoretical discourse in HCI: (1) reconciling the conflict between theory-based design and hermeneutics and (2) resolving methodological perplexity about the legitimacy and composition of the field.

Theory-based design as described by Carroll and Kellogg seems to be rooted in psychology. Users and artifacts are studied in lab settings. And one of its goals appears to be the generation of a collection of general theories that designers might use to make design decisions aimed at achieving specific outcomes in user behavior or experience. By contrast, the goal of hermeneutics is to cultivate HCI design as a "subjective process of discovery" where situations, users, and artifacts are treated as "ultimate particulars" (Nelson & Stolterman, 2014), and understanding them is achieved through a process of "consensual interpretation." A hermeneutic approach is highly critical of attempts to "reduce" situations, users, and artifacts to general theories. It views the theory-based approach as (1) distorting user behavior and experience by studying them in lab settings and (2) undermining design by reducing it to a process of deductive inference from general theories to an ultimate particular. An ideal resolution to this "conflict" may

involve maintaining the integrity of the theory-based and hermeneutic approaches and proposing ways in which they might complement one another. But Carroll and Kellogg seem to propose (primarily) modifying the hermeneutic approach in order to bolster the following perceived shortcomings: (1) lack of *systematic* methodology, (2) no conceptual framework, and (3) an inability to generalize/abstract from particular instances.

Carroll and Campbell (1989) proposed that framing artifacts as psychological theories would "resolve [the] methodological perplexity about the legitimacy and composition of [HCI]" (1989, p. 247). This claim is relevant to the field today, and it may undermine the purported novelty of recent claims expressing similar "perplexity" about the field's legitimacy and composition. For instance, Rogers suggests that HCI used to be "a confined problem space with a clear focus and a small set of methods" whereas now there is a "worrying lack of direction, structure, and purpose in the field" (Rogers, 2012, p. 1). But Carroll and Campbell's characterization of HCI as methodologically perplexed and grappling with issues of legitimacy and composition (in 1989) seems to challenge Rogers' narrative—at least in terms of her timeline.

So how does framing artifacts as psychological theories potentially contribute to resolving methodological perplexity about the legitimacy and composition of the field? Carroll and Campbell examine the way(s) designed artifacts could be said to complement scientific research. In parallel with Carroll and Kellogg, they explain how artifacts can be analyzed in terms of their embodied psychological "theories" and used to generate falsifiable basic statements about user behavior or experience. But Carroll and Campbell do not propose changes to the design process in order to make it more systematic or rigorous. They treat design and its artifacts (1) on their own terms and (2) as means to

facilitate scientific activities such as theory development, which is similar to some of the views expressed more recently in (Stolterman & Wiberg, 2010). The point is not to adapt one to meet the needs to the other—but perhaps to find something like points of consilience (Wilson, 1999).

What role should theory play in HCI Design research?

In a previous section, I mentioned literature that examines the potential of research through design to produce and contribute to the development of theory (Forlizzi, Zimmerman, & Stolterman, 2009; Zimmerman & Forlizzi, 2008). Stolterman and Wiberg (2010) have also argued for "concept designs" partly as a means to develop theoretical constructs that could be used to guide subsequent interaction design research. This literature in part responds to questions about the legitimacy and rigor of research through design as a means of producing knowledge. However, it is possible that such questions assume a scientific position with regard to "[research] purposes, intended outcomes, and internal logics" (Fallman & Stolterman, 2010, p. 265). The predominance of scientific perspectives could be seen as motivating recent contributions to the field exploring different (i.e. non-scientific) roles and/or functions of theory in research (Bowers, 2012; Gaver, 2012).

What is an *appropriate* role for theory in research through design? This is the key question Gaver (2012) examines. But what does it mean for a role to be appropriate? What would be an example of an *in*appropriate role for theory? These questions are important to Gaver because of what he perceives to be the consequences of answering them from a scientific standpoint. The consequences could include: (1) overly restrictive constraints on research through design and (2) a hampered ability to challenge status quo thinking. And if HCI is, as Gaver describes it, "prone to 'scientism' in its cultural

assumptions," (2012, p. 938) then perhaps these consequences are of genuine concern. To mitigate the risk of devaluing or changing research through design (and the integrity of its knowledge contributions to HCI) Gaver looks to design itself in order to determine what might be an appropriate role for theory.

In his analysis, Gaver argues that designers do not engage with "theoretical approaches" in their design work. This may be because they lack time or other resources (Rogers, 2012). Or it may be because theory is too abstract to be applicable (Höök & Löwgren, 2012). These reasons are frequently cited though rarely subject to further examination in the theory-practice gap literature (Dalsgaard & Dindler, 2014; Goodman et al., 2011; Remy, Gegenbauer, & Huang, 2015). Gaver provides two other possible reasons in his paper. First, he suggests that theories underspecify designs, which means that they cannot account for *most* of the decisions a designer will make. Second, he suggests that theory is underspecified by design, which means that a given theory will fail to explain many aspects of a successful design (Gaver, 2012, p. 944). Theory is therefore not useful to designers due to its inability to support design decisions and its inability to explain *many* aspects of a successful design. It may be worth mentioning that Gaver's critiques of theory are actually critiques of *scientific* theory. *Scientific* theories underspecify designs and *scientific* theories are underspecified by design. An example from Carroll and Kellogg (1989) may help to illustrate this point.

Carroll and Kellogg analyze HyperCard as embodying multiple theories about learning and information processing. From Gaver's perspective, these theories will not provide sufficient support to designers confronting "wicked" (Rittel & Webber, 1973) HCI design problems nor will they explain many of HyperCard's successful features.

Gaver might suggest that HyperCard itself embodies "the myriad choices made by [its] designers with a definiteness and level of detail that would be difficult or impossible to attain in a written (or diagrammatic) account" (Gaver, 2012, p. 944). He thus seems to imply that designers can intuit these myriad choices by collecting and studying artifacts themselves. And in cases where designers are focused on solving a problem as opposed to producing knowledge or advancing theory, this kind of design intuition may work well. But researchers contribute and share knowledge in a discipline, which may require some kind of written or diagrammatic account. And Gaver does not challenge the notion that designs embody multiple theories. Rather, he proposes a role/function of theory in relation to design(s) that aims to respect the integrity of design as a distinct way of doing research—he proposes theory as a form of annotation.

What does it mean to use theory as an annotation? To use theory as an annotation is "to explain and point to features of 'ultimate particulars,' the truths of design" (Gaver, 2012, p. 944). Gaver does not claim that theories reveal *all* features of an ultimate particular. It may be more accurate to say that designers can use theory to point to *some* interesting features of an ultimate particular. Gaver illustrates this point by characterizing Dieter Rams' ten principles of good design as theoretical annotations on a portfolio of Rams' design work.

Here is where Gaver plays with the meaning of the word "theory" a little bit. He does not define what he means by theory and perhaps assumes that the reader can draw conclusions about what theory means (or can mean) based on his example. And I think this is intentional. An issue that Gaver raises *but does not examine* in his paper is that there is an underlying scientism permeating HCI's cultural assumptions, which probably

includes assumptions about theory and its meaning(s). By using principles as an example of theory, Gaver could be seen to encourage readers to question what theory could or should mean for research through design—to find a place for research through design as a distinct approach to HCI based on its relation to theory. For research through design, "theory" might simply refer to abstract knowledge that does not reside at the level of general, scientific theories but resides at a more abstract level than the ultimate particulars it annotates. I will return to this when I discuss intermediate-level knowledge objects (Höök & Löwgren, 2012; Löwgren, 2013) in the next section of the review.

The principles "draw attention to important features and salient details that might otherwise be overlooked" (Gaver, 2012, p. 944). This example provides some clarity as to what might constitute a theoretical annotation (e.g. principles of good design), and it suggests that part of the value of annotations is their capacity to distinguish between portfolios. Jon Bowers (2012) elaborates on this latter point in his descriptions of annotations:

1. **Turning a collection into a portfolio.** A collection of designs does not constitute a portfolio because it lacks systematicity. Portfolios are "systematic bodies of work." They position-take, make arguments, or represent ideas. "Works do not speak for themselves," (Bowers, 2012, p. 71). Annotations speak for them.
2. **Creating relationships between designs.** Theories can capture similarities and differences between designs—similar to the Linnaean system of biological classification where specimens are sorted into species and then into genera, and so forth (Wilson, 1999).
3. **Enabling comparison between portfolios.** Theoretical annotations function as answers to the question, "What is this portfolio like?" (Bowers, 2012, p. 72). Answering this question enables designers or researchers to compare different portfolios.

Theory as annotation seems like it could be a powerful taxonomic system for research through design to organize knowledge about groups of ultimate particulars. It could be seen as a way of generalizing or abstracting judgments or choices or principles from ultimate particulars and applying them to broader sets. Gaver writes, "… *multiple* examples can start to tease the individual concerns and judgments involved in a single situated design out of the particular configuration to which they were applied" (Gaver, 2012, p. 944).

Research through design (using theory as annotation) thus seemingly has the capacity to produce a kind of generalizable knowledge *without* the need to "turn greater attention to theory-making" in the scientific sense. And such a turn would seem to run counter to the preliminary arguments Gaver lays out in his paper, which imply that research through design succeeds if: (1) it creates artifacts, (2) creates possible new realities, and (3) challenges status quo thinking. Whether it complements scientific work in HCI is not among these criteria.

The idea of using theory as a *post hoc* explanatory tool could be seen as an attempt to formulate a role/function for theory based on the "purposes, intended outcomes, and internal logic [of design instead of science]" (Fallman & Stolterman, 2010, p. 265). However, to see it this way may overlook the way in which Gaver and Bowers play with the meaning of the word "theory" in their texts. It is not as though they are attempting to formulate a role for *scientific* theories. They could be seen as calling out an injustice they see in the HCI research community—that primacy is given to scientific understanding(s) of theory and scientific research. It's not just the role/function of theory

that they challenge with annotated portfolios. It is the meaning of theory, too. But I have not yet come across any texts in the literature exploring this idea.

The extent to which "theory as annotation" has actually been used—let alone whether it is useful—in HCI research remains underexplored. Have annotated portfolios contributed to shaping the HCI research agenda? How are they similar to and different from methods like generic design thinking (Wiberg & Stolterman, 2014)? What kinds of theories are most useful for annotating portfolios? This latter question points toward another thread in the HCI literature—one that has yielded contributions addressing the practical utility of theory.

What kinds of theory are useful to HCI practitioners?

So far I have mentioned a few reasons scholars give in support of their arguments as to why professional designers do not engage with theory or theoretical approaches propagated by HCI researchers. This lack of engagement has been characterized as a gap between theory and practice. Rogers (2012) has suggested that theory and theoretical approaches are too resource intensive for practitioners to learn and apply. And Gaver has suggested that theories are deficient in their ability to account for all of the decisions designers confront (Gaver, 2012). Another argument about the gap goes as follows: (1) General theories are too abstract and are not directly applicable to designing. (2) If designers cannot see the direct application of a theory then they will not use it in their work. (3) Theoretical knowledge is important and relevant to design. So (4) perhaps what is needed is some kind of intermediate-level knowledge object, like strong concepts (Höök & Löwgren, 2012) or bridging concepts (Dalsgaard & Dindler, 2014).

What are intermediate-level knowledge objects and what makes them different from general theories? Höök & Löwgren (2012) define intermediate-level knowledge as

the non-empty space between ultimate particulars and general theories, and intermediate-level knowledge objects are the elements that occupy this space. Examples of intermediate-level knowledge objects include: methods, tools, heuristics, principles, guidelines, and strong concepts. Dieter Rams' ten principles of good design can thus be seen as intermediate-level knowledge objects and so can usability heuristics (Nielsen, 1994). Höök & Löwgren suggest that intermediate-level knowledge objects have the capacity to play a more "direct role in the creation of new designs" (Höök & Löwgren, 2012, p. 2) than general theories due to their lower level of abstraction. In their view, principles and heuristics are *more* concrete than activity theory or actor-network theory but abstract enough so that they could apply to a variety of design problems.

The concept of intermediate-level knowledge (and knowledge objects) is potentially useful for HCI researchers whose purpose is to produce "practical" knowledge for designers. This purpose is distinct from theoretical advancement (Stolterman & Wiberg, 2010). For instance, a researcher might use the concept of intermediate-level knowledge to develop a set of criteria against which to evaluate a knowledge object to determine its level of abstraction. What could these criteria be? How might we measure a knowledge object's level of abstraction? Could this be construed as a way of measuring its utility? Since there are many existing intermediate-level knowledge objects it might also be worthwhile to develop taxonomies to categorize and compare them. When and how are principles and guidelines useful? Are they more or less useful than strong concepts? Categorizing and comparing different knowledge objects might also be a way of revealing opportunities for novel contributions to intermediate-level knowledge.

Höök & Löwgren proposed "strong concepts" as an intermediate-level knowledge object. "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 particular instantiations" (Höök & Löwgren, 2012, p. 5). Strong concepts seem similar to design patterns (Alexander et al., 1977) and theory as annotation (Gaver, 2012), both of which could be said to abstract design elements beyond "ultimate particulars" such that they might be applied elsewhere. So the definition is not necessarily an effective tool for distinguishing strong concepts from other kinds of intermediate-level knowledge. But Höök & Löwgren (2012, p. 5-6) provide a set of four criteria for this purpose, and they discuss two concrete examples (social navigation and seamfulness) in terms of these criteria. Their discussion is interesting both for what it includes and for what it seemingly omits.

For instance, the authors discuss how applying strong concepts "requires skills and a deep understanding of the particulars of a specific design situation" (2012, p. 6). This raises interesting questions about how the design situation contributes to the perceived applicability of a knowledge object. Intermediate-level knowledge objects have been framed as *more* directly applicable to design situations than general theories. But less has been said about the role the design situation plays in strengthening or undermining this applicability. For instance, if a designer lacks a deep understanding of a specific design situation then perhaps even intermediate-level knowledge objects may not seem applicable. Can intermediate-level knowledge objects potentially deepen one's understanding of a design situation?

Höök & Löwgren's discussion about the resources required to integrate strong concepts into a design process creates the possibility for an interesting comparison between integrating and applying (1) strong concepts and (2) general theories. General theories may reside at a higher level of abstraction than strong concepts. But does level of abstraction provide us with a good indication of the skills (and other resources) required for its perceived utility or application *in situ*? Höök & Löwgren might answer in the affirmative. They may elaborate that an intermediate-level knowledge object is more concrete than a general theory, which means that its potential application is clearer. For example, the "biophilia effect," which has been categorized as a design principle, refers to the tendency of "environments rich in natural views and imagery to reduce stress and enhance focus and concentration" (Lidwell, Holden, & Butler, 2003, p. 36-37). The potential for application seems clear even in the absence of a design situation.

By contrast consider ecological rationality (Rogers, 2012; Simon, 1979), which explains the context-dependence of rational decision-making. Ecological rationality theorizes rationality as determined *both* by internal *and* external criteria. This explanation is oversimplified, but it may be sufficient to demonstrate that (1) the potential for application does not seem as immediately apparent and (2) ecological rationality requires more time and attention in order for its potential application to become clearer.

It is important to keep in mind that Höök & Löwgren are not arguing against the potential applicability of something like ecological rationality. They maintain that general theories like ecological rationality are less *directly* applicable than intermediate-level knowledge objects. Moreover, I think there can be very little confusion about what Höök

& Löwgren mean when they refer to general theories. It seems clear that they are referring to general *scientific* theories.

While Höök & Löwgren (2012) and Löwgren (2013), building on Rogers (2012), question the applicability of general theories in design practice, Haynes and Carroll (2010) set out to study whether and how general theories inform design work in information systems. They conducted an interview study with 68 researchers about the role or function of theory in their work. All interviewees characterized their work as research through design. Haynes and Carroll do not make assumptions about whether their interviewees use theory nor do they prescribe any definition of theory. A fascinating consequence of their decision *not* to provide a definition was the variety of "knowledge objects" interviewees considered to be theory. Contextual inquiry, phenomenology, and user-centered design are just some of the "theories" that interviewees reported applying in their design work. Yet these three knowledge objects arguably fall outside the traditional boundaries of what counts as a theory. One is a research method. One might be a philosophical school of thought or an approach to inquiry. And one is an approach to design. So it seems clear that there are multiple notions of what constitutes a theory amongst these interviewees. But there were also general theories given as well, including: activity theory, actor-network theory, complexity theory, and option-value theory. See (Haynes and Carroll, 2010, p. 7) for the full list.

Haynes and Carroll organize their findings into a conceptual framework of seven kinds of "theory translation," which I think is a misleading way of naming their findings. Translation seems like it might refer to the process by which designers either translate theories into more concrete representations in an attempt to make them more directly

applicable to design or translate theories directly into design decisions. But theory translation actually refers to the "ways that participants use theories and their elements in the translation of concepts and ideas into working information systems" (Haynes & Carroll, 2010, p. 8). So the theories themselves function as tools for translating concepts and ideas into designs. This does not mean that participants did not also have to translate the theories into more concrete, applicable forms. It simply means that participants did not talk about this process during their interview. This may be an important gap in our knowledge of how general theories might be applied in design. Do general theories require translation into a more concrete representation to be useful? Or are they useful even at their typical level of abstraction?

A key claim in the theory-practice gap literature (Dalsgaard & Dindler, 2014; Höök & Löwgren, 2012; Rogers, 2004) is that abstract theories are not *directly applicable* to practitioners and so intermediate-level knowledge objects like strong concepts, bridging concepts, principles, and heuristics are needed. While "level of abstraction" is a useful way to examine and evaluate theory, there are other criteria that might also be useful, such as: parsimony, maturity, or disciplinary origin. A review of key texts about theory in HCI (Carroll, 2003; Rogers, 2012) suggests that the discipline has been shaped by theories imported from other disciplines. Are theories imported from psychology or sociology, for example, more or less useful to HCI practitioners? Is it possible that more theories about concepts like interaction and interactivity (Stolterman & Wiberg, 2010) are needed? And how can we cultivate a community of researchers focused on developing such theories?

How do HCI researchers use theory in their publications?

Recent research in HCI has examined explicit theory use in scholarly publications

(Clemmensen, Kaptelinin, & Nardi, 2016; Velt, Benford, & Reeves, 2017). Explicit theory use can be defined as "the mention of the terms 'theory' or 'model' or any grammatical derivatives thereof together with at least one [in text citation], or… the identification of constructs and relationships in a body of conceptual argumentation…" (Hannay, Sjoberg, & Dyba, 2007, p. 93). Clemmensen, Kaptelinin, and Nardi (2016) examine the explicit use of activity theory whereas Velt, Benford, and Reeves (2017) analyze texts citing the trajectories conceptual framework. The singular focus on particular theories distinguishes these recent studies from other studies of theory use in HCI as well as studies in other research communities.

For example, in HCI research, Hekler et al. (2013) examine the use of behavioral theory, which includes multiple *individual* theories, such as: the transtheoretical model of behavior change, social cognitive theory, and the health belief model, among several others. Some studies of theory use in Information Science (IS) have been even broader and more inclusive – including theories, models, and frameworks from any discipline so long as they appear in an IS publication.

Conducting textual analyses is a prevalent approach to studying theory use in different research communities. For example, Clemmensen, Kaptelinin, & Nardi (2016) conduct a qualitative analysis of 109 full journal and conference papers that use activity theory. Velt, Benford, and Reeves examine 60 papers "considered to be actively engaging with the trajectories conceptual framework" (2017, p. 2092). I have collected a total of 36 publications whose stated aim is to study theory use, ascertain the current state of theory use, or identify trends in theory use in a variety of research communities. 20 of these studies apply textual analysis as the primary method of inquiry; that is, they

assemble a corpus of publications and then examine those publications in terms of theory use. The remaining five studies include essays and interview studies. And although essays and interview studies do not seem to be the dominant means of studying theory use, they have the potential to reveal insights that may not be possible through textual analysis.

For example, Haynes & Carroll interviewed 68 design researchers to ascertain "how theories are used in a design research project to motivate and inform the particulars of designed artifacts and design methods," they found "a broad and inclusive diversity of thinking about what counts as a theory" (Haynes and Carroll, 2007 pgs. 1-2). In addition to naming actor-network theory and personal construct theory, their participants categorized phenomenology, ethnomethodology, and user-centered design as examples of theory. It would have been impossible to achieve this insight through textual analysis since textual analyses tend to adopt clear definitions of theory and/or theory use. Adopting clear definitions is one way textual analyses maintain certain standards of rigor (Rourke et al., 2001; Stemler, 2001), but such definitions are by their nature exclusive. They exclude user-centered design and ethnomethodology from analyses of theory use even though the authors who invoke these concepts might intend them to be understood as instances of theory.

Although there are different approaches to studying theory use, there are some common research outcomes. For example, textual analysis, essays, and interviews may yield some kind of typology aimed at describing different kinds of theory use. For example, Clemmensen, Kaptelinin, & Nardi produce the following typology to capture the different uses of Activity Theory in HCI research publications (2016, pgs. 630-631):

- **Object of Analysis.** "Identified unique features and principles, as well as problematic aspects of the theory and compared it to other 'contextual' theories in HCI" (2016, p. 630)
- **Tool for New Analytical Tool Development.** "Identified the needs and requirements for new theoretical tools and employed AT to inform and guide the development of such tools" (2016, p. 630)
- **Conceptual Analysis and Development Tool.** "Applied the theory to address central issues and challenges in HCI" (2016, p. 630)
- **Empirical Analytic Tool.** "Key theoretical constructs [were used] to identify and categorize specific empirical phenomena." (2016, pgs. 630-631)
- **Framework for Design.** "The theory guides the iterative design process, or helped develop claims about the nature of the design process." (2016, p. 631)

Velt, Benford, and Reeves (2017) develop the following typology describing different uses of the Trajectories Conceptual Framework:

- **Generally situating one's work.** "The first purpose we identified was to include trajectories as part of a literature review" (2017, p. 2094).
- **Analyzing and describing an experience.** "28 in our selection of papers use trajectories to analyze or describe experiences as trajectories in a variety of ways" (2017, p. 2094).
- **Generating designs/conceptual work.** "We divide the 24 papers for which we identified a design purpose into two sub-categories: actual (9) and prospective designs (15)" (2017, p. 2094).
- **Building or critiquing concepts.** "[There are] different ways in which trajectories have led to building concepts, including comparing and borrowing concepts, as well as building implicit and explicit extensions to the framework" 2017, p. 2095).

In their 2013 CHI best paper, Hekler et al. describe three uses of behavioral theory in HCI research, which I recapitulate here:

1. **To inform the design of technical systems.** "Theory can be used to make decisions about which functionality to support and how to implement such functionality" (2013, p. 3309)
2. **To guide evaluation strategies.** Theory can be used to "guide evaluations of behavior change technologies" (2013, p. 3310)
3. **To define target users.** "Theories… suggest that different user groups will have diverse needs, and interventions that effectively support one group might be ineffective for another" (2013, p. 3312)

Haynes and Carroll (2010) describe seven kinds of theory use in design research, including:

1. **Theory as an idea bank** provides "direct prescriptions for design action and more subtle raw material to fuel design reasoning" (2010, p. 8).
2. **Theory as methodology** "is the use of theory as a very direct prescription on how to approach a particular class of design problem in a particular domain and with a particular set of tools to-hand" (2010, p. 9).
3. **"Social theories identify problems and opportunities"** (2010, p. 10).
4. **"Technical theories suggest solutions"** (2010, p. 10).
5. **"Theories identify knowledge gaps**… in a way that suggests opportunities for supporting human activities not currently supported by technology" (2010, p. 11)
6. **"Theory guiding reflection on design… [is]** not so much an input to the design process as… a guide to how an artifact can be understood in the context of use" (2010, p. 12).
7. **"Theory use [as] implicit or tacit…** is a device to inform their perspective towards the design domain" (2010, p. 12)

From their study of theory use in Software Engineering publications, Hannay, Sjoberg, & Dyba (2007, pgs. 91-92) generate the following typology:

1. **Design.** "A theory is said to be used in the design of an experiment if the research questions and hypotheses are justified or motivated by the theory" (2007, p. 91).
2. **Post hoc explanation.** "A theory is used as a post hoc explanation if is it used as an explanation of observations pertaining to the cause-effect relationship(s) after

the experiment has been conducted" (2007, p. 91).

3. **Tested.** "A theory, or an instance or derivation thereof, is tested if clear attempts are made to validate any of the theory's predictions that are directly related to the investigated cause-effect relationship(s)" (2007, p. 91).
4. **Modified.** "A theory is modified if there is a constructive effort to enhance, refine, conditionalize, etc., an existing theory based on results from the experiment" (2007, p. 92).
5. **Proposed.** "A theory is proposed if the authors 1) present their own theory in the article… and [it] pertains to explaining the cause-effect relationship under investigation in one of the roles above or 2) the theory is proposed on the basis of the experiment's treatment outcome relations" (2007, p. 92).
6. **Basis.** "A theory is referred to as constituting a basis if it transitively entails or provides structural elements for another theory in the roles above" (2007, p. 92).

Hannay, Sjoberg, and Dyba acknowledge that their typology does not account for *all* kinds of theory use. For instance, they do not account for "subsidiary, circumstantial [theory use]," which refers to mentioning theory but not engaging with it in any depth.

Hall et al.'s study of theory use in software engineering (2009) might be one of the only studies of theory use to compare different typologies of theory use. Through their analysis of the use of classic theories of motivation in software engineering publications, they develop the following typology of theory use:

1. **Interpretational.** "Classic theory was mentioned in the introduction, discussion, or conclusion of the paper to give some background and/or to generally interpret findings" (2009, p. 11).
2. **Underpinning.** "Classic theory was used in the design of the study and findings were interpreted in terms of classic theory" (2009, p. 11).
3. **Motivational.** "The motivation of the study was to replicate, validate, or extend classic theory. Classic theory provides the basis for the study" (2009, p. 11).

Following their presentation of this typology, they conduct a comparative analysis pitting

their typology against Hannay, Sjoberg, & Dyba's. Hall et al. claim that while the two typologies are related, theirs occupies a "higher level of abstraction" (2009 p. 11).

There are more typologies in the literature than I have listed here. My goal is to provide a sense for what these different look like. For example, there are many other typologies of theory use from research communities such as information science and occupational therapy, among others. They range from concise, simple lists to longer, more detailed accounts of the complexity of theory use.

These different studies motivated me to conduct my own interpretive research on theory use in HCI research. They suggested that it was possible (and perhaps even "good") to go about studying theory use by analyzing research publications, and served as justification that it could be possible to create a typology of different kinds of theory use on the basis of such research. Moreover, they revealed the possibility that it is not necessary to study theory use and create typologies in order to revise or extend existing studies. So far only one of the studies of theory use I have come across attempts to compare their results with those of other researchers. This could mean that studying theory use is in a state of expansion – where multiple explanations or descriptions of theory use are being generated. In some sense, my research contributes to this expansion. I have not found it suitable to pick one of these typologies in my efforts to study theory use.

Theory as a Knowledge Object

A generic characteristic of publications where theory is a key concept is an acknowledgment that theory can mean different things to different researchers. Sometimes, authors will generate lists of different possible meanings, such as:

- A "family of thought" (Bardzell & Bardzell, 2013, p. 3302),

- A "kind of tool for thinking often referred to as a 'lens'" (Gorard, 2009, p. 3),
- A "set of propositions which provides principles of analysis or explanation of a subject matter" (Mautner, 2005, p. 426),
- "A statement of relations among concepts within a set of boundary assumptions and constraints" (Bacharach, 1989, p. 496),
- "[A] well-substantiated explanation of some aspect of a phenomenon (Rogers, 2012, p. 4),
- "[Abstracted] knowledge that tells us something about fundamental entities at the core of a discipline" (Stolterman & Wiberg, 2010, p. 99), or simply
- Predictive knowledge (Chinn & Jacobs, 1978, p. 2).

Most of these meanings could be seen to adhere to a common scientific core even though there are other possible meanings (Bederson & Shneiderman, 2003; Carroll & Rosson, 2003; Friedman, 2003; Lee, 2014). For example, theories have been characterized *both* as representations of the natural world and its phenomena *and* as useful tools that help researchers think about the world without making claims of correspondence with reality (Godfrey-Smith, 2009).

For my purposes, I have tried to approach the meaning of theory by making a distinction between theory as a knowledge object (i.e., as a kind of artifact) or as a process (i.e., as theorizing). For example, when a researcher develops an explanation of how or why some phenomenon occurs, they are theorizing in a *scientific* sense. This is the process. The explanation itself becomes a *scientific* theoretical knowledge object. Both aspects are important and interesting, and there are papers addressing both the process of scientific theorizing (Corley & Gioia, 2011; Friedman, 2003; Weick, 1989, 1995) and the constitution of theoretical objects (Gregor & Jones, 2007; Whetten, 1989; Wieringa, Daneva, & Condori-Fernandez, 2011).

When choosing or ignoring a particular understanding of theory, I believe it is imperative to consider the intentions of the research project. A researcher whose goal is to understand the role/function of classic theories of motivation in software engineering research publications (Hall et al., 2009) has perhaps already adopted an understanding of what constitutes a theory as well as a perspective on how theories might be used in research. One of my research questions in this dissertation – *how is theory used in CHI best paper award winners?* – aspires to frame theory one a more general level as knowledge objects that can be practically used in scholarly publications. In spite of my scientific biases, my ambition is to be inclusive with what counts as theory, since previous work has shown that authors refer to theory in research publications as "theory," "model," "perspective," "rationale," "idea," "process," and "phenomenon" (Hannay, Sjoberg, & Dyba, 2007).

One understanding of theory that could be a good fit given my purpose is "abstracted knowledge that tells us something about fundamental entities at the core of [a research community]" (Stolterman & Wiberg, 2010). A key challenge with this perspective is its possible imprecision and scientific leanings. What are the fundamental entities at the core of HCI research? It might be more useful for my purposes to focus simply on abstracted knowledge that says something about fundamental entities of interest or relevance to HCI researchers *regardless of whether those entities are "at the core" of the research community*. A psychological theory of adolescent resilience might be relevant to an HCI researcher even if adolescent resilience is not part of HCI's intellectual core. And abstracted knowledge need not take the form of a scientific explanation or description of some fundamental entity. An open question is whether my

scholarly ambition matches with my execution. For instance, do I treat theory in an inclusive way when I analyze theory use in scholarly publications? Or do I tend to treat theory in a way that aligns with the preliminary understanding I developed through working with Popper's texts?

Chapter 3. Research Approach

In this chapter I summarize key concepts, methodologies, and methods in my various formative studies. And I distill key insights that shape my thinking about theory, HCI research, and studying theory use. I organize this section around the following key questions:

- Why do I use the term "formative" studies?
- Why did I conduct as many studies as I did?
- Was the order/organization of my studies important?
- Why did I start studying theory in the way I did?
- How did my approach evolve?

Why do I use the term "formative" studies?

I refer to eight of the nine studies described in this chapter as "formative studies," in an attempt to clarify their role in *forming* the foundation of my research and my standpoint as a researcher. One criticism that I have confronted in my research is that is lacks an explanation of my theoretical standpoint. I interpret this critique to mean that I have not explained how a family of thought shapes the ways I have approached my research. One of my goals in this chapter is to distill a set of insights that could be seen to form a basic outline of a theoretical standpoint – one that helps explain the approach I take in my final study of theory use in CHI best paper award winners.

Why did I conduct as many studies as I did?

I conducted as many studies as necessary to explore the research questions that struck me as interesting and important to the research communities in which I work. This does not mean I conducted as many studies as I had questions. There are several questions that I have yet to examine, but I had to make judgments about which questions I ought to pursue. It is possible to identify common themes that run throughout the formative

studies that I describe in this dissertation. But I did not conceive of these themes as I worked. Nor did I take them into consideration as I developed and planned my research.

All of my studies cuts across two separate but related themes: (1) theory and theory use and (2) the transfer and interplay of knowledge in intellectual communities. These themes have led me to ask questions about how HCI and design researchers use theory in their work, whether HCI and designerly theories have distinguishing qualities, and if researchers in these fields interact with knowledge in unique ways. I believe the ability to communicate and assess scholarship and to distinguish HCI and design as independent research communities hinges on good answers to these questions. But it is only possible for me to say this in hindsight; after devoting significant time to thinking deeply about the ties that bind my work. This resonates with the way Nobel Laureate Roald Hoffmann characterizes his approach to research. Hoffmann states his disposition is "not to work on big questions… [and that he likes working on] many detailed small problems… while keeping his eyes open for connections" (Ball, 2006, p. 502).

Was the order/organization of my studies important?

It is possible to speculate about elements in early studies that may have motivated questions or approaches in later ones. For example, my review of big questions literature (Beck & Stolterman, 2017) has roots in my previous studies of scientific theorizing (Beck & Stolterman, 2015) and knowledge claims (Beck & Stolterman, 2016). In each study, I explore the concepts of cumulative knowledge growth as a gauge of intellectual progress in HCI and design research. For example, in my study of scientific theorizing I explore the possibility that cumulative knowledge of designing may not be possible. Studying the types of knowledge claims made in design research publications gave me perspective on the prevalence of additive knowledge growth in design research. Finally, reviewing the

big questions literature raised the possibility that cumulative knowledge growth may not be appropriate or desirable for HCI research.

For instance, it is possible to construct a rudimentary thematic analysis by analyzing the most frequently appearing words in my all of my publications, and I can sort the results by text. This means I can see which words appear more or less frequently in each text, and, thus, I can group the texts according these keywords or themes. In my studies, *theory, design, research, knowledge*, *questions,* and *scientific* are the top six most frequently occurring words. Here is how the 963 instances of "theory" map to each study:

# Of instances	Study
339	*Practical, Everyday Theory Use in Design Research*
293	*Theory Use in HCI Research*
137	*The Theory-Practice Gap as Generative Metaphor*
88	*Scientific Theories of Designing*
83	*Why Aren't There More Scientific Theories About Designing?*
14	*Reviewing the Big Questions Literature; or Should HCI Have Big Questions*
5	*Schön's Legacy: Examining Contemporary Citation Practices in DRS Publications*
4	*Examining the Types of Knowledge Claims Made in Design Research Publications*

Table 1. Grouping of Formative Studies by "Theory" Topic.

Conducting this sort of preliminary analysis also tests some of my assumptions about my own work and reveals the possible limitations of the admittedly rudimentary analytic exercise. For example, when I sort the 375 instances of the keyword "knowledge" according to study, I end up with the following organization:

# Of instances	Study
164	*Examining the Types of Knowledge Claims Made in Design Research Publications*
48	*Why Aren't There More Scientific Theories About Designing?*
45	*The Theory-Practice Gap as Generative Metaphor*
32	*Practical, Everyday Theory Use in Design Research*
25	*Reviewing the Big Questions Literature; or Should HCI Have Big Questions*
24	*Theory Use in HCI Research*
19	*Schön's Legacy: Examining Contemporary Citation Practices in DRS Publications*
18	*Scientific Theories of Designing*

Table 2. Grouping of Formative Studies by "Knowledge" Topic

I see knowledge as one of the core concepts in *Schön's Legacy*, and yet it appears in the second-to-last spot on the list. In my view, an examination of citation practices is an examination of the "transfer and interplay of knowledge" (Teufel, Siddharthan, & Tidhar, 2009) in intellectual groups. It is about how "knowledge is… negotiated and confirmed within different academic communities" (Hyland, 1999, p. 341). Knowledge is at the core of my study of citation function, and yet this study appears at the bottom of the list as though knowledge is somehow a *less* significant theme. Just because the word "knowledge" appears less frequently in that text does not mean that knowledge is not (or cannot be) one of its central themes.

This will be an important point later in this dissertation when I discuss the naming of theory in CHI Best Papers. Seven out of 90 best papers do not mention any theories, models, or frameworks. But just because these papers do not mention specific theories or theoretical devices (e.g. theoretical lenses or frameworks) does not mean that they are

atheoretical or that they do not use theory. Yet in HCI research *and* in other research communities where theory use has been studied, there is a tendency to study theory use by looking at texts where "an explicit mention of a theory [is] made" (Pitt et al., 2005). This gives rise to an important question for researchers interested in studying theory use: How is it possible to conduct an empirical study of theory use in publications that make no explicit mention of theory?

Which methods and methodologies have I used?

It is possible to make sense of my studies according to the different methodologies and methods used. Adapting methodological categories from Weerakkody (Weerakkody, Dwivedi, & Irani, 2009) citing Avison (2008) my studies are split between conceptual/theoretical and qualitative approaches. A conceptual study is one where I take a descriptive or argumentative approach and do not adopt or name a formal "research methodology." And a qualitative study is one where I aim to describe or understand something like theory use or citation function without "[using] numerical analysis to illustrate the relationship among factors in the phenomenon studied" (Avison et al., 2008 pg. 13).

Methodology	**Study**
Conceptual	*Scientific Theories of Designing*
	Why aren't there more scientific theories about designing?
	The Theory-Practice Gap as Generative Metaphor
Qualitative	*Practical, Everyday Theory Use in Design Research*
	Theory Use in HCI Research
	Schön's Legacy: Examining Contemporary Citation Practices in DRS Publications
	Reviewing the Big Questions Literature; or, Should HCI Have Big Questions?

	Examining the Types of Knowledge Claims Made in Design Research Publications
	Investigating Theory Use in the Best Papers @CHI

Table 3. Grouping of formative studies according to methodology.

Each of my studies mixes conceptual and qualitative work, but it is possible to group them according to the dominant methodology. For instance, in my study of theory use in design research, even though I engage in a conceptual examination of what theory can mean, that study is primarily a textual analysis. I categorize that study as qualitative. By contrast, my examination of the apparent lack of scientific theories about the design process does not involve empirical work, and so I categorize it as a conceptual study. In addition to grouping my studies by methodology, I have organized them according to primary research method:

Method	**Study**
Textual Analysis	*Practical, Everyday Theory Use in Design Research*
	Theory Use in HCI Research
	Examining the Types of Knowledge Claims Made in Design Research Publications
	Schön's Legacy: Examining Contemporary Citation Practices in DRS Publications
	Investigating Theory Use in the Best Papers @CHI
Artifact Analysis	*Scientific Theories of Designing*
Essay	*Why aren't there more scientific theories about designing?*
	The Theory-Practice Gap as Generative Metaphor; or, The Issue of Problem Setting in HCI Research
Lit Review	*Reviewing the Big Questions Literature; or, Should HCI Have Big Questions?*

Table 4. Grouping of studies according to primary research method.

Grouping my studies according to method reveals textual analysis to be a dominant approach. By "textual analysis" I mean content analysis *and* discourse analysis, both of which I have drawn upon in my examinations of theory use in scholarly publications. By "text" I mean scholarly publications; although I recognize that "text" could refer to theories themselves, technological artifacts, transcripts of interviews or field observations, among other kinds of data. My tendency to gravitate towards textual analysis could be driven by my interest in the visible manifestations of scholarly knowledge production, such as knowledge claims and citations.

Why did I approach my studies in these ways?

There are many ways to study theory use. For example, theory use has been studied with interviews (Haynes & Carroll, 2010) and essays (Cleuziou et al., 1991). But textual analysis is a strong approach if (1) one is interested in analyzing the output (the artifacts) of scholarly research and (2) the definition of "output" is limited to written publications such as conference papers, journal articles, and books. In addition, there is precedent in HCI research (Clemmensen, Kaptelinin, & Nardi, 2016; Velt, Benford, & Reeves, 2017) and in other research communities for taking textual-analytic approaches for studying theory use.

So, in some cases my decision to approach a study in a particular way was driven partly by my interests and partly by what the field deems to be a useful, acceptable way to study a given topic. And this means I had to build an understanding of how HCI and design research evaluate knowledge production and knowledge contributions. I had to determine the way(s) researchers in these communities judge validity, relevance, novelty, and interest, and *then* frame and evaluate my own work with this understanding in mind. I am still building this understanding.

In other cases, my decision to adopt a particular methodology or method evolved as I worked. For example, when I set out to study big questions, my initial plan was to survey researchers in the HCI community and ask them to provide me with a list of candidate big questions for HCI research. But as I gathered and read literature on/about big questions, my interests and research questions evolved. *What kinds of problems did scholars perceive in their communities that motivated them to propose big questions? Could HCI be facing similar ones and would it make sense to propose big questions as a possible solution?* As I explored these questions, I further refined my interests to focus on the concept of big questions. *What distinguishes big questions from other kinds?* The decision to conduct a lit review of big questions publications was not a *post hoc* decision. But I did not make the decision to conduct a lit review until I had gone through several iterations on my initial research questions.

An awareness of and openness to the evolution of research questions and approaches is an important part of doing research. It can lead to important insights about the value and utility of certain approaches for certain questions.

Chapter 4. Formative Studies

In this section, I summarize the formative studies that I have completed throughout my doctoral career. One of my goals in presenting the studies in chronological order is to trace the evolution of my thinking about theory and theory use in HCI research. How did my research evolve? What tools did I use along the way? My intention is to provide a high-level methodological narrative in this chapter. I introduce key concepts, methods, and findings from each of my eight formative studies.

Overview

My research projects examine widely discussed and debated questions in HCI and design research. What are the unique qualities of each field? What distinguishes HCI theory and design theory from other kinds of theory? What constitutes a knowledge contribution in these fields? And how do researchers measure intellectual progress? In both HCI and design these are core questions whose answers have significant consequences for researchers and practitioners.

I believe our ability to communicate and assess scholarship and to compete with other knowledge producing research communities hinges (in part) on good answers to these questions. And I see a strong connection between our understanding of knowledge contributions and progress and our ability to support and strengthen HCI and design practice. I am a qualitative researcher, and so I take a qualitative approach to contemplating these questions. These include: discourse and conversation analysis, artifact analysis, and narrative analysis, among others. However, I also use quantitative techniques such as content analysis.

Understanding and Analyzing Theories

I started the doctoral program planning to do research on design pedagogy, but my plan changed during my first semester after I read two classic papers by Karl Popper and Thomas Kuhn. In *Science: Conjectures and Refutations* (1962), Popper articulated a set of criteria that could be used to distinguish scientific theories from other kinds of theories. Popper summarized his criteria with the notion of falsification. In *Logic of Discovery or Psychology of Research* (1970), Kuhn critiqued falsification *as a demarcating criterion for scientific theories* – crafting a convincing argument that non-scientific theories could be falsifiable and, thus, that falsifiability could not be used to distinguish scientific theories from other kinds.

These texts sparked my interest in design theory. What criteria could be used to distinguish design theory from other kinds? This question motivated my first study, which was an analysis of four classic theories of the design process (Beck & Stolterman, 2015). My initial goal was to examine each theory with an eye towards extracting a set of demarcating criteria. But my goal evolved. At some point I became curious about whether Popper's criterion of falsification could be applied to these theories. Could they be deemed scientific without framing the design process as something rational and systematic. I ended up framing the paper in terms of the question: *Can there be scientific theories of design that do not scientize design?*

Instead of trying to extract demarcating criteria to distinguish design theories from other kinds, I set out to determine (1) if design theories could be scientific in Popper's terms and, if so, (2) whether their scientific qualities undermined the integrity of the design process. I developed an analytical framework based on Popper's demarcating criterion of falsification and used it to analyze CK Theory (Hatchuel & Weil, 2003), The

FBS Framework (Gero, 1990), Figural Complexity (Schön, 1990), and Bounded Rationality (Hatchuel, 2001; Simon, 1996). I extracted falsifiable basic statements from each theory and argued that in spite of their possible predictive power, each theory could be interpreted as describing the design process as one that has no given problem, no given process, and no given solution.

As I examined these four different design theories I began to think about *how design researchers use theories in their work.* I was examining design theories in order to determine whether they could be considered scientific. But design research is not an exclusively scientific discipline. So how do its constituents use theories in their research?

Shifting From Theories to Theory Use

One way to study theory use in a research community is to examine its scholarly communication. Recent studies in HCI research examine publications in an effort to understand how researchers use theory. For example, Clemmensen, Kaptelinin, & Nardi (2016) conduct a "qualitative meta-synthesis," which involves "developing a template for analysis and synthesis of the content of the selected papers, given what is learned from the papers in each step, until it reaches a final version, which is then applied systematically on all papers" (2016, p. 613). And in a recently published CHI paper, Velt, Benford, and Reeves (2017) conduct what they refer to as an analytic and systematic review to generate a corpus of publications followed by iterative emergent coding in order to develop a typology of theory use in HCI publications. My initial approach to studying theory use in design research falls somewhere between the two, but it skews towards the Velt, Benford, and Reeves in the sense that, after deciding on a corpus of texts, I engaged in several rounds of iterative emergent coding in an effort to describe the different kinds of theory use. I also wanted to explore the possibility of creating models

to represent different kinds of theory use – an approach that I had not yet encountered in other studies of theory use.

Using content analytic techniques described in (Krippendorff, 2012) I used emergent coding to examine theory use in a year's worth of publications from *Design Studies*; one of the leading publication venues in the field. This examination led to the development of six models describing different kinds of theory use in design research publications. These are: (1) no theory, (2) theory as an object of study, (3) theory as a shaping tool, (4) theory as a contextual tool, (5) theory as analytical tool, and (6) theory as a methodological tool. I published these findings in *She Ji: The Journal of Design, Economics, and Innovation* (Beck & Stolterman, 2016b).

The models struck me as having the potential to function as an *a priori* coding scheme, so I followed up my initial study of design research publications with an examination of 35 randomly sampled publications from the ACM Computer-Human Interaction (CHI) conference. In this follow-up study of CHI publications, I used the six models as a coding scheme and adopted an approach more closely aligned with a quantitative content analysis – applying each model as an exclusive code to each instance of theory in the publications.

I viewed this study partly as affirmation that it was possible to make use of the models to study theory use in HCI publications, and I found the coding process to be useful and interesting. In most cases I managed to apply the models exclusively. However, there were a handful of instances that made me question the exclusivity of the codes. For example, I wondered whether all named theories *by default* perform a

contextualizing role in research publications regardless of author intent. And I continued grappling with the question of how to identify an instance of theory use in a publication.

Around the time I was coding the CHI publications, I presented the findings from my first study of four design theories at the European Academy of Design. The presentation led to a conversation with another delegate about Donald Schön and the use of his scholarship in the design research community. The conversation helped us articulate a mutual curiosity about how researchers cite Schön's work in their scholarly communication. Schön is known to be one of the most highly cited scholars in the field (Chai & Xiao, 2012) yet the nature of these citations remained a mystery.

Examining Citations as Functional Knowledge Objects

To understand how and why researchers cite Schön's work, I conducted a content analysis of 63 texts published at two Design Research Society (DRS) conferences. I used a citation function framework (Harwood, 2009) as a coding scheme to analyze 194 individual citations and found that most scholars cite Schön to justify aspects of their own research *or* to credit him for concepts. Moreover, few scholars cite Schön critically or build on his work. One outcome of this study was a (new) assumption that the quality of knowledge produced in a research community is partly a consequence of the citation networks scholars create through their publications. And I wondered if a lack of critical engagement with Schön's work could be indicative of a more general disinterest in argumentation and cumulative knowledge growth.

Studying Knowledge Growth in General

My interest in cumulative knowledge growth predated my examination of DRS publications. It grew out of my study of four design theories. In the early stages of that study, I collected 100+ candidate design theories before deciding to analyze CK theory,

the FBS Framework, Figural Complexity, and Bounded Rationality. Most of these candidate theories were models and theories describing the design process (e.g. Dubberly, 2015), and it seemed to me that significantly fewer of these theories aspired to scientific status. If it were true that fewer theories about designing aspire to scientific status, why might this be so? This question serves as the title of a paper accepted for publication at the EAD12 conference: *Why aren't there more scientific theories of designing?*

Design is not purely scientific discipline. It involves knowledge production practices from the arts, humanities, and history. It is a mix of cumulative and horizontal knowledge growth. But what if it favors one or the other? Why might this be the case? I propose three possible explanations, including: (1) Scientific theories have less utility and value for design practice, (2) design research is attempting to build a unique intellectual culture, and (3) there is a lack of consensus on what it means for a theory to be scientific and so a different understanding may yield different findings.

This question about knowledge growth in design research can be traced back to a growing discourse about the identity and boundaries of the field. Just as HCI researchers grapple with questions about what makes their research community unique, design researchers are also concerned with building their own intellectual culture. Some researchers have turned to the notion of "design knowledge" (Carvalho, Dong, & Maton, 2009; Dong, Maton, & Carvalho, 2015) as a means to distinguish design from other fields. This inspired me to conduct a comparative analysis of the types of knowledge claims made in publications from different fields. Is it possible to distinguish design on the basis of the knowledge claims its researchers make in scholarly communications?

Combining Hart's (1999) typology of knowledge claims and Fisher's method for extracting and constructing a hierarchical map of claims in an argument (Fisher, 2004), I examined a corpus of texts published in *Nature*, *The American Sociological Review (ASR)*, and *Design Studies*. I found that the texts published in *Design Studies* contained multiple knowledge claims of different kinds whereas *Nature* and *ASR* publications tended to make singular claims of similar kinds. The diversity of knowledge claims within a text could be seen as a reflection of the diversity of interests and purpose of knowledge producers in a given research community. And many researchers frame this diversity as a strength worthy of protection and cultivation (Carroll, 2010; Carroll, 2014).

However, in the HCI community diversity is not necessarily framed as a good thing at least where knowledge production practices are concerned. Here I am pivoting just a bit. The previous study describes diverse knowledge claims within scholarly communication. When I refer to how some researchers in the HCI field frame diverse knowledge production practices I refer to core objects of study and ways of studying them. HCI is such an eclectic mix of objects of study and research methods that some scholars have difficulty describing the field in a cohesive way. And they interpret this as problematic insofar as other fields seem to be able to say with greater clarity what they study and how they study it. HCI is certainly not the first field to grapple with this issue. I found this out when I conducted a lit review of scholarly publications proposing "big questions" as a means of organizing research around common sets of questions (Beck & Stolterman, 2017a).

The review focused on how scholars describe the current states of their research communities and how these descriptions justify the proposal of big questions. For

instance, scholars who propose big questions tend to characterize their communities in terms of (1) fragmented knowledge production and disunity, (2) low/no intellectual status, and (3) intellectual stagnation *or* stalled knowledge growth. Big Questions, which lack a clear definition, are proposed as way(s) to *unify* knowledge production, achieve higher intellectual *status*, and jumpstart stalled knowledge *production*. Notably, none of the contributions included in the review (n=71) examined or reflected on previous big questions to determine whether the questions facilitate the desired effects.

One of the interesting outcomes of this review project was the realization that, within HCI research, there are multiple ways of framing the research community. Some scholars frame its complexity as problematic whereas others frame this same complexity as a virtue. And these different ways of interpreting the community thus have consequences for knowledge growth. For example, framing HCI research in terms of "fragmentation" and "disunity" establishes a project geared towards creating a more unified, cohesive knowledge production. Identifying sets of big questions or grand challenges reflects this sort of effort (Engeström et al., 2010). Framing the same phenomenon in terms of "diversity" suggests different paths forward; ones where diversity is no longer a problem to be solved but a virtue to be embraced and cultivated.

I became interested in the relationship between problem setting (Schön, 1979) and knowledge growth, which led to my most recent completed study: an examination of the theory-practice gap in HCI research. I examined the theory-practice gap in HCI using Schön's notion of generative metaphor as an analytical framework. I an essay I attempt to show how the theory-practice gap is a problem that has been made by the HCI research

community – it is not given. Moreover, it has been interpreted and developed differently over the years.

Some researchers characterize the gap as a communication problem. Others describe it as a problem of abstraction. Constructing this narrative of how the gap has been used and developed involved unpacking the problematic nature of the problem solving perspective in research; a perspective that, according to Schön, takes problems for granted and thus begins with the search for solutions without examining the nature of the problem itself. It is not that Schön is uninterested in solving problems. Instead, he is interested in examining problems rather than taking them for granted so as to mitigation the proliferation of unexpected new problems and to arrive at more effective solutions.

Summary

In the following sections I describe in more detail the approach and findings from each formative study. The length of these descriptions varies according to the nature of the study. For instance, I include more material from conceptual essays than I do from empirical studies. I made this decision because it seems to me that the approach and findings run throughout a conceptual essay whereas empirical studies include dedicated discussions of the approach and findings. Following the summary of my formative studies I include a reflection on them *as a set*.

Understanding and Analyzing Theories

Study 1. Scientific Theories of Designing

One way to analyze theories in terms of falsifiability is by considering each one in light of those theories that Popper described as non-scientific (e.g. Freudian psychoanalytic theories or Marxist theories of history). My point of departure can be a question asked by Popper, but revised for my current purposes: What makes Marx's theory of history or Freud's theory of psychoanalysis different from my chosen theories of designing?

Think of a proposition as simple as "all men are mortal." It is unfalsifiable since, as with Marx and Freud's theories, everywhere we look we can only find confirming evidence of its truth. No factual propositions exist that clash with it. I define factual propositions as those propositions with high truth-values, where truth-values are functions of empirical observations and mutual consensus within a community. Newtonian mechanics, for instance, had centuries of empiricism and consensus within the scientific community. And so, when Einstein proposed his theory of relativity, it clashed with established, antithetical factual propositions about the way the world worked. In addition, unlike Marx and Freud's theories, Einstein's could be falsified by empirical observation. This means that it was capable of producing basic statements, which must be "testable, inter-subjectively, by 'observation'" (Popper, 2002). Since I am concerned with evaluating the falsifiability of a theory, I must attempt to deduce basic statements from each theory.

Findings

In my analysis I explored the possibility that C-K theory, the FBS framework, and Figural Complexity communicate an understanding of designing as having no given

problem, no given process, and no given solution. And I claimed that designing (as understood by these three theories) is distinct from science.

Science strives towards establishing clear problems, clear processes, and "definitive" solutions, which relate to each other in nontrivial ways. I suggested that there is a causal relationship between problems, processes, and solutions in science—a relationship that is absent (or at least not required) when it comes to designing. In design, (1) problems do not determine the process or the solution, (2) solutions do not require a specific process, and (3) a specific process does not inevitably lead to a particular solution. Instead, all three elements continuously influence each other, as captured by Schön's concept of figural complexity, Gero's notion of iterative transformation, and Hatchuel and Weil's description of the relationship between spaces C and K.

If it is true that designing has no given problem, no given process, and no given solution, what are some possible consequences of this proposition?

The outcome of my analysis moves us a few steps closer to a possible "solution" to the problem of demarcation for design. Design is an approach that has no given problem, no given process, and no given solution. And just as Popper's solution to the problem of demarcation for science enabled him to distinguish science and scientific theories from pseudo-science, my solution similarly enables us to scrutinize particular processes in order to determine whether they truly are instantiations of designing. There are other potentially significant, interesting consequences for research as well.

One way researchers currently support design practitioners is through the generation of design methods and prescriptive design insights, which could be said to be designed to mitigate the potentially paralyzing effects of lacking problems and processes.

C-K theory, for instance, can also be used as a "method" in the sense that it "prescribes" starting with a concept, generating new knowledge about that concept, and then iterating on it to develop new concepts. It is clear, however, that prescriptive insights and methods must operate at an abstract level in order to maintain the integrity of design as an approach distinct from science. While design problems can be identified during the design process, they are necessarily subject to change. They are neither given, nor are they fixed. And any method or insight that attempts to "give" or "fix" a problem undermines the integrity of designing.

Any attempt to prescribe designing would have to accord with the three characteristics I describe. Fixing a problem or prescribing a rigid process, such that neither the problem nor the process could/would change would "break" with the understanding of designing my theories express. Thus there are limits to what can be prescribed. For example, prescribing a specific process based on a particular problem or based on an anticipated solution would not be possible since the problem, process, and solution necessarily co-evolve (Dorst and Cross, 2001) in designing. This consequence has significant implications for design research since so much research today is aimed at improving designing by producing prescriptive insights for designers.

A third possible consequence of my analysis is a reaffirmation of the importance of understanding design judgment. If it is true that problems, processes, and solutions are not given and cannot be fixed, then the question of how designers develop the capacity to make judgments regarding problems, processes, and solutions becomes crucial. To fix a problem or a process is to undermine the integrity of designing, but the decision to do so is also paradoxically essential. This is what Schön refers to when he writes of "rule

governed procedures for transforming" (1990, p. 111) design representations in the design process. How do designers set and modify these rules? The answer offered by design scholars is that designers do it through the application of design judgment (Cross, 2011; Nelson and Stolterman, 2012). I would argue that further inquiry about the nature and applications of design judgment will potentially lead to deeper and more useful insights about designing than any attempt to prescribe the process.

Shifting from Theories to Theory Use

Study 2. Examining Practical, Everyday Theory Use in Design Research

This study discusses how theories are used in articles published in *Design Studies*. While the concepts of "theory" and "theory construction" have been studied in the design research literature, less is known about how researchers put theories to work in their written texts. I refer to this kind of theory use as "practical, everyday" theory use. To explore this topic, I perform a textual analysis of 32 articles and synthesize six models of "theory use" based on my examination.

Findings

Prior to assembling a corpus of texts, I established that I would engage in a round of "unmotivated looking" (Psathas, 1995; Sacks, 1984) in order to see how the texts could be said to use theory without establishing or imposing strict definitions of "theory" or of "use." One of the challenges I faced at the outset of my work was that of defining theory use. What does it mean to use theory in a research publication? I found that framing theory as a knowledge object guided me toward an answer. When theory is seen as an object or a thing then it becomes possible to see a theory as a tool. And when theory is seen as a tool then "theory use" can refer to how it functions in a text. My initial questions and decisions were not guided by existing "theoretical frameworks" but rather by a "general perspective… [and a] general problem area" (Glaser & Strauss, 1999). These initial decisions could therefore be seen to be in alignment with the initial decisions of a grounded theory approach.

There are many different publication venues one might look at in order to study how design researchers use theory in written texts. I decided to collect one year's worth

of articles (n=32) published in *Design Studies*, which is a top journal in the field. It is one of the oldest design research journals, and it aims to provide an "interdisciplinary forum" for inquiry into design activities. It has been a key source of material for scholars exploring ways to define, construct, and evaluate theory with a particular focus on *design theory* (Friedman, 2003; Love, 2000, 2002). My analysis is not a response to or critique of this existing content. Rather, it is intended to be a complementary contribution to the collective knowledge of theory in design research.

In order to determine what function theory performs in my corpus I adopted an emergent coding approach. I reviewed a randomly sampled subset (n=5) of the corpus and recorded preliminary observations about how theory appeared to function in each article. This stage yielded four categories, which I named: originating, positioning, shaping, and shaped. Originating articles were those whose research questions "originated" from theory or whose question was about a specific theory or theories. Positioning articles were those that "positioned" research in relation to existing work that may or may not have included theory. Shaping articles used theory in a manner similar to positioning papers with the difference being that theory seemed to shape the initial research question. Finally, "shaped" papers appeared to use theory as a filter through with to pass preliminary research findings. In other words, findings were shaped by theory.

I adopted these four categories as a coding scheme and applied them to all the articles in the corpus. However, when applied to the whole corpus, I found that this preliminary coding scheme to be inadequate. Many examples fell outside the bounds of each category. So I iterated upon the coding scheme accordingly.

In parallel with this iteration, I developed models to represent the relationships

and interactions between theory and the other core elements of the research articles. In attempting to establish what could constitute the core elements, I made the decision to model as few elements as possible. Modeling fewer elements reduces complexity but also lead to coarser descriptions. And while I relied on grounded theory techniques to generate kinds of theory use, I developed a list of the core elements of a research publication based on two widely used texts on academic writing (Booth, Colomb, & Williams, 2003; Turabian, 2013).

I ended up with the following core elements: question, examination, findings, and theory. Questions identify the needs or interests that the researcher deems worthy of understanding, explaining, predicting, or describing. For example, my framing question in this study identifies an interest in understanding how theory is used in design research. Examination captures the approach taken to answer the question. It includes all forms of analytical or empirical work done by the researcher to investigate into the question at hand. And findings refer to the outcome of the examination. Theory is the fourth core element.

Using a few elements to model complex objects like research papers results in a loss of precision. However, it is not my intent to capture on a detailed level the structure of each article. Instead, my purpose is to find a level of analysis that makes it possible to extract patterns, similarities and differences across articles in a manageable way.

After developing the original set of four models, I critiqued and iterated on them by applying them to the entire corpus of *Design Studies* publications. My critique focused primarily on the match between the models and the papers. Did the models capture the essential structure of the core elements in each paper? Or did they distort the structure

and interaction between the core elements? I also questioned whether the category names conveyed the content of the models. Both questions motivated several rounds of iteration. For instance, my first four models did not account for the use of theory as a methodological and/or analytical tool. So I developed additional models to account for these types. In the interest of comprehensiveness, I also developed a model to account for articles that did not seem to show any use of theory.

My work led to six models:

(0) No theory,

(1) Theory as the object of study,

(2) Theory as a contextualizing tool,

(3) Theory as a shaping tool,

(4) Theory as a methodological tool, and

(5) Theory as an analytical tool.

Each model includes an explanation and a visual component consisting of a linear structure. This structure is made manifest by the core elements and a line intended to be read from left to right. A key component of each model is the relationship between findings and other elements of the paper. For instance, findings might manifest as an answer to an initial research question or a reflection on the usefulness or validity of a particular approach to analysis. Findings might also influence or "feed back" to other elements in the model, including theory. I visualize this feedback with two lines: a solid grey line and a dotted grey line. These two lines distinguish between intentional feedback and (potential) intentional feedback. Intentional feedback describes cases in which an article explicitly states or shows feedback from findings to theory or other core elements.

And (potential) intentional feedback describes cases where feedback remains unstated or unknown. Now, I will briefly summarize each model.

No Theory

Figure 1. The No Theory Model of Theory Use

This model accounts for texts that do not use theory. Such texts are motivated by a question, which is followed by an examination and findings. The findings are then intentionally fed back to the original question but not to the examination. I did not find any examples of "no theory" articles in this study. However, articles that do not use theory do exist and so I developed this model for the sake of completeness. For example, articles that do not use theory may still lead to theory. This could mean that the intentional feedback to the question may be in the form of a proposal of a new theory. However, as I see it (at this stage) this is not an example of theory use. It is an example of theory development, and so it should be seen as a product (not a tool) of research.

Theory as the Object of Study

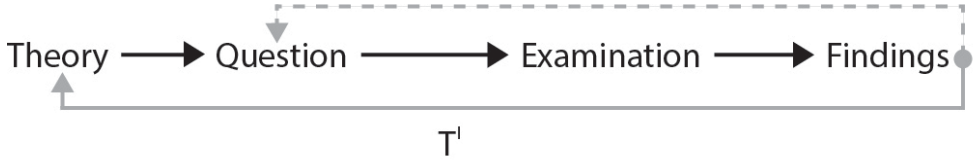

Figure 2. The Object of Study Model of Theory Use

In this model, a theory or some aspect of a theory drives the question. This could be restated as the research question is about theory itself. Once the researchers formulate a question about a theory or one of its aspects they move on to the examination stage. The

examination stage might entail empirical or analytical research or it could take the form of scholarly reasoning or thought experiments. This stage yields a potentially wide variety of findings whose nature is tightly coupled with the nature of the examination. For instance, empirical research is likely to yield findings of a different kind than a thought experiment. Of central importance for my question of how theory is used is the way these findings are intentionally fed back to the initial theoretical question. In my model, findings can result in a revision or iteration of the initial theory or theoretical aspect.

Theory as a Contextual Tool

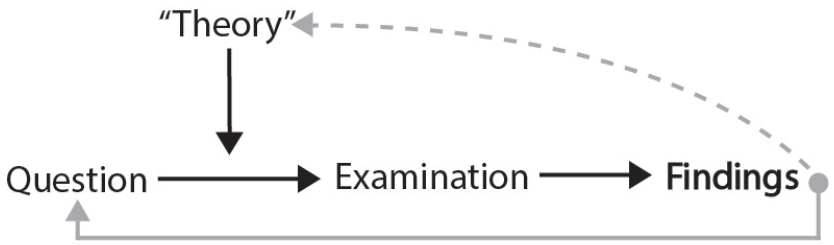

Figure 3. The Contextual Model of Theory Use

In this model, an article starts with a research question and theory contextualizes and positions the question in relation to a particular scholarly discourse. Theory does not change the question. Rather, it results in position taking relative to other questions and existing research. In many cases, the knowledge objects that an article references may be frameworks or models or even in some cases just concepts or definitions. Examination proceeds once the question has been contextualized. It yields findings and, in this model, findings (1) respond to the original question, and (2) either feed back to the positioning theory or not.

Theory as a Shaping Tool

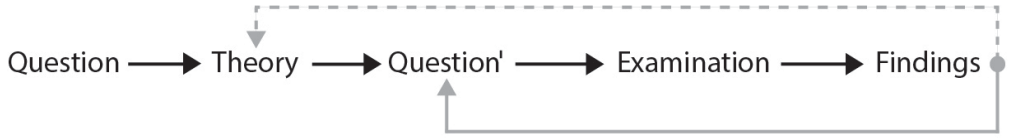

Figure 4. The Shaping Model of Theory Use

In this model, the researcher poses a question and puts it into dialogue with some existing theory. The outcome of this dialogue is a new question or set of questions. Once these new questions emerge, then the researchers proceed to the examination stage and, ultimately to findings. In this model, the findings feed back to question(s) and either to the shaping theory or not.

Theory as an Analytical Tool

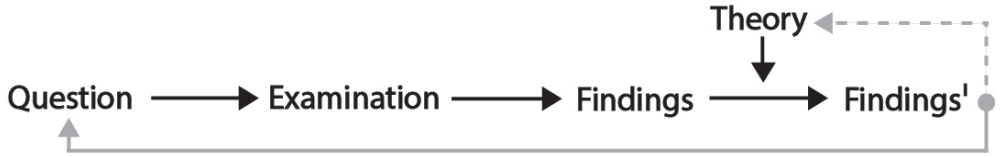

Figure 5. The Analytical Model of Theory Use

In this model, theory is used as a tool for analyzing and interpreting data and findings. The results of this analysis then feed back to the original question and either to the analytical tool or not. It is worth pointing out that even as an analytical tool, theory in this model also has a contextualizing function, i.e., the theory chosen for analytical purposes also reflects the researcher's position and aim and therefore to some extent also contextualizes the research.

Theory as a Methodological Tool

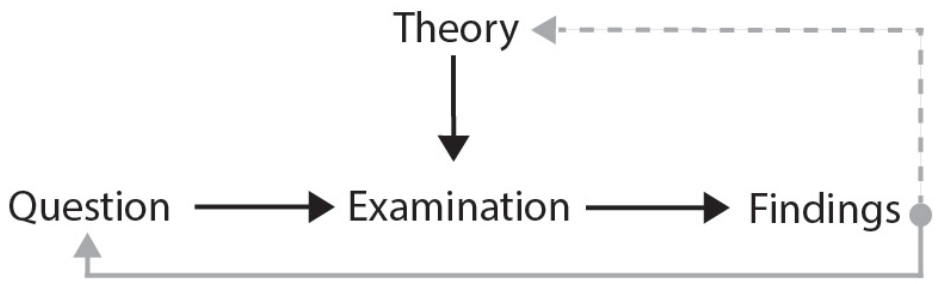

Figure 6. The Methodological Model of Theory Use

As a methodological tool, theory shapes the examination stage. Theory is used to shape and develop the research approach and methods. The range of examples here is broad and deep. For instance, a philosophical examination of the nature of design from a pragmatist perspective informs the kinds of questions one would ask as well as how one might go about answering those questions. Critical theory informs a particular kind of research design. Narrative theory informs particular kinds of data collection. And there are many others. In this model, the findings are fed back to the original research question and, as with other models, the findings may either feedback to the theory or not.

Summary of the Models

These six models reflect the different ways researchers make use of theory beyond the commonly referenced uses of explanation, generalization, prediction, and so forth. Theory can be used to motivate inquiry, contextualize research, shape research questions, and guide methodology and analysis.

Discussion

Most texts use theory in multiple ways. For instance, several articles in my corpus use theory both as an object of study *and* as a contextual tool. Where there seemed to be a combination of types of use, I distinguished "primary" from "secondary" types. I

considered a type of use to be primary if (1) it was essential in framing the paper or (2) I found *more* instances of its presence within the text.

- 16 articles used theory as an object of study. 14 of these 16 used it primarily as an object of study. Only two did not.
- Overall 27 articles used theory as a contextual tool. 12 of these 27 used theory primarily as a contextual tool.
- Nine articles used theory as a shaping tool. Six of these nine used it primarily as a shaping tool.
- Seven articles used theory as a methodological tool—none of these seven used it primarily as a methodological tool.
- Finally, 11 articles used theory as an analytical tool, and only two of these 11 used it primarily as an analytical tool.

During the process of developing and applying the models, I generated a list of questions about the current state of theory use in design research. It is possible to see the potential application of these models in other research venues, but I limit the scope of my claims to the corpus of 32 articles published in *Design Studies*. As such, I do not frame my approach or findings as an attempt to provide generalizable answers to questions about theory use in design research. Nor do I claim that my findings represent design research. At most they represent a subset of the field. However, I am convinced that my approach creates possibilities for asking interesting questions about theory use.

For instance, why is theory used in some ways more than others? Why are some combinations of models within a single text more common than others? But it is also possible to ask more complex questions, such as, What does it mean to say that research findings feed back to theory? Are there different kinds of feedback? What is the difference between models where theory is an internal component of the linear structure and those where it is an external component?

Why is theory used in some ways more than others?

My preliminary findings indicate a prevalence of texts using theory as an object of study and as a contextual tool. How might we account for this pattern?

As with most scholarship, it is necessary for an author to demonstrate knowledge of related work as a means of warranting authorial claims of interest or novelty. Furthermore, related work serves as evidence of one's overall qualifications to contribute knowledge to a particular field. In this way, referring to theory could be seen as a way to distinguish legitimate knowledge contributions from illegitimate ones.

It is also necessary for a researcher to justify or provide reasons for their research projects and the approaches they take. This points toward another possible answer to the question of why theory is used quite often as a contextual tool. By referencing existing research and thus contextualizing their own authors do not have to explain in as much detail the reasons behind their research project or the approach itself since these have potentially been established or anticipated by others.

Taken together these two explanations may account for why theory as a contextual tool appears so frequently. But it goes without saying that frequency does not equal necessity. Authors do not *have to* use theory as a contextual tool. There were a few articles in my corpus that did not appear to use theory as a contextual tool, and yet they were still published. What does it take for a text that does not use theory as a contextual tool to count as legitimate, valid, or authentic? How do the authors of such texts justify or give reasons for their work?

If we accept the claim that theory as a contextual tool bolsters claims to legitimacy, then we might also perceive a great deal of value in using theory as a contextual tool. This does not mean that theory as a contextual tool is more valuable than,

say, theory as an analytical tool. Furthermore, my intention here is not to argue for the value of one kind of theory use over another. Instead, I want to draw attention to *perceived value* as a potential answer to the question of why theory is used in some ways more than others. If using theory as a contextual tool increases the likelihood of publishing, then perhaps it is more likely that theory will be used as such. If using theory as an object of study seemingly leads to more interesting or novel approaches to conducting research, then perhaps it is more likely that theory will be used as such. And if using theory as an analytical tool seemingly leads to a novel interpretation of empirical results, then perhaps it is more likely that theory will be used as such.

However, my findings suggest that authors do not perceive a great deal of value in using theory as an analytical or methodological tool. Only two out of 32 articles appear to use theory primarily as an analytical tool, and I found no articles use theory primarily as a methodological tool. I find this quite surprising.

Using theory as an analytical and/or methodological tool is commonly taught in research courses. Most PhD students are trained in research methodology (Archer, 1995; Durling, 2002), which includes both practical or "mechanical" application of methods and the more philosophical and theoretical underpinnings that shape different approaches. Taken to its extreme, I might say that all research design, observation, and analysis is theory-laden. That is, that there is no way to approach, capture, or analyze data without the influence of some theoretical lens. This is perhaps why PhD students are trained to analyze data through theoretical lenses. Why then do we see so little use of theory as a methodological and/or analytical tool? Is this unique to the 32 articles in my corpus?

My intent is not to suggest that authors do not use theory as an analytical or methodological tool. I only want to point out that they do not appear to write about such use. If researchers in fact use theory as an analytical tool then how do we account for the disconnect between use and writing? And, if it is uncommon to use theory as an analytical tool, then perhaps we need to ask why.

Do the findings talk back to theory?

It seems as though not all research findings are put into dialogue with theory. Yet there exists in each model the *potential* for findings to talk back to theory. Why do some findings talk back to theory?

One possible answer is that findings talk back to theory if the researcher is actively engaged in theorizing, as is probably the case when theory is the object of study. If the purpose of a text is to build upon, revise, or critique existing theory, then the findings will naturally take the form of talk back. But if theory is a methodological tool, for example, then the research questions are not about theory and perhaps there is no need or desire for that kind of talk back. However, the potential for talk back in some form always exists. For example, an author might acknowledge the ways in which theory as a methodological tool lends itself towards particular analyses and outcomes. Or they might acknowledge the limitations of a theory as a analytical tool in light of their findings.

While this kind of talk back is interesting and potentially useful to the community of design researchers, it is not necessary. The point of a publication that makes use of theory as a methodological tool is not necessarily to assess the value of that theory. There is more often than not a different primary question. But what about theory as a shaping tool? In my corpus, why is there very little talk back between findings and theory as a

shaping tool, when theory as a shaping tool plays such a central role in influencing the research project?

An important distinction between theory as an object of study and "shaping theory" is the relationship between theory and the question. Recall that when theory is the object of study, the question is about a particular theory. When theory is used as a shaping tool, it does not result in a question about the theory. For instance, Perry and Krippendorff establish a research project around "measuring reliability of segmenting verbal protocols of design activity…" (2013, p. 612) The authors use the concept of design moves to reshape their research question. But their question does not take the concept of design moves as an object of inquiry. That is, they do not examine, critique, or build upon design moves as they might if it were an object of study.

It has been argued elsewhere (Hannay, Sjoberg, & Dyba, 2007) that talk back to theory can be inferred in an argument even if it is not explicitly stated in the text. I call this tacit talk back, where the reader must infer theoretical talk back since it is not explicitly stated in the text. But when I ask whether findings talk back to theory, I am not asking about tacit talk back. I am asking about explicit talk back visible in the text since I believe, in alignment with Friedman, that "explicit and articulate statements are the basis of all theoretical activity" (2003, p. 520). Tacit talkback moves away from this conception of theoretical activity.

I find the results of my analysis interesting since they reveal patterns of theory use and theorizing that are otherwise difficult to see. To what extent these results say something specific about design research and whether it is less engaged in theory

development than other disciplines is impossible to know without conducting a comparative study.

Research does not have to lead to theory development. New observations and discoveries can also be deemed meaningful research contributions. And when it comes to design research, it has been argued that a design or prototype can be a knowledge contribution in itself (Wiberg & Stolterman, 2014). However, I suspect that as a result of the way theory development is done, design research is less successful if its purpose is to accomplish substantial cumulative knowledge production.

Is theory an internal or an external component?

Three of my six models position theory as an *external* element relative to the other key elements of a research publication. By external, I mean that the theory sits *outside* the linear path from question to examination and findings. In contrast, internally positioned theory sits along the path. Two of my models position theory as an internal element: theory as object of study and theory as shaping tool. What does theory as an internal element imply about its relationship with other key elements? What does its position as an external element imply? One way to explore answers to these questions is to consider research publications as figurally complex artifacts.

Schön defines figurally complex artifacts as those "where addition or subtraction of one element changes the functional meanings of other elements with the result that the [text] must be considered different as a whole" (Schön, 1990, p. 120). Schön illustrates figural complexity with two examples: (1) the activity of adding or subtracting a note to/from a melody, and (2) adding "a patch of color" to a painting. In both cases, the partial change motivates a change in the way a composer or painter considers the whole.

The same could be true of a publication. Theory is a key element in my models. And so the addition, removal, or modification of theory has implications for the whole text.

Perhaps some elements are more readily changeable and varying in their impact on the whole text. Theory's internal or external position relative to other core elements of a publication might result in greater or lesser impact on the text as a whole. For example, theory as a shaping tool occupies an internal position relative to other key elements. Modifying it modifies the other three key elements: question, examination, and findings. But theory as an analytical tool occupies an external position relative to the other key elements. Modifying it modifies only the findings and leaves the question and examination in tact. Internal theories could thus be seen as having broader impact on the whole text than external theories.

Since external theories potentially have lesser impact on other key elements of a text, one could conclude that they can be treated with less care and attention. I will explore this conclusion with contextualizing theories in mind.

Contextualizing theory is externally positioned relative to the other key elements in a text, and it is also (arguably) more flexible. It can be added and removed ad hoc with seemingly little consequence for other key elements. Unlike adding a note to a melody or adding a patch of color to a painting, citing an additional piece of literature may do little to change the whole scholarly publication in an obvious way – especially if the citation amounts to little more than a name or number. It is even possible to imagine cases where specific theories are added to publications days before submission deadlines with no consideration given to how these late additions impact the rest of the text.

Even if contextualizing theory seemingly has lesser impact on the other core elements in a text, this does not mean they should be treated with any less care and attention than content with more apparent textual impact, such as: methodological or analytical theory, both of which are external. The addition or subtraction of contextualizing theories has the result that the text "must be considered different as a whole" (Schön, 1990, p. 120)

I have discussed the ways in which contextualizing theory demonstrates knowledge and authenticates knowledge contributions. Demonstrating knowledge and authenticating contributions do not necessarily prescribe changes or modifications to other key elements of the text. But they certainly change the framing of the other key elements. Not treating contextualizing theories with care and attention potentially calls into question the knowledge of the researchers as well as the legitimacy of their contribution. This is similar to the issue Friedman identifies in his critique of "scholars who have not read the works they cite" (2008, p. 155).

My models help illustrate the ways in which external theories may seem to have less impact on the other key elements of a text. But this seemingly lesser impact misrepresents the important role of external theories to the text as a whole.

Study 3. Practical, Everyday Theory Use in CHI Research

To construct a corpus of texts to analyze in terms of theory use, I filtered the ACM Digital Library (DL) for publications from CHI 2015. The DL results were sorted by "relevance" by default. I do not know what criteria influence the relevance of the results and so I do not make any claims about the biases that may be built into the results. However, I did not observe any apparent patterns in the results. They did not appear to be

alphabetical nor did they appear in ascending or descending citation order. I set no additional selection criteria since my interest was not in looking for a particular kind of theory use or a particular kind of publication. For instance, I did not look specifically for papers that use design theory or for papers that make theoretical *or* empirical contributions per se. I selected the first 35 full papers from the list and excluded notes and extended abstracts.

The 35 full papers came from 33 unique presentation sessions, and there were 115 total sessions at CHI2015. So while the breadth of the corpus may be a good step towards broadly surveying the field, it is possible that my examination reflects theory use in *certain types* of HCI research more than others.

Each publication had at least two authors, and one publication had nine listed authors. Some author groups came exclusively from academic institutions, some came exclusively from research departments at private companies, such as (Amershi et al., 2015), and some groups were a mix of both. Authors indicated a range of disciplinary affiliations, including: departments of electrical engineering, computer science, information science, architecture, and interaction design, among others.

I utilized the six models of theory use developed in my examination of Design Studies publications as an a priori coding scheme for analyzing the 35 full papers in my corpus. That is, I examined each text for theoretical knowledge objects and used the models to categorize each object according to a particular type of theory use. This approach could be construed as a kind of content analysis (Krippendorff, 2012; Rourke et al., 2001; Stemler, 2001).

While content analytic techniques can be powerful tools for descriptive research, something like "theory use" could be seen as a "latent projective variable" in the text, which means that "the target variable [does not] reside on the surface of the content" as much as it might in manifest content or latent pattern variables (Rourke et al., 2001, p. 15). An example of manifest content would be the number of times scholars explicitly name theories in their texts. An example of latent pattern variables is the coding of arguments. Presence of one property of an argument (e.g. a claim) "[sensitizes] coders to the possibility that a message could be coded as an argument" (Rourke et al., 2001, p. 15) but they must corroborate this initial recognition with other elements of an argument, such as grounds or warrant. Latent projective variables are different in that they rely much more so on analyst interpretation.

For my purposes, "use of theory," could manifest an issue Rourke et al. (2001) discuss their examination of latent projective variables. Namely, researchers with different academic backgrounds, research training, and standpoints could differ in their interpretation of use of theory. But since the analysts working on this study come from similar academic backgrounds and possess similar research training, this is less of an issue. In addition, I define particular kinds of theory use, which means I establish the boundaries of what constitutes theory as an object of study as opposed to theory as a shaping tool. While there may be shades of grey, I attempt to circumvent unreliable analysis by focusing only on the most obvious instances theory use as opposed to scrutinizing ambiguous cases.

Findings

I identified 25 papers that use theory as an object of study, which means that a theory or theories or some theoretical aspect is the focus of the research question. In their paper on group interaction around multi-touch tabletops, Block et al. frame their project as follows:

> *"Several research studies have established that multi-touch technology has the potential to engage visitors in fruitful collaborative learning... Many of these studies are based on qualitative analysis. Surprisingly little quantitative evidence exists that explains clearly the factors contributing to visitor engagement around interactive surfaces"* (2015, p. 867).

Re-stated in terms of my model of theory as an object of study, the researchers' question could be about a theory of collaborative learning as it pertains to multi-touch technology. And while this kind of theory use not necessitate intentional feedback between findings and theory, Block et al. at least foreshadow the possibility of feedback when they establish an expectation that their work will provide greater clarity regarding "the factors contributing to visitor engagement" (2015, p. 867)

Theory as a Contextual Tool

All 35 papers seem to use theory as a contextual tool, and obvious examples of theory as a contextual tool were abundant. For example, Bianchi, Ban, and Oakley write about how "prior work in HCI has comprehensively contrasted how individuals perform active reading on paper versus on personal computers [19,21] or tablets [6]," (2015, p. 700).

Theory as a contextual tool does not change the research question. However, it does result in position taking relative to other questions and existing research. Bianchi, Ban, and Oakley could be seen to exemplify position taking when they state that "the goal of [their] paper is to combine these powerful interface and interaction ideas from literature into a novel, concrete and practically feasible… design-led prototype that can

support active reading tasks" (2015, p. 701). By clearly mentioning theory ("interface and interaction ideas from literature") the authors make their position more visible to readers. Furthermore, it creates a frame through which readers can evaluate their contributions.

Theory as a Shaping Tool

One publication in the corpus appears to use theory as a shaping tool, which entails using existing theory to influence and shape an initial research question. The result of the shaping process is a revised research question, which I call question prime. At the outset of their paper on wearables, Tajadura-Jimenez et al. identify the need to "make people feel good about their bodies and motivate them towards physical activity so that they stay physically and mentally healthy and independent" (2015, p. 2943). Next, the authors gloss existing ways in which this issue has been addressed in HCI literature, which can be interpreted as a relevant family of thought. Their summary yields a revised research question, in which the authors propose to investigate whether it is possible "to induce changes in perceived body weight by manipulating the sound feedback received while walking" (Tajadura-Jiménez et al., 2015, p. 2943).

Theory as a Methodological Tool

I identified five papers using theory as a methodological tool, which is theory that shapes the examination stage. For example, in their study on "learning ecologies among people experiencing homelessness," Strohmayer et al. write that

> *"the design methods therefore respond to the perceived hidden nature of everyday learning. Consequently, a mixed methods approach was chosen, to allow the researcher to triangulate information, and to take the most appropriate action for specific situations. The various methods informed one another through clarification and elaboration… [And] throughout the study the ethical frameworks set out by Newcastle University [29], and BERA [4] were followed"* (2015, p. 2277).

Design methods, which have been described by others as theoretical objects (Höök & Löwgren, 2012; Löwgren, 2013), shaped the choice of data collection techniques and ethical frameworks contributed to shaping the researchers' examination.

Theory as an Analytical Tool

Finally, I found 11 papers using theory as an analytical tool for analyzing and interpreting data or findings. Skov et al. authored one of the only papers in my corpus with a section explicitly describing the data analysis process. The authors wrote that they

> *"... were inspired by Ricoeur [24] in [their] data analysis where understanding is achieved through a spiral way of thinking. [Their] data analysis was done in three steps namely naïve reading, structured analysis, and critical interpretation and discussion"* (2015, p. 830).

This seems to us to be a direct reference to hermeneutics. But although the authors revisit certain methodological considerations at the end of their paper, they do not revisit analytical ones, which could be construed as a lack of intentional feedback from their findings to theory as an analytical tool.

A More Nuanced Understanding of Theory Use

Rogers states the use of theory in HCI "has been stretched beyond its original role as part of the scientific method," (2012, p. 17) and my findings could be interpreted as grounds for this claim. In fact, I believe they provide a more nuanced understanding of the ways in which theory "has been stretched" and what role it plays in HCI research. In this way, my findings extend Rogers's descriptions of theory as a generative or argumentative tool. However, my findings also inspire new questions about the current state of theory use in HCI research publications.

Examining Citations as Functional Knowledge Objects

Study 4. Examining Contemporary Citation Practices in DRS Publications

I collected all the DRS conference publications citing Donald Schön's work from the two most recent DRS conferences: Umea (2014) and Bangkok (2012). I found 63 texts out of 286 citing Schön's work—33 publications from Bangkok and 30 from Umea.

I intend my work in this study to be interpreted as idiographic, which means I seek to describe a phenomenon in a particular context and therefore do not seek to generalize to a discipline or field (Larsson, 2013). In contrast, a "nomothetic study" seeks to discover generalizable laws or principles. An idiographic study may still have broader implications, but its outcomes are qualified. This is one reason why I chose to frame the study as an examination of contemporary citation practices in DRS publications—and not as a historical or comprehensive study or one focused on citation practices in design research or the design field.

Additionally, even though the sample is small, it is made up of a diverse set of publications authored by a wide variety of scholars from different disciplinary affiliations in many different university and/or professional settings around the world. Equally important, these scholars address a diverse set of topics, including: research through design, student characterizations of designing, analyzing written texts visually, and informal peer critique, among other topics. The variety of authors and topics can partially ground the claim that my corpus has the capacity for generalizability (Larsson, 2013).

Schön's work is seemingly relevant to a wide variety of research projects. When I refer to Schön's work I refer to any work where Schön played an authorship role (e.g. first or second author and individual or collaborative publications). My corpus contains

references to 14 of Schön's publications, which is interesting since Schön authored over 100 publications during his career.

Once I identified the publications citing Schön, I conducted a content analysis (Krippendorff, 2012; Rourke et al., 2001; Stemler, 2001) to determine the function of each citation. I developed a coding scheme using a framework that describes 11 different citation functions developed by Harwood (2009) in the field of language studies. Following is my paraphrasing of the 11 citation functions. For the original descriptions, see: Harwood, 2009, p. 501-510.

> **Signposting** citations direct readers to other sources in order to (i) help/interest less informed readers; (ii) to keep the argument on track; and (iii) to save space.
>
> **Supporting** citations help authors justify (i) the topic of their research; (ii) the method and/or methodology employed; and/or (iii) the authors' claims.
>
> **Credit** citations acknowledged authors' debt to others for ideas or methods.
>
> **Position** citations allowed authors to (i) identify representatives and exemplars of different viewpoints; (ii) explicate researchers' standpoints in detail; and (iii) trace the development of a researcher's/field's thinking over time.
>
> **Engaging** citations appear when authors are in critical dialogue with their sources.
>
> **Building** citations are found when authors use sources' methods or ideas as foundations, which they then develop further.
>
> **Tying** citations aligned authors with (i) other sources' methods/methodology; (ii) specific schools of thought/ disciplinary traditions; or (iii) debates on specific issues. The first extract discussed is multifunctional.
>
> **Advertising** citations alerted readers either to the author's earlier work, or to the work of others.
>
> **Future** citations served to establish future research plans.
>
> **Competence** citations helped underscore writers' expertise by displaying (i) knowledge of their field; and (ii) their ability to conduct research.

> **Topical** citations allowed writers to show they and their research were concerned with state-of-the-art issues.

Harwood developed this framework through a qualitative, semi-structured interview study with computer scientists and sociologists, in which he asked them to explain the function of each citation in a publication of their choosing (2009, p. 500-501). Harwood created interview transcripts and emergently coded 11 citation functions. These were developed without the input of his interviewees. So I do not know whether the interviewees agreed or disagreed with Harwood's findings. But Harwood anticipates this criticism when he explains "the terminology used to describe each function is derived from the informants' words rather than from the researcher" (2009, p. 501).

Using his participants' terminology to "describe each function" is one way of attempting to present valid findings. Harwood could have translated his interviewees' remarks into his own words to describe each function. But staying true to the interviewees' descriptions strengthens his (validity) claim that the functions accurately capture the interviewees' intentions. Another way of validating his framework is in its accordance with "the functions identified by previous citation studies, despite some terminological differences" (2009, p. 511). So, Harwood's framework might be valid because it reflects the subjective experience of its participants, and other scholars have looked at the same phenomenon and seen the same thing.

Since I do not interview the authors of any of the papers in my corpus, I cannot make any claims about agreement between my coding and their motivations in citing Schön. As Harwood points out,

> *"[Studies] have shown that citers' motivations may be complex, [and so] it would seem sensible not to debar authors from identifying multiple citation motivations and functions [for a single citation]"* (2009, p. 498)

I do not know, for example, whether those who cite Schön in support of their claims might also view the citation as demonstrating their research competence or as tying their work to a particular discourse. Furthermore, Harwood does not present the citation functions in his framework as discrete. A given citation may have several functions. Hence, the functions are not designed to function as discrete categories, which may account for some of the difficulty I encountered when I conducted my analysis. I made the decision to apply only one code to the most evident function of each citation in order to adhere to standards of rigor in conducting a content analysis.

Findings

I find scholars primarily cite Schön's work either to support their own research topics, methods or methodologies, and arguments *or* to credit Schön for his concepts or ideas. And I observe few instances of citations that engage critically with Schön or build on his ideas. My conclusions suggest that a deeper understanding of citation function would be an interesting and important project.

The two most highly occurring functions are credit (78) and supporting (59). Tying (17), competence (13), position (11), and signposting (10) hover in the mid-range of my findings. I found the fewest instances of engaging (4) and building (2) citations. And I found no instances of advertising, future, or topical citations (Figure 7).

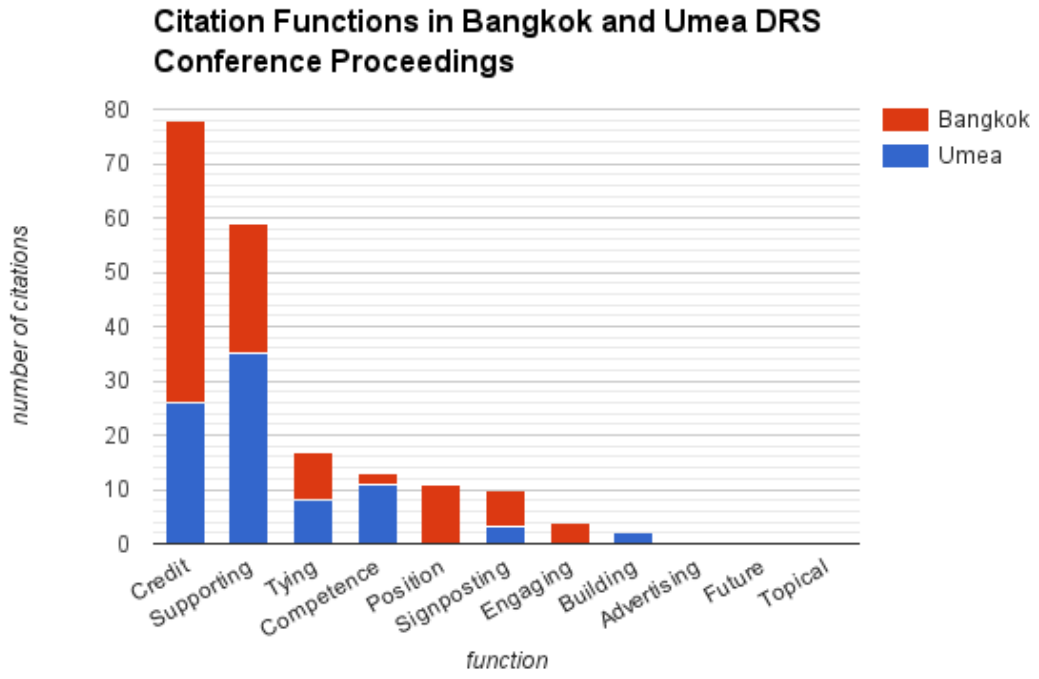

Figure 7. Results of coding different types of citation function in DRS publications

Credit and Supporting

Crediting citations acknowledge authors' debt to other scholars for ideas or methods. For instance, Godin and Zahedi (2014), writing about reflective practice, describe two different "timeframes" in which reflection might occur. And since Schön distinguishes two types of reflection that operate in two different "timeframes" the authors credit Schön with originating the concept. "Reflexive [sic] action can also occur in two different timeframes (Schön, 1983)" (Godin & Zahedi, 2014, p. 1674).

Credit citations do not challenge or extend ideas. They simply give credit for ideas where the authors perceive credit is due. And I note a significant difference between the number of crediting citations and the next most voluminous category. There are 19 *more* instances of crediting citations than there are of supporting citations.

Supporting

Supporting citations help authors justify (i) the topic of their research; (ii) the method and/or methodology employed; and/or (iii) the authors' claims. For instance, Bang et al. write:

> *"Design students are special in the sense that they are trained to use the power of conjecture (Lawson, 2006) for instance through sketching and visualizing possible solutions (Schön, 1983; Cross, 1995)"* (2014, p. 1116).

This quote appears in the authors' "theoretical foundation" section, in which they seek to establish a base upon which to discuss their research question of how design students learn from visualizing theory in design education. Their use of Schön can be seen as a justification at least for the topic of their research if not the claims they make in this section of the paper.

Tying and Competence

Tying citations align authors with (i) other sources' methods/methodology; (ii) specific schools of thought/ disciplinary traditions; or (iii) debates on specific issues. Tying citations may seem to take a form similar to signposting citations in the sense that they might appear as multiple sources in a single reference. For example, Feast writes:

> *"This insight connecting reflection and dialogue [in my work] corroborates significant research within the literature concerning Reflective Practice (Dorst & Dijkhuis, 1995; Schön, 1983; Valkenburg & Dorst, 1998)"* (Feast, p. 186).

This quote can be compared with an example of signposting, which I will discuss in a subsequent section. For now I want to point out that, in their use of a signposting citation, Bang et al. gloss 30 years of research on sketching and drawing as reflective tools. They do not discuss the specifics of this work or how their work relates to it. For instance, they do not say whether their work adopts a similar approach to, corroborates, critiques, or attempts to falsify existing work. In order to "tie" their work with others, this is a

necessary step. By contrast, Feast "ties" his work to specific schools of thought on the relation between reflection and dialogue.

Competence

Competence citations "underscore writers' expertise by displaying (i) knowledge of their field; and (ii) their ability to conduct research" (Harwood, 2009, p. 510). Many citations could be interpreted *partly* as demonstrating competence, and so it was challenging for us to identify competence as the most evident function of a given citation.

I determined that competence could be the most evident function if (1) a given citation did not reference a specific idea or claim, (2) it did not clearly advance the argument or provide support for other rhetorical or methodological choices, and (3) it could not be construed as tying the author to a specific idea from Schön's work. Competence citations could therefore be seen as a demonstration of the author's awareness of a relevant citation but where the specifics of the citation remain ambiguous.

For example, in his discussion section, van der Waarde (2014) writes about the body of work to which his design diagrams refer:

> *"…the second pattern can be directly related to theories of 'reflective practice'. Starting with the work of Donald Schön, this topic has developed into a sizable area of study"* (2014, p. 408).

I coded this as competence since van der Waarde is not crediting a particular source text with the notion of reflective practice. Rather, he refers to plural "theories" and then seemingly connects the patterns identified in his study and an existing body of work. This is different than tying in the sense that this particular citation does not align the author with or disavow Schön's work. I see this quote as a demonstration that the author knows

that Schön's name is relevant to the discourse on reflective practice and that much research has developed since Schön's contributions.

Positioning and Signposting

Harwood describes the positioning function as:

> *"[allowing] authors to (i) identify representatives and exemplars of different viewpoints; (ii) explicate researchers' standpoints in detail; and (iii) trace the development of a researcher's/field's thinking over time"* (2009, p. 505).

I found a good example of positioning in the work of Taneri and Dogan:

> *"Simon (1973) defines design as a problem solving activity where the actual 'state' is structured through 'analysis' and solved with a proposition of a preferred one by 'synthesis'. Counter to Simon, Schön saw design as construction of steps of changes in the given situation by 'reflection in action' followed by 'reflection on action'. Designers construct and impose a coherence of their own that guides subsequent moves"* (2012, p. 1817).

The authors position Schön's perspective on designing in opposition to Herbert Simon's, a position which Schön himself assumed in *The Reflective Practitioner* (1983, p.45-48) and *The Design Process* (Schön, 1990). One could interpret this positioning as the identification of different "exemplar" viewpoints of designing. But it could also be seen as an act of tracing the development of the design field's thinking about designing *if* Simon and Schön could be seen as initiating Kuhnian paradigm shifts (Galle, 2011) in the way the field thought about designing.

Signposting

Signposting citations direct readers to other sources. Harwood (2009) suggests that they do so for three main reasons, namely (i) to help/interest less informed readers; (ii) to keep the argument on track; and (iii) to save space. In analysing this corpus, I found that identifying signposting citations for their 'helpful' and 'space saving' qualities tended to be more straightforward than determining the ways in which they keep the argument on

track, unless it could be said that they keep the argument on track by virtue of not taking up space. Bang et al. illustrate signposting when they write:

> *"During many years design researchers have studied, discussed and acknowledged sketching and drawing as a tool for reflection as well as designing in various ways (see for example Schön, 1983; Cross, 1995; Lawson & Dorst, 2009; Goldschmidt 1991, 2013)"* (Bang et al., 2014, p. 1109).

This quote demonstrates authors (1) providing support in the form of relevant readings to less informed or interested readers, (2) keeping their argument on track or, in this case, laying its foundations, and (3) saving space by summarizing the development of the field with regard to sketching and drawing as tools for reflection in broad strokes rather than summarizing each source text in detail.

In signposting citations, since the details of the cited source material are not given, I do not have a sense of what the various, nuanced lines of thinking within each text might be and which line – if any – may align with the author's work.

Building and Engaging

I found two instances of building citations. Building citations appear to use source material as foundations to build on or develop. For example, Gray (2014) wrote of Schön's work on critique,

> "*While Schön (1983,1987) modelled reflection primarily through verbal interaction in a desk crit, other forms of reflection might encourage other forms of evaluation to occur, moving the locus of interaction out of the classroom into a more regular, self-initiated act*" (Gray, 2014, p. 1136)

Gray could thus be seen to build on Schön's work on reflection by expanding upon the forms (e.g. verbal, visual, etc.) reflection might take. Gray does not challenge Schön's existing work per se, but he does use it as a starting point for proposing a more nuanced

understanding of the forms of reflection and the implications for those different forms of evaluation in and out of the design studio.

Engaging

"Engaging citations appear when authors are in critical dialogue with their sources. This criticality can be more or less marked… " (Harwood, 2009, p. 506). I found four instances of citations that could be interpreted as engaging in a critical dialogue with Schön's work. Three of these occur in close proximity in a publication by Wallis and Williams (2012) and some could perhaps more accurately described as *indirect* or *secondary* engaging citations. For instance, Wallis and Williams write:

> "*Usher, Bryant and Johnston (1997) dispute the coach/ student relationship described by Schön as the learner does not need to take responsibility or ownership in reframing the project problem, as the coach will eventually demonstrate*" (2012, p. 1976).

In this case, it seems that Usher, Bryant, and Johnston—not Wallis and Williams—are the ones engaging in a critical dialogue with the way Schön characterized the coach/student relationship. The latter cite *other* examples of critical engagement with Schön's work without necessarily engaging Schön's work. They let existing work do the engagement for them. However, Wallis and Williams also engage in a direct, first person style with Schön.

Direct, first person engagement means that the authors, *not* their secondary sources, engage in a critical dialogue with Schön. For example, Wallis and Williams write:

> "*It also seems that the use of 'co- experimentation' by Schön does not represent a contemporary understanding of 'facilitation' where working with the student to allow them to recognize their learning process*" (2012, p. 1976).

I would describe this an instance of what Harwood might call "less marked" engagement. The critique that Schön's use of "co-experimentation" is anachronistic with regard to "facilitation" could be construed as minor flaw. Wallis and Williams do not argue that Schön was wrong nor do they push their claim to reveal any other kind of major flaw, such as: lack of empirical support, weak empirical support, or incommensurability with other aspects of Schön's work on design studio pedagogy. They *do* imply that an aspect of Schön's work is out-dated, which is a kind of critical engagement.

Few authors seem to engage in a critical dialogue with Schön. This could mean that contemporary design researchers are less concerned with the problems or inconsistencies in Schön's work and, thus, to the consequences of these issues. By and large, Schön's work tends to be intuitively accepted without much additional explanation or discussion.

Studying Knowledge Growth in General

Study 5. Why aren't there more scientific theories of designing?

The design process is a central object of inquiry for design research (Chai & Xiao, 2012) and many scholars have examined designing and presented their results in the form of models, frameworks, and schemas. So why aren't there more scientific theories about the design process?

There are many different goals for studying designing. For instance, researchers whose intention is to understand concrete and practical aspects of designing might describe particular instances of it with no aspiration to achieve a universally applicable or general understanding. Others may take a more "designerly" approach to studying the design process with the goal being to establish an "ideal" or "desirable" version of it. Others may seek to develop a general understanding of the design process in ways that align with more traditional notions of scientific theorizing, that is, to achieve an explanation of its generic behavior or structure. It may be the case that these approaches aspire to develop theory *if* theory means abstract knowledge about designing that has the potential to be useful to others. But such theory is not necessarily scientific.

When I use the word "theory" in this study, I refer to knowledge that provides an explanatory framework for some observed phenomena with the goal of generating testable hypotheses and making predictions. In using such a broad definition, my aim is to account for nascent theories as well as more developed, mature theories (Weick, 1995). And while I know that this is an incomplete definition, I believe it is adequate for my present purposes.

The primary focus of this study is an examination of an apparent imbalance

between scientific and non-scientific theories about designing in the design research community. To conduct this examination, I refrain from engaging in detail with the substantial body of literature around theory, its various definitions, roles and functions in research. This sort of analysis has been done (Friedman, 2003; Galle, 2011; Gregor & Jones, 2007; Weick, 1989, 1995), and I believe it would exceed necessity to summarize it here. However, I will refer to some of its salient points throughout the paper.

When I ask why there aren't more scientific theories of designing, I might be misinterpreted as setting up an argument for more scientific theorizing or for claiming scientific theories are better or stronger than other kinds of theories. But neither of these is the case. I am not arguing that there should be more scientific theories of designing. Nor do I claim that scientific theories are objectively or generally better than other kinds of theories. But if different approaches to studying the design process have as (one of) their goals the generation of abstract knowledge about designing that is potentially useful to others, then it seems like developing scientific theories would be a relevant if not important approach.

I have been engaged in an ongoing research project examining many theories, models, and frameworks purporting to provide an explanation or description of the design process (Dubberly, 2015; Friedman, 2012; Gero & Kannengiesser, 2014; Hatchuel & Weil, 2009). But among these I have found fewer theories that *appear to be framed* as scientific. This observation was not the result of an intentional examination. That is, I was not looking for the proportion of scientific theories relative to other kinds. Rather, this was something that over time struck me as both apparent and intriguing. Confident in the potential validity of this observation, I have taken it as an assumption that will frame

the rest of this study.

The assumption that there are fewer scientific theories of designing means that I have to be able to distinguish a scientific theory from other kinds. And so in order to make this distinction, I will briefly discuss relevant work from the philosophy of science that has been central in framing contemporary perspectives on what distinguishes scientific theories from other kinds. I will also, as a contrast, briefly discuss what non-scientific theories of designing could be. Finally, I will explore three possible explanations as to why there seem to be fewer attempts to develop scientific theories about designing. If there are fewer scientific theories of designing relative to other kinds, then why might this be so and what could it mean for the design research community?

Cumulative and Additive Knowledge Growth

My primary purpose in this study is to examine why there seem to be fewer scientific theories of the design process relative to other kinds of theories. It may be prudent to contextualize this question in relation to a growing discourse in design research examining knowledge and knowledge growth (Carvalho, Dong, & Maton, 2009; Dong, Maton, & Carvalho, 2015). I begin with a discussion of two types of knowledge growth: cumulative and additive.

How does the design field measure intellectual progress? Is it a field characterized by cumulative or additive knowledge growth? The answers to these questions are relevant to my purpose. For instance, if design is characterized primarily by *additive* knowledge growth, then perhaps I should expect to see fewer scientific theories about designing than other kinds. This could be a simple explanation for my preliminary observation. But first I must establish what it means for knowledge to grow cumulatively and additively.

Cumulative knowledge growth is also called hierarchical. In hierarchical growth, new knowledge is "ranked higher" than existing knowledge because of its *greater* explanatory power. This is part of what Basil Bernstein meant when he described hierarchical knowledge growth as "motivated towards building an apex of greater integrating propositions [with fewer and fewer axioms]" (Maton & Muller, 2009). An "apex of greater integrating propositions" describes propositions that explain more than their predecessors without the need for axioms. For example, when Einstein was developing his theory of general relativity, he had full knowledge of Newtonian mechanics. Einstein's theory retains the explanatory power held by mechanics, but, importantly, it explains things that Newton's theory cannot. This novel explanatory power illustrates hierarchical growth. Relativity accounted for everything that scientists knew about the world and more, such as how, during the day, stars in the sky near the sun would appear as though they had moved *away* from the sun and from each other. In this way, it can be seen as better and more powerful.

A hierarchical structure has important implications for knowledge building. For instance, if hierarchical growth converges on particular truths then there is probably an agreed upon set of problems or questions. It would seem difficult if not impossible to converge on particular truths if all the knowledge work being done in a field addressed disparate problems or questions. At the very least, progress would be much more incremental. In fact, quite a few scientific disciplines have established or proposed common questions, problems, or challenges around which to organize their intellectual resources. In Physics, this is apparent in a document like the Oxford Questions (Briggs, Butterfield, & Zeilinger, 2013), which lists the big questions about the world that

quantum physicists are trying to answer.

A hierarchical structure may also imply an agreed upon methodology for knowledge building. There must be some consensus regarding what constitutes a novel contribution and this presumably requires an agreed upon means of evaluating validity and relevance. It would not make sense, for example, for a scientist to evaluate a philosophical contribution on scientific terms. But do agreed upon measures of validity, relevance, and rigor require an agreed upon methodology of knowledge building? And would these same requirements be in place for fields characterized by additive knowledge growth?

Additive growth is also called horizontal. In horizontal fields, new knowledge is not necessarily judged to be better or more powerful in its ability to explain some phenomenon. Horizontal fields embrace a plurality of perspectives, which may emphasize diversity and divergence of knowledge production as opposed to unity and convergence. New knowledge in a horizontal field may provide a different perspective on a well-known topic (such as a new interpretation of a classic novel or film) or it might introduce a new topic to a field. This means that, where new theories are concerned, there is no need to address existing phenomena or even to work from common ontological and epistemological assumptions about the world.

In a horizontal field a researcher has more flexibility in their choice of topic since they may not have to demonstrate how new knowledge builds on or extends existing knowledge. They might develop a new theory about a previously unaddressed and unknown phenomenon. In addition, scholars working in a horizontal field are less likely to be subject to common methodologies for generating knowledge. It is also possible that

scholars working in horizontal fields have more freedom to import and experiment with practices and procedures for generating knowledge.

In distinguishing between horizontal and hierarchical knowledge growth I am not saying that any academic field *exclusively* adheres to one of the other. For example, while the primary concerns in the natural sciences are universal laws, principles, and facts about natural phenomena in the world and, thus, primarily aimed at hierarchical knowledge growth, there are aspects of it that could rightly be interpreted as horizontal. Proposing a theory to explain some new aspects of reality not previously known would be one example of horizontal growth in the natural sciences. And as I discussed, there are examples of hierarchical growth in primarily horizontal fields (Chakrabarti & Blessing, 2014a).

In this study, I assume that knowledge growth in the design field is primarily horizontal. If this assumption is correct, then it may be a simple explanation as to why I do not see more scientific theories of designing. While there are researchers in the field conducting inquiry from a scientific perspective there are *more* conducting inquiry from philosophical, humanistic, and designerly perspectives. But when I ask why there are not more scientific theories I am asking why there is not more "building on" existing knowledge about the design process in design research as opposed to "building next to" existing knowledge.

In my experience working on the question of what constitutes a design theory, I have encountered (1) few theories about designing that explicitly claim scientific status, (2) few theories that seemingly aspire to scientific status, and (3) few theories that could be interpreted as scientific. In the next section, I summarize key elements of a discourse

from the philosophy of science whose primary interest is in distinguishing scientific theories from other kinds. I have found some of its key elements to be useful and intelligible in distinguishing scientific theories from other kinds.

Scientific Theories of the Design Process

Some design research literature (Chakrabarti & Blessing, 2014b) seemingly assumes that models and theories developed about designing are testable and refutable but I found that there had not been much inquiry into this assumption. Vermaas (2014) explores this idea in depth in a text on the scientific status of design research, and he draws on the same concepts from the philosophy of science as I do in my previous work and in this study. In my previous work (Beck & Stolterman, 2015) I analyzed four theories about the design process to determine whether they could be construed as scientific in Popper's terms. These were: CK theory (Hatchuel et al., 2011; Hatchuel & Weil, 2002, 2009), the FBS framework (Gero, 1990; Gero & Kannengiesser, 2014), Figural Complexity (Schön, 1990), and Bounded Rationality (Simon, 1969).

The aim of this previous work was to use the concept of falsification as an analytical framework to examine four theories about the design process. I wanted to provide a perspective from which to understand theories about designing as scientific and to propose that this perspective has interesting and significant implications for design research. The four theories that I selected to analyze have been and continue to be influential in the design field (Beck & Chiapello, 2016; Cascini, Fantoni, & Montagna, 2013; Hatchuel & Weil, 2009; Vermaas & Dorst, 2007).

For my present purposes I will not describe each theory but will instead briefly summarize the analysis I undertook in order to determine the scientific status of CK

theory, the FBS framework, Figural Complexity, and Bounded Rationality.

It is possible to argue, as Popper did, that Marx and Freud's theories are *un*falsifiable—that wherever we look we can always find confirming evidence of their truth. No factual propositions exist that clash with them. This means that if it is possible to extract factual propositions from a theory—propositions with high truth-values—where truth-values are functions of empirical observations and mutual consensus within a community, then the theory is falsifiable in Popper's view.

Newtonian mechanics, for example, had centuries of empiricism and consensus within the scientific community. And so, when Einstein proposed his theory of relativity, it clashed with established factual propositions about the way the world worked. In addition, unlike Marx and Freud's theories, Einstein's theory had an "empirical basis," which meant that it had a set of potentially falsifying basic statements, which were "testable, inter-subjectively, by 'observation'" (Popper [1959] 2002). Importantly, these basic statements could be extracted for theories that explain new aspects of reality. A theory does not need to clash with existing empirical work and/or consensus within a community in order to be falsifiable.

Since I was interested in evaluating the falsifiability of a theory, I attempted to extract a falsifying basic statement from each theory. The question became: What basic, factual statements about designing are possible to derive from C-K theory, the FBS framework, Figural Complexity, and Bounded Rationality? Following an analytical exercise during which I examined each theory in terms of their internal constitution and structure, I proposed a set of basic statements that could be derived from each theory *and* speculated about observations that each theory forbids.

Through my analysis I became convinced that each of the four theories supported the extraction of basic statements about designing, which could be disproved through empirical observation. Moreover, this disproof seemed to us to have consequences for the theory as a whole—not just for the particular axiom(s) that allowed for the generation of basic statements. I also found that these basic statements could be seen as forbidding certain observational states. For example, C-K theory forbids designing from concept "stasis" or "contraction." The FBS framework forbids designing that does not include transformations of functions, behaviors, or structures. Figural Complexity forbids designing from excluding types of learning whereby the designer reframes the requirements, trials, or criteria of fit.

My previous investigation led to some observations that may be relevant to this study. First, I found strong indications that there actually exist some theories about designing that satisfy Popper's criterion for establishing scientific status. Second, I believe that it would be possible to develop these theories even further by adhering to the methodological standards of science, even though this is not something I explored in detail. However, I also believe that there is sufficient evidence for this kind of scientific theory development in existing literature (Cascini et al., 2013; Chakrabarti & Blessing, 2014b; Gero & Kannengiesser, 2004). Finally, it seems probable that there are few other theories about designing developed to the same degree as these four. As I encountered theories about designing I categorized them into scientific and non-scientific theories. I categorized 150 non-scientific theories and 25 scientific theories.

Taken together, this leads me to believe that the framing assumption in this study—that there are comparatively fewer scientific theories about designing—is a

reasonable one. *So,* how might I go about describing or characterizing these other, non-scientific kinds?

Other Theories About Designing

It may be the case that most theories of designing are not claimed to be scientific by their originators or by other scholars in the field. Some theories of the design process have been framed and discussed as though they are methods that can be applied in practice (Hatchuel, Le Masson, & Weil, 2004). Other theories are seemingly taken for granted as *particular* descriptions of one design process without any aspirations to achieve a higher level of abstraction. It seems to us that very few scholars describe or discuss theories of the design process as though they are (or could be) scientific.

Of course a *claim* to scientific status is not the same thing as scientific status. A theory may be presented as scientific yet lack the qualities of a scientific theory. As Popper makes clear, we cannot take the word of the theorist regarding the scientific status of a theory (Popper, 1953). Similarly, *no* claim to scientific status is different from non-scientific status. A theory may be presented as non-scientific, and yet it may still be examined and found to have the qualities of a scientific theory. There must therefore be some criteria, such as falsification, by which we can evaluate a given theory in order to determine its scientific*ness*.

There are a large number of descriptions and explanations of designing that could be interpreted as theories based on my initial definition of theories as knowledge objects that provide explanatory frameworks for some observed phenomenon. There are collections of models (Dubberly, 2015; Friedman, 2012), frameworks (Halskov & Ebsen, 2013), and what have been called theories of designing that do not aim to present a fully

developed, scientific explanation or description of the design process. A fully developed theory can be understood as one that has gone through multiple iterations and revisions based on a dialogue between the theorists and other scholars in the intellectual fields of which they are a part.

Hatchuel and Weil's CK theory, Schön's theory of synthesis, and Gero's FBS Framework are examples of well-developed, scientific theories of designing. And I would contrast these with any of the 141 models of the design process that Dubberly has collected and catalogued. Although they are not presented as scientific theories *per se* it may be possible to develop them into scientific explanations of the design process by, for example, developing each theory to manifest the qualities of outlined in (Bunge, 1961), which include falsifiability.

Moreover, if I adopt a different understanding of a theory, for example, as a collection of models, then by definition Dubberly's collection represents a theory about the design process. But to my knowledge, Dubberly's models have not been critiqued, tested, engaged with or developed further by anyone in the design research community in a significant, meaningful way, which means they are a preliminary scientific theory and most likely inaccurate or wrong. But this is not necessarily the intention behind them.

Dubberly's collection and other similar entities could be understood as *schemas* in the sense that they express a particular way of thinking about designing that may serve a practical purpose of supporting designers in their daily practice (Nelson & Stolterman, 2012). Such schemas do not aim to provide an "absolute truth" about designing but rather aim, in a practical and useful way, to support the process of designing by providing the designer or researcher with a simple framework for thinking about the design process.

But the fact that these are not theories in a strict scientific sense does not necessarily mean that they should not (or cannot) be engaged with and built upon. Nor does their intended applicability during designing mean that they are actually useful to designers. In a subsequent section, I explore the possibility that practical utility may be one way to account for a higher proportion of non-scientific theories of designing. For now I will point out that practical utility and scientificness are not mutually exclusive. It is possible for theories to be both scientific and useful.

Many scholars frame design research as a practice-oriented discipline (Friedman, 2003; Galle, 2011). This framing implies that that it seeks to generate knowledge in a way that is useful *primarily* for design practitioners. Other disciplines, such as education and management likewise have been framed and discussed as practice or professionally oriented. However, there are indications that these other disciplines also value and cultivate strong scientific theories that they believe are important and relevant to practitioners. I believe that this makes my question all the more interesting.

It seems as if other practice-oriented disciplines aspire to maintain and cultivate a strong culture built around scientific theorizing. Is design research different? Or does it have a desire to cultivate a strong, scientific culture? If it does have such a desire, then why are the comparatively fewer scientific theories of the design process? And why does it seem as though there are few scholars calling for more scientific theories? In the next section, I explore three potential explanations for the apparent proportion of scientific theories about designing to other kinds of theories.

Explanations for the Proportion of Scientific Theories

There are different approaches I might take to generate explanations in response to my

key question, Why aren't there more scientific theories about designing? For instance, it would be possible to generate explanations that adhere to existing scholarship or explanations designed to yield testable hypotheses. My ambition is to establish explanations that are sufficiently different (Weick, 1989) and intelligible to my readers. With this framing in mind, I propose three possible explanations:

1. Design research develops theories for multiple stakeholders and not all of these stakeholders value scientific theories,
2. Design research is building its own intellectual culture, which could involve exploring different, culturally unique approaches to theory development, and
3. Different understandings of what constitutes a scientific theory may yield different insights about the proportion of scientific theories to other kinds.

There is less demand for scientific theories about designing

Design research has multiple stakeholders, such as: researchers and practitioners. These two groups potentially have different desires and needs (Weber, 2014) when it comes to theories about designing.

Researchers may be more interested in developing theories that revise or extend established understandings of the design process, and they may also believe that it is possible to achieve some "absolute truth" or "predictive knowledge" about the design process. By contrast, practitioners may be more interested in developing theories about designing that are useful and applicable in practice. Whether a theory is scientifically true may be less important to them. It may only be important that a theory works for their purposes. This means that these two groups have different measures of success (scientific truth versus practical utility) when it comes to evaluating theory.

Distinguishing researchers from practitioners within the design field could help make sense of the *co-presence* of scientific theories and other kinds of theories. If different stakeholders in the same field have different needs and measures of success, then it stands to reason that, in response, the field would produce different kinds of theories. This is a simple illustration of supply and demand. It could be argued that since there are seemingly *fewer* scientific theories, the demand for practical theories applicable in the professions is *greater* than the demand for scientific theories.

It is of course the case that "useful and applicable" and "scientific" are not mutually exclusive categories. A particular theory about designing may be useful, applicable, *and* scientific, which is arguably the case with CK theory.

CK theory has been presented both as an ontological theory about the design process and as a more prescriptive, applicable theory that designers might use as a framework for designing. Its originators, Hatchuel and Weil, may have *intended* to develop a theory that was both useful/applicable *and* scientific. However, this may be an exceptional case rather than the norm.

It could also be the case that the demand for useful/applicable theories has grown over time as practitioners have refined their sense of what they need from a theory about designing. It is possible that the early days of design research intended to produce more scientific theories about designing because researchers and practitioners thought that this kind of theory would be useful. This sort of thinking may be reflected in early attempts (e.g. during 'the design methods movement' of the 1960's, which has been called the 'design science decade') to discover "the underlying logic" of designing and to use this discovery to generate a universal "design method" in the style of the scientific method.

Researchers and practitioners sought, as Nigel Cross writes, "to base design processes (as well as the products of design) on objectivity and rationality" (Cross, 2001, p. 49).

But it is apparent that soon after these efforts began, practitioners and researchers realized that scientific approaches—both to designing and to *studying* designing—might not yield the kind of useful results that they previously thought. Christopher Alexander famously disavowed the design methods movement saying, "…There is so little in what is called 'design methods' that has anything useful to say about how to design buildings" (Cross, 2001, p 50).

Saying something true about designing does not necessarily mean that what is said is also useful or applicable to practitioners. And if design is a practice-oriented discipline, then saying something useful or applicable to practitioners is important. It makes up part of the core of the discipline—though not the *whole* core. This is in contrast to a discipline like theoretical physics where the question of "practical" utility and applicability may not make sense.

But a practice orientation alone does not explain the preponderance of useful, applicable theories compared to scientific ones. There are other practice-oriented disciplines where this does not seem to be the case. For instance, management studies has been described as practice oriented, yet its researchers are "pushed to produce insight for both the professional and academic realms" (Corley & Gioia, 2011, p. 18). Their disciplinary norms could be said to promote and support the production of theories that are both scientific and useful *and* applicable to managers and organizational practitioners.

Moreover, Corley and Gioia (2011) have argued that management studies skews toward producing theories—including theories about managing—that primarily aspire to

scientific truth and utility. Does design research move in a different direction? And if so, why?

Design research is building its own intellectual culture

An interesting and important theme for inquiry in the design research community has to do with building a unique intellectual culture (Cross, 2001; Nelson & Stolterman, 2012). This initiative is predicated on the notion that there are ways of knowing (and generating knowledge for and about design) that are unique to design and designing.

Building this intellectual culture, which Nigel Cross has called "Design as a Discipline," (2001) could therefore be understood as an effort to cultivate "designerly" ways of knowing and theorizing rather than importing and relying primarily on scientific ways of knowing and theorizing. This effort may seem similar to previous attempts to develop the design version of the scientific method. But whereas the design version of the scientific method was built around scientific values, including objectivity and testability, the attempt to build a unique intellectual culture for design aims to identify and cultivate designerly values.

This may complicate my previous division of the multiple stakeholders of design research. I divided them into two groups: researchers and practitioners, and I discussed how shifting needs and desires of practitioners may account for the proportion of scientific theories to other kinds of theories about designing. But now it becomes possible to speculate about researchers themselves experiencing a shift in needs and/or desires when it comes to theories about designing. For example, there are a growing number of researchers in the field conducting *research through design* — an approach that utilizes design methods and processes as a legitimate means of inquiry (Zimmerman et al. 2010).

Theories with strong scientific utility can be seen as (1) advancing knowledge and (2) guiding its production; that is, helping researchers identify what to study as well as how to study it. But if a researcher does not intend to study something in a scientific way, or if they complement scientific research with research through design, then perhaps other kinds of theory are necessary. A scientific theory may not be the appropriate tool for guiding concept generation or for judging whether a concept is a good fit (or not) for a given design brief.

Researchers using design methods and processes may find—as some practitioners did—that scientific theories about designing are useful or applicable in some ways but not others. They may therefore share in the demand for other kinds of theories. And it would thus make some sense that researchers using design methods and processes would intend or present their theories about designing *not* as scientific or having scientific aspirations but as practical and useful. While these kinds of theories have the potential to contribute to a general understanding of designing, their purpose is not to present a "true," scientific account of it. Rather, their purpose can be understood as strengthening researchers' ability to design and conduct research through design.

It is also possible that research through design can produce theories about designing in the form of frameworks and methods that are useful and applicable. This illustrates a relationship between a particular research approach and its theoretical output. Simply put, the way researchers think about theory affects the theory they produce (Galle, 2011) and there are many ways to think about theory. But while this explanation may account for the presence of non-scientific theories about designing, by itself it might not account for the ratio of scientific theories to other kinds. There are *some* researchers

using design methods and practices in their work, but research through design still seems to be a peripheral approach in the design disciplines despite strong arguments for its legitimacy (Gaver, 2012; Zimmerman, Stolterman, & Forlizzi, 2010).

The potentially evolving needs and desires of researchers in concert with a broader effort to build a unique intellectual culture for design may contribute to the proliferation of other kinds of theories and theoretical knowledge objects such as annotated portfolios (Bowers, 2012; Löwgren, 2013), strong concepts (Höök & Löwgren, 2012), bridging concepts (Dalsgaard & Dindler, 2014), and generic design thinking (Wiberg & Stolterman, 2014). Taken together, these phenomena may contribute to a decline in the development of scientific theories about designing.

There are different ways to distinguish scientific theories from other kinds

In a previous section of this study, I discussed Karl Popper's criterion of falsification as one way to distinguish scientific theories from other kinds. I acknowledge that Popper's criterion has been criticized (Kuhn, 1970) and that there are differing perspectives on what scientific theories are or should be (Chakravartty, 2001). Adopting a different perspective on the nature and constitution of scientific theories has implications for my key question.

My interpretation of the proportion of scientific theories about designing relative to other kinds of theories could be explained as a consequence of my philosophical view of scientific theories. A different view could yield different findings. Consider two competing perspectives on scientific theories: (1) the received view (Suppe, 1972) and (2) the semantic view (Chakravartty, 2001).

The received view of scientific theories frames theories as "sets of sentences

given in a logical domain language" (Winther, 2016). A domain language could be the language of mathematics or the language of physics, for example. And the sets of sentences written in these languages are treated as axiomatic. Newton's laws of motion are one example of a set of sentences given in a logical domain language.

The received view provides us with a framework for examining theories to determine whether they are scientific. Is there a set of sentences given in a logical domain language? I could ask this question of any number of theories and explore the possibility that a theory is scientific *according to the received view*.

The semantic view of theories is different. A simple definition of the semantic view of scientific theories is "a family of models: systems that satisfy the theoretical laws we commonly associate with scientific theories" (Chakravartty, 2001, p. 326). This definition points toward criteria to evaluate the scientific*ness* of a theory, which are different from the criteria derived from the received view. The semantic view could thus be seen as providing a different framework for evaluating the scientific*ness* of a given theory.

It is not my intention to present comprehensive descriptions of the received and semantic views of scientific theories. Rather, my intention is to present each view in sufficient detail to illustrate the point that different perspectives on what constitutes a scientific theory have implications for my key question. For example, if I adopt the semantic view, then it may become possible to interpret Dubberly's collection of 141 models as (a) scientific theory about designing.

If design research is primarily characterized by horizontal knowledge growth, then it stands to reason that there will be scientific theories about designing alongside

other kinds of theories about designing. However, the horizontal structure does not account for the proportion of scientific theories to these other kinds. Nor does it present a clear picture of the epistemological values held by researchers in the field.

My starting assumption in this study was that there are fewer scientific theories that explain or describe the design process than other kinds. I discussed one way to distinguish scientific theories from other kinds by drawing on a discourse from the philosophy of science, and I explored three possible explanations regarding why there seem to be fewer scientific theories about designing in design research when compared to other kinds:

1. Scientific theories about designing are not useful to practitioners,
2. Design research is building its own intellectual culture, and
3. Different ways of understanding scientific theories may yield different results

For each of these explanations, I also explored possible consequences for the field, including: (1) a decreasing ratio of scientific theories to other kinds, (2) developing more designerly ways of understanding of theories and theorizing, and (3) reflecting on the philosophical views that one adopts when building and studying theories about designing.

Theory construction and theory use have been addressed in the field in different ways (Baskerville & Pries-Heje, 2010; Friedman, 2003; Gregor, 2010; Gregor & Jones, 2007; Lee, Pries-Heje, & Baskerville, 2011). And there is a growing discourse around the possibility of scientific theories about designing (Beck & Stolterman, 2015; Vermaas 2014). This study assumes that (1) scientific theories about designing are possible and in existence today, and (2) that there are fewer scientific theories relative to other kinds.

My tentative explanations should be seen as steps towards a more robust picture

of the intellectual culture within design research. Individually, each explanation points toward future questions for inquiry, such as: How do design researchers account for or address multiple stakeholders in their publications and presentations? What is the current state of the effort to build a unique intellectual culture for design research? How and why do design researchers choose between different, potentially competing philosophical views to inform their work?

As I have stated, this study is not a call for more scientific theorizing of the design process. It is an examination of the presence and proportion of scientific theories in relation to other kinds. However, based on my conclusions it seems as if the field would benefit from a debate about the overall need for theory about designing. Is there is a need for scientific theories today or are designerly theories enough? What does it mean if the field moves even more in one or the other direction?

When a field produces multiple theories of different kinds about the same phenomenon, an examination of the presence and proportion of different kinds of theory can lead to insights about what kinds of theories the field values, how these values have changed over time, and potential directions in which these values are moving. I am confident that design research will always actively generate theories about designing, but I am less confident that these theories will aspire to be scientific.

Study 6. Examining the Types of Knowledge Claims Made in Design Research

Comparing knowledge claims made in different disciplines opens up the possibility of identifying unique patterns in one discipline that are absent in the others. In this study, I pose a two-part question: What kinds of knowledge claims do design researchers make and are they similar to or different from the kinds of claims made in other disciplines?

Despite the proliferation of ways and sites of knowledge production (Gibbons et al., 1994 p. 1), the natural and social sciences have well-established research traditions and quality control mechanisms for vetting research for publication. My assumption was that these two disciplines would yield publications whose knowledge claims manifest more coherent, stable, and uniform patterns. However, my purpose was not to search for uniformity in these two bodies of scholarship. It was to identify patterns in design research publications using benchmarks from the natural and social sciences.

I randomly sampled 10 publications each from *Design Studies*, *Nature*, and the *American Sociological Review (ASR)*. Each journal in my view represents paramount research in its respective field. *Design Studies* was selected because of its stated provision of an "interdisciplinary forum" for research and because it is one of the oldest journals in the field. *Nature* and the *ASR* are two of the highest impact research journals, and each publishes original research on diverse topics.

To create a random corpus, I identified a single calendar year (2013) from which to select publications and compiled lists of all the publications from that year for each journal. I assigned each publication a numeric value and, using a random number table, selected 10 publications from each journal. This may strike some readers as a small sample given my aim of identifying broader patterns in design research publications. However, I believe in alignment with others that it is reasonable to expect even a few texts to reflect broader patterns in a discourse (Potter and Wetherell, 1987). Even though I am limited in my ability to generalize about the types of knowledge claims made in design research, I believe my sample has the capacity to reflect general patterns in knowledge claiming practices. To validate this belief would require wider examinations

of different publication venues. Moreover, there is a distinction that can be made between attempts to be representative of research in a field and an attempt to be representative of knowledge claiming practices. I am working towards the latter.

In my sample of *Nature* publications, there are articles relevant to structural biology, neuroscience, theoretical physics, microbiology, and human anatomy, among others. My *ASR* sample publications address wide-ranging topics, such as: illegal immigration, scientific discourse and eugenics, gender and white-collar crime, unionization, and paternal incarceration, among others. Finally, my *Design Studies* articles address diverse topics such as: the cultural boundedness of affordances, inclusive design, design as a deliberative enterprise, 2D v. 3D sketching tools, the FBS framework, and methodological prescriptions, among others.

There were two components of my analysis. First, I distinguished the primary knowledge claims made in each paper. To distinguish primary claims, I applied Fisher's method (2004) for extracting the claims and grounds of an argument. I read through each text circling inference indicators (e.g. thus, therefore), underling claims, and bracketing grounds.

I identified primary claims from others by comparing the abstract, the introduction and conclusion sections, and a set of argument diagrams constructed using Fisher's method whereby claims are ranked into a hierarchy to distinguish primary claims from secondary, supporting claims. In a few cases, the main claims identified through Fisher's method did not seem to match the author's stated claims. However, the stated claim may not be the *actual* claim made in a given paper (Fisher, 2004). Once I identified

the primary knowledge claims in each text, I coded these primary claims using Hart's typology as a coding scheme.

Findings

In this section I present the results of my coding for each publication by venue. I organize the results into tables containing three columns: (1) authors, (2) type of claim coded, and (3) the primary knowledge claim as it appears in the source text. Then, I address the relationship between the authors' stated primary claims and the actual primary claims made in the body of the text. In *Design Studies*, unlike *Nature* and *ASR*, I found several discrepancies between stated primary claims and actual primary claims.

I held several assumptions prior to and during the coding activity. First, I assumed that articles in *Nature* would only make claims of fact. Second, I assumed that articles in *ASR* would show a strong tendency toward claims of fact—though I anticipated finding other kinds of claims as well. Given the interdisciplinary nature of design research, I held no assumptions about the knowledge claiming patterns I might find in *Design Studies*.

Nature

Citation	Type	Primary Knowledge Claim
(Alonzo et al., 2013)	FACT	"Here we identify the human immunodeficiency virus (HIV) co-receptor CCR5 as a cellular determinant required for cytotoxic targeting of subsets of myeloid cells and T lymphocytes by the S. aureus leukotoxin ED (LukED)."
(Amador et al., 2013)	FACT	"… the HVC precisely encodes vocal motor output through activity at the times of extreme points of movement trajectories."
(Buczacki et al., 2013)	FACT	"Quiescent [mouse intestinal quiescent cells] can be recalled to the stem cell state."
(The Cancer Genome Atlas Research Network, 2013)	FACT	"Remodeling cellular metabolism thus constitutes a recurrent pattern in ccRCC that correlates with tumor stage severity and offers new views on the opportunities for disease treatment."
(Chiu et al., 2013)	FACT	"The nervous system has direct sensory and modulatory roles in host-pathogen interactions during acute staphylococcal infection."
(Fradet-Turcotte et al., 2013)	FACT	"53BP1 is a bivalent histone modification reader that recognizes the histone code produced by DSB signaling."
(Jiang et al., 2013)	FACT	"We show that this remarkable quantum phase is the ground state of a reasonable microscopic Hamiltonian… which we here examine extensively on the square lattice two-leg ladder."
(Li et al., 2013)	FACT	"Here we report the crystal structure of a presenilin/SPP homologue (PSH) from the archaeon Methanoculleus marisnigri JR1."
(Makino, Baumgärtner, & Conti, 2013)	FACT	"The substrate binding and channeling mechanisms of 3'-5' RNA degradation complexes are conserved through all kingdoms of life."
(Schloissnig et al., 2013)	FACT	"Individual-specific [SNP] strains are not easily replaced and… an individual might have a unique metagenomic genotype, which may be exploitable for personalized diet or drug intake."

Table 5. Kinds of primary knowledge claims made in 10 published papers from Nature.

I found that each of 10 papers from *Nature* made primary claims of fact. My assumption that *Nature* publications would manifest a strong tendency for making primary claims of fact seems to have been correct. Moreover, in all but one publication the authors report the results of empirical experiments. The only non-empirical publication was a theoretical physics text (Jiang et al., 2013). There was strong correspondence between stated primary

claims and actual primary claims in *Nature*. There were no instances where a stated claim in the abstract did not match the primary claim made in the body of the text.

Most of the publications offered some speculation about the significance (value) of their findings for their respective fields, and some speculated about possible practical (policy) implications of their findings. For example, The Cancer Genome Atlas Research Network has as its stated goal, "to improve our ability to, treat and prevent cancer" (TCGA: The Next Stage). Hence, its paper, *Comprehensive molecular characterization of clear cell renal cell carcinoma,* devotes notably more text to exploring the implications of its findings for medical practice. One reason why fewer *Nature* publications explore the implications of their findings for practice could be the paradigmatic scientific commitment to disinterested research. That is, the goal of science is to describe the world; to say "what is" rather than "what ought to be." While the findings in my corpus of *Nature* publications may have implications for practical domains, it is not necessarily within the scientists' purview to speculate about those implications.

American Sociological Review

Citation	Type	Primary Knowledge Claim
(Brady, Baker, & Finnigan, 2013)	FACT	"… state-level unionization is robustly significantly negative for working poverty."
(Burgard & Ailshire, 2013)	FACT	"Overall and at most life course stages, women slept more than men."
(Desmond & Valdez, 2013)	FACT	"Women [in Milwaukee] were disproportionately affected by [coercive third-party policing on the urban poor.]"
(Hasan & Bagde, 2013)	FACT	"Academic performance is a social phenomenon."
(Kristal, 2013)	FACT	"… the main factor leading to the decline of labor's share [of national income in the U.S.] was the erosion of worker's positional power…"
(Phelan, Link, & Feldman, 2013)	FACT	"An unintended consequence of the genomic revolution may be the reinvigoration of belief in essential racial differences."
(Ryo, 2013)	INTERPRETATION	"The decision to migrate illegally cannot be understood without considering an individual's underlying values and norms."
Steffenmeister et al.	FACT	"Typically, women were not part of [corporate] conspiracy groups."
(Turney & Wildeman, 2013)	INTERPRETATION	"… the collateral consequences of paternal incarceration for family life are complex and countervailing."
(Rijt et al., 2013)	FACT	"Once a person's name is decoupled from the initial event that lent it momentary [fame], self-reinforcing processes, career structures, and commemorative practices perpetuate fame."

Table 6. Kinds of primary knowledge claims made in 10 published papers from ASR.

The majority of *ASR* publications make primary claims of fact based on empirical research. However, two publications seemingly make primary claims of interpretation. *ASR* abstracts presented multiple claims to the reader, which is one way they differed significantly from *Nature* abstracts. While *Nature* abstracts tended to present only the primary knowledge claim, *ASR* abstracts introduced the primary knowledge claim as well

as what might be deemed secondary, supporting claims. For example, from Turney & Wildeman (2013) it is possible to construct the following diagram based on the knowledge claims presented in the abstract:

Secondary (Supporting) Claims	**Primary Knowledge Claim**
"… *we find* recent paternal incarceration sharply diminishes parenting behaviors among residential but not nonresidential fathers."	*"Taken together*, the collateral consequences of paternal incarceration for family life are complex and countervailing."
"… our findings show recent paternal incarceration sharply increases the probability a mother repartners, potentially offsetting some losses from the biological father's lesser involvement while simultaneously leading to greater family complexity."	

Table 7. Secondary/Primary Claim diagram

Not all the *ASR* articles present multiple knowledge claims using language that creates a clear, logical thread, such as the "we find" "furthermore," and "taken together" language in Turney and Wildeman's text. Some presented knowledge claims in a sequence, and I inferred from the order of the claims an implied hierarchy, i.e. that authors *built up* to the primary knowledge claims by listing supporting claims first. I validated such readings by triangulating the inferred primary claim against the body of the text.

I found no discrepancies between the stated primary knowledge claims and the knowledge claims made in the body of the texts in any *ASR* articles. Notably, *ASR* texts include claims of policy far more frequently than *Nature* publications. Perhaps the underlying values of sociology do not accord fully with the notion of "objective research," which seeks only to describe rather than describe and make policy recommendations.

Design Studies

Citation	Type(s)	Primary Knowledge Claim
(Bertoni, 2013)	FACT	"… the use of printouts of color-coded CAD models drive the design teams in a longer discussion about the needs of the solution to be developed, while fostering the use of value-related information to analyze the problem and propose new solutions."
(Cascini, Fantoni, & Montagna, 2013)	CONCEPT / VALUE	"It is possible to properly represent all the tasks and related cognitive processes characterizing the earliest stages of new product development… by situating needs and requirements in the FBS framework."
(Fowler, 2013)	CONCEPT	"… I introduce the notion of soundscape and the terminology used by the interdisciplinary field of soundscape studies."
(Goldschmidt & Rodgers, 2013)*	POLICY	"In open-ended design tasks, and under time constraints, methodological prescriptions should be eased."
(Herriott & Jensen, 2013)*	FACT	"[Student design projects look] like a compromise between the methodical, sequential design process as described by waterfall models and the oft-cited observation that design is more like a disorderly sequence of events concluded only due to a lack of time…"
(Heylighen & Bianchin, 2013)	CONCEPT	"Design is a deliberative enterprise."
(Alcaide-Marzal et al., 2013)*	VALUE / FACT	"2D pencil sketches are more suitable tools that 3D sculpt sketches for conceptual design. Digital sculpting can complement 2D drawings."
(Oak, 2013)*	FACT	"Talk is used in a design meeting to provide evidence, deflect decision-making, and deliver assessments."
(Still & Dark, 2013)*	INTERPRETATION	"Affordances are both perceptually and culturally bound."
(Xenakis & Arnellos, 2013)*	FACT	"Interaction aesthetics are one among other factors in the design process that recommends users to anticipate a successful (or not) interaction through the artifact *thus* enhancing the detection of affordances."

Table 8. Kinds of primary knowledge claims made in 10 published papers from Design Studies. A complete bibliography is available in appendix a. An '*' signifies that these papers make multiple claims of different kinds that are inextricably linked and problematic.

I found that *Design Studies* publications put forth fewer claims of fact than *Nature* and *ASR*. I categorized four standalone claims of fact and one combination of a claim of fact with a claim of value. I applied the same analytical process to this combined claim as I did to the publications from *Nature* or the *ASR* when I was unable to draw a clear distinction between types.

The *Design Studies* texts also yielded the first instances of primary claims of concept, policy, and value. While policy played a role in most of the *ASR* articles, only one article from *Design Studies* appeared to make a primary claim of policy. There seemed to be consistent, explicit distinctions made between primary claims and claims of policy in *ASR* publications, which was a pattern I did not observe in *Design Studies*.

The relationship between stated and actual claims in *Design Studies* is not as consonant as it seems to be in *Nature* and the *ASR*. While I found strong agreement between stated and actual claims in both of the latter publications, I found agreement and divergence between stated and actual claims in *Design Studies*. In some cases, there was no apparent stated claim, and so I had to proceed to the next stage of analysis before identifying a primary claim.

In addition, *Design Studies* publications seemed to eschew a linear, hierarchical reading. In many cases, I was unable to identify the primary claim by following the logical thread of the author's writing. Claims presented in sequence did not necessarily or consistently build on one another. These kinds of "claim sequences" are related in the sense that they are outcomes of a particular research project. However, a reader does not need to accept one on the basis of the others. It is possible to accept one and reject the

others without significant consequences. The same cannot be said of the claim sequences presented in my *ASR* sample. Rejecting one undermines the others.

A third and particularly interesting distinguishing feature of my *Design Studies* sample was the pattern making multiple knowledge claims of different kinds. All publications, regardless of field or approach, make multiple knowledge claims of different kinds. The *Nature* publications in my corpus make claims of fact and claims of concept. And some ASR publications made claims of fact and claims of policy. I am therefore not arguing that the presence of these multiple claims is a unique feature of *Design Studies* publications. However, there are ways to distinguish the practice of making multiple knowledge claims of different kinds in *Design Studies* from *ASR* and *Nature*.

I will now discuss three distinguishing features in greater depth. These include: (1) Some *Design Studies* publications lack a clear division between grounded claims and speculative claims, (2) In some publications, primary claims do not necessarily follow from the reported research findings, and (3) In some publications, foundational claims (e.g. claims on which other key claims rest) are ungrounded and treated as axioms.

In both my *ASR* and *Nature* samples there is a clear division between grounded knowledge claims and speculation. In *Design Studies*, I found instances of knowledge claims of policy that do not necessarily follow from the findings. In one instance, a claim was put forth that

> "*designers or design teams [should periodically] video record meetings and review them with an analyst who understands the structure and performance of natural interaction so that issues that arise within the talk of design meetings may be reflected upon and addressed*" (Oak 2013, p. 51).

But this claim does not follow from the findings presented in the paper.

The paper reports findings on how language functions in design meetings between designers and clients. The findings have potentially interesting implications both for design practitioners and design researchers; especially those researchers seeking to broaden the presence of conversation analysis in the field. And in fact, the aforementioned claim of policy might be better served as a future research project. Is it productive and useful for designers to collaborate with conversation analysts? In this study, I do not claim to have an answer to this question.

In separate paper, Goldschmidt & Rogers report the findings of a study conducted to ascertain whether there are any observable differences in the "design thinking approaches of three different groups [of student designers]" (2013, p. 454). In their discussion, the authors claim "[their] findings converge to show that in open-ended design tasks and under time constraints, methodological prescriptions should be eased" (2013, p. 467). However, they do not provide sufficient grounds to support this claim.

The convergent findings are as follows: (1) undergraduate students all proposed physical object 'solutions', (2) Most participants did not plan or follow a linear process, (3) Between 1/3 and 1/4 of the total time spent on the project was spent on the final presentation, (4) Doctoral students spent much less time on "thinking about solutions and sketching them" than undergrads, (5) The most important source for collecting information was the internet. Why does it follow from these findings that methodological prescriptions for open-ended, time-constrained design tasks should be eased when the authors have not presented findings from a study run with strict methodological prescriptions? I am not challenging the merits of the claim so much as the practice of

making it, which, in my view, does not represent a standard we should strive for in design research.

Finally, in a publication explicating the application of digital sculpting in a product design process, the authors claim that, "[T]he problem of computer aided conceptual design is not the computer, but the way the designers have to work with it" (Alcaide-Marzal et al. 2013, p. 269). This claim appears twice in the paper. First, it appears in the introduction as grounds for the authors' four hypotheses about digital versus analogue tools. Second, it appears later in the paper in slightly modified language. "It may be true [that extra time spent with 3D sketching tools is a hindrance at the conceptual stage of design], but we think the problem is not the tool itself, but the way it is used" (Alcaide-Marzal et al. 2013, p. 278). In other words, the problem is with the way the designers use the tool; the problem is not with the tool itself.

While the authors provide evidence in the form of references to support their claim that different tools yield different processes, they do not ground the claim that this difference is problematic. They speculate as to why this difference *could be construed as* problematic in the conceptual stage of designing (e.g. designers need flexibility and speed, which CAD systems do not provide as well as pencil and paper). But they provide no evidence for their speculations. My agenda here is not to rebut the claim. Instead, it is to point out that a key claim, one on which the main hypotheses of their paper purport to rest, is grounded in speculations that are limited in their perspective of what a design process looks like and in their assessment of what constitutes a "good" process.

Study 7. Reviewing the 'Big Questions' Literature; or, Should HCI Have Big Questions?

Although big questions have been proposed in many other disciplines, as a concept, "big questions" has not been examined in much depth. It may be the case that the notion of big questions is at risk of becoming a kind of mindless slogan for the research communities that invoke them. And so to mitigate the risk invoking a mindless slogan in HCI research, I believe it is necessary to examine big questions in terms of meaning and value as well as in terms of the different ways others have gone about generating them.

Using Google Scholar and the Web of Science, I conducted keyword searches using the term "big questions." I collected texts with "big questions" in the title and texts whose abstract indicated an aim of proposing, developing, or revising big questions. My interest in cultivating a rich, conceptual understanding of big questions meant that I was especially attentive to texts that in some way addressed the meaning and value of big questions or ways of generating them. When I encountered texts that proposed big questions but did not discuss their meaning, value, or generation, e.g. (Fredkin, 2004; Hazell, 2011; McGuire & Agranoff, 2007; Sussman, 2010; Tufekci, 2014; Walvoord, 2008; Wilczek, 2004), I used them mainly as sources of example big questions. There are also several texts in my collection that were not part of my keyword search but instead came through snowball sampling bibliographies. Bibliography mining also resulted in my engaging with texts proposing grand challenges (Shneiderman, 2009; D. F. Sittig et al., 2008; D. Sittig, Kirshner, & Maupome, 2003) and key questions (Carroll, 2000; Elwood, 2008; Hanson, 1998). In the end, I collected and examined 71 texts from a diverse set of research communities that I believe illustrate the core meanings, values, and ways of generating big questions.

Findings

Although many researchers have proposed big questions there have been fewer attempts to define or describe what it means to ask big questions. Big questions may not be as complex as a word like theory, where the uses and meanings can vary significantly. But in my reading I have found that scholars tend to "define" big questions in unique and nuanced ways. I add quotes around "define" to call attention to the fact that in my reading I seldom came across explicit definitions. This means that in many cases I had to infer a definition through scholars' descriptions of the questions they pose.

Some descriptions of big questions are quite ambiguous and thus open to interpretation. For instance, they have been called "questions with no easy answers" (Garber, Silvestri, & Feinberg, 2004, p. 397). Big questions have also been described as questions that call attention to "what we don't know" (Kennedy & Norman, 2005, p. 75), as "[questions that] tend to have big answers" (Botting, 2011, p. 25), and as major questions (Wilczek, 2004). They could also be questions that have "resisted answers for decades" (Barabási, 2011, p. 14) are "intractable" (Ward, Carey, & Westwood, 2002) or questions that are "never really completely answered" (Neumann, 1996, p. 412). One of the more interesting descriptions frames big questions as those questions that "haunt the human evolutionary story" (Mazlish, 1999, p. 232).

Descriptions like these may be useful in the sense that they provoke more questions, such as: who decides whether a question is big? Is it possible to know *a priori* if a question is a major one? Or do we need to determine first that a question has a big answer? How do we know when an answer is big? And what constitutes an easy answer?

Other descriptions of big questions call attention to the timescale and resources required to find answers. I came across questions described as capturing "common goals

[that are] valuable and achievable within a predicted timescale" (Engeström et al., 2010). Such questions are thus called big in the sense that they are relevant to a large group of scholars and are answerable within a large timescale. Other descriptions frame big questions as "[ones] that require significant infrastructure, large experiments, networks of observations, and complex data and computation" (Schimel & Keller, 2015, p. 925). Thus, big questions are questions that require significant time, energy, and other resources in order to achieve answers.

A third set of descriptions emphasizes the relationship between big questions and the institutions for which they are relevant. For instance, they have been described as capturing "remaining major research gaps" (Boxall et al., 2012, p. 1222) in a discipline and as promoting the development of knowledge growth in a field. They have been characterized as demarcating *and* challenging what a field studies (Lohmann, 2007) in the sense that they "they create a boundary between what a [research] project will and will not address" (Schimel & Keller, 2015, p. 928). And they have been portrayed as guides for future research (Perera, 2011; C. Ward, 2013).

Briggs, Butterfield, & Zeilinger (2013) adopt a more prescriptive stance along these same lines when they suggest that big questions ought to "stimulate and guide future research and scholarship" at the level of a discipline or field as opposed to at the level of an individual research project (2013, p. 3). They also describe big questions as compositions of "the collected wisdom [of a discipline] in a form that is both far-reaching and tractable" (Briggs, Butterfield, & Zeilinger, 2013, p. 3).

Big questions have also been described in terms of their impact beyond academic institutions, such as those found in Wisner and Walker (2005), Kincaid and Sternberg (

(2011), and Morton et al. (2009). Salbu, in particular, describes big questions as drawing attention to "some important issues [that are] likely to have an impact on the challenges the world faces in the 21st century" (2000, p. 437).

Some descriptions seem to be intuitively resonant, such as when Mayer describes big questions as "simple, important, and central to many people's lives" (Mayer, 2007, p. 3). While others reveal a polysemy issue in the sense that "[big questions] could refer to macro-level issues or those issues least exhaustively addressed to date or to those issues that are most pressing because they will have the greatest impact [or effect]" (Salbu, 2000, p. 437).

While there is no description that accounts for the nuance I have described, one of the more encompassing descriptions is Donaldson's:

> *"big questions… [are those that] are of interest and importance for a large number of people (over long periods of time)… are of such a nature that answers have the potential for significant and lasting impact… and subsume many other smaller questions"*(Donaldson, 2011, p. 73) .

My purpose in summarizing these different descriptions is not to argue for one over any of the others. Instead, it is to try to provide a richer understanding of the perceived qualities that big questions possess based on an illustrative set of descriptions.

Contextualizing Big Questions

Researchers who write about big questions tend to describe the ways in which they will improve the state of things in a discipline or field. In other words, context matters. For instance, big questions may unify scholarship in a discipline or "impact the challenges the world faces in the 21st century" (Salbu, 2000, p. 437). From these kinds of descriptions, I can infer the current state of things in a discipline. For instance, big questions *characterized as unifiers* may be relevant to a discipline whose knowledge production

appears fragmented and whose aspirations include unification. Understanding the current state of a discipline as described by one or a group of its scholars provides insight into why big questions are perceived to be useful, valuable tools. Providing insight into the current state of a discipline or field may guide speculation about the context(s) in which big questions are deemed to be relevant and valuable. In my review of the big questions literature, I found that scholars tend to characterize their disciplines as (1) fragmented, (2) immature, and/or (3) stagnating.

Fragmentation and Intellectual Disunity

One reason why scholars propose big questions has to do with what they perceive to be a lack (or potential lack) of focus and cohesion within a given scholarly community. Here focus and cohesion are used somewhat interchangeably. They mean that there is *not* broad consensus in a field about what to study, how to study it, and how to evaluate the outcomes of these studies.

Several authors describe the current state of their discipline or field in terms of its lack of unity. This unity captures the current state of existing scholarship as well as the lack of collaborative relationships between scholars. For instance, Rohr describes the literature in administrative ethics in terms of its "chaotic nature" and observes that "we seem to have trouble building on one another's work" (Rohr, 2004, p. 408). Kristensson describes the text entry research community as "scattered across different fields[, which results in] many researchers being unaware of [relevant] progress…" (2013, p. 3316). Similarly, Reardon emphasizes the disunity of scholarly activity (rather than its output) when he describes vocational psychology as a field where "interdisciplinary synergy is sorely missing" (Reardon et al., 2011, p. 242). Hoeksema and Bruna write about how the "surge of varied approaches [to research] in interspecific mutualism has resulted in a

large and potentially confusing literature" (2000, p. 321). And Shneiderman (2009) has more recently characterized scientific communities in HCI as balkanized.

While many scholars write about fragmentation from a first-person perspective, that is, as a member of the fragmented discipline or field, others adopt an external perspective. For instance, Mayer points out how the field of personality psychology is often "viewed as fragmented and specialized" (2007, p. 4). This external perspective emphasizes how fields or disciplines are judged or evaluated by researchers in other academic fields; perhaps ones with greater perceived unity and coherence. It is a perspective that becomes quite important when scholars discuss big questions in terms of their ability to bring about a future state characterized by intellectual prominence and respect. I will discuss issues of prominence and respect (or the lack thereof) in the next section. At this point, I note that when scholars discuss the problematic qualities that motivate big questions, they also discuss the consequences of these qualities. Fragmentation, for example, has consequences for knowledge production in a discipline.

Barabási writes about "the daunting reality of complexity research [being that] the problems it tackles are so diverse that no single theory can satisfy all needs" (2011, p. 15). Fragmentation can also have a negative impact on researchers' ability to find literature that is relevant to their own projects (Kristensson et al., 2013). Peterson et al. point out that the field of biodiversity informatics has been growing "without overarching scientific questions to guide its development," (2010, p. 159). In broad terms, the primary consequence of fragmentation could be an inability to advance knowledge (Lim, Blevis, & Stolterman, 2007) and an undesired ability to "reinvent [wheels]" (DiSalvo, Sengers, & Brynjarsdóttir, 2010, p. 1980).

Cooper (2004) discusses fragmentation as undermining a broader agenda in administrative ethics research, which involves advancing it into the field of public administration. In his words, administrative ethics lacks

> *"anything like a focused effort by groups of scholars to study specific sets of significant research questions in a sustained and systematic fashion… [and that such a focused effort] may be required to provide sustainability, coherence, and sufficient weight to advance it solidly into the core of public administration"* (2004, p. 395).

The negative consequences of fragmentation are treated in depth since they are significant grounds in the argument for big questions. But not all scholars characterize fragmentation *only* in negative terms. Some balance their critique with descriptions that could be interpreted as strengths.

For instance, Cooper describes "an enormous amount of interesting but highly disparate scholarship on administrative ethics reflecting the diverse… interests that capture our attention" (2004, p. 395). Although administrative ethics literature is disparate, it is also interesting and diverse, both of which I believe should be seen as strengths. In what ways do these qualities impact one another? Would the scholarship be as interesting if it were less disparate? Is some disparity a necessary thing in order to cultivate a diverse body of scholarship? And what would be the threshold for too much disparity?

Fragmentation may also be a good thing because it does not seem to "risk narrowing the possibilities of inherently creative discipline" (Ball, 2006, p. 502). At the very least, it seems like some balance may need to be struck between fragmentation and unity since "the biggest breakthroughs… often come from unexpected directions," and that "excessive focus [on big questions or the like] has not been terribly productive for

physics or biology" (Ball, 2006, p. 502). Moreover, as Hoffmann points out, not all researchers in a given discipline will have the "natural philosophical disposition" to work on big questions (Ball, 2006, p. 502), and this is perhaps something that should not be taken for granted.

Low/No Intellectual Status

Another reason why scholars generate big questions has to do with disciplinary status. Status is a broad term that I use here to capture qualities like: immaturity, prestige, or even death. For example, some authors, e.g. Behn (1995), write about how big questions serve as a kind of compass leading towards maturity—where maturity is characterized by deep knowledge of a few core objects of study. In short, status connotes a stable disciplinary identity that is recognized and respected by scholars within and beyond the boundaries of the field.

A notable trend in the literature is to use the word "science" to imply status or indicate the key signifier of a discipline having achieved status or prestige. In other words, scientific disciplines are often framed as having status and prestige whereas nonscientific disciplines are not. For instance, big questions have been proposed in public management in support of scholars of public management aspirations "to make their field a science" since, at least according to Behn (1995, p. 314) what defines a field of inquiry are the questions that it asks.

Similar scientific aspirations appear in international business literature, where Peng citing Toyne argues that consensus about big questions is important "to the extent that [international business] aspires to become a scientific inquiry" (2004, p. 101). Peng further suggests that the very act of discussing and debating big questions has the capacity to unite scholars, "make scientific progress, and enhance the status and prestige

of the field" (2004, p. 101). Note that science most often refers to the "physical and life sciences," which have been more successful in producing "coherent theoretical frameworks that can account for their discoveries" (Watts, 2007, p. 489).

Science as an indicator of status in some cases involves an interesting metaphor where fields or disciplines are described in terms of their maturity. For instance, writing about biodiversity informatics, Peterson et al. describe the potential of big questions to help the field move past "gee-whiz [activities]" and towards a "fundamental science infrastructure" (2010, p. 159). Rogers (2012) has similarly characterized HCI as being in its adolescence, although she did not explore the implications of this characterization for the field's status or prestige. Others who write about big questions and status describe the current state of their field or discipline with words that could be interpreted as characterizations of children or the immature, such as: foolish, naïve, having episodic interests, and ignorance, among others.

There is a notable lack of analysis of the perceived relationship between scientific*ness* and disciplinary maturity, status, or prestige. What is it about *scientific* maturity, status, or prestige that makes it more desirable than, say, philosophical maturity, status, or prestige? Several branches of philosophy have discussed and debated their own big questions (Botting, 2011; Connor, 2006; Korsmeyer, 1998; Van Inwagen & Zimmerman, 2008). And it seems unreasonable to claim that philosophy lacks status or prestige or that it is immature. Although the extent to which philosophy makes progress (Chalmers, 2015) has been questioned.

So far I have described how the words status and "science" are used interchangeably in much of the big questions literature and about how status relates to a

discipline's sense of identity. *Are we a mature discipline or an immature one? Do we have the respect of our peer disciplines? Or not?* But status is also seen as a tool for other purposes.

For instance, Cooper describes administrative ethics as "an interesting but peripheral concern" (2004, p. 395) to public administration and suggests that a scientific focus and progress on core objects of inquiry are necessary to lend the field "sufficient weight to *advance it* solidly into the core of public administration" (2004, p. 395). This sort of focus and progress is described as achievable by having big questions. Ball writes about how chemists cannot be sure that

> "*their discipline will continue to be seen as a core science… [since] many of its most important questions are being framed in terms of the 'chemical' aspects of another discipline, rather than being seen as central to chemistry itself*" (Ball, 2006, p. 500).

This results in academic chemistry "[facing] an uncertain future" (Ball, 2006, p. 500). The nature of the uncertainty could be the closure of university chemistry departments or their absorption by other departments as it becomes harder to distinguish chemistry from synthetic biology, bio-molecular engineering, and others disciplines. Even in Physics, big questions are examined in response to ominous *possible* futures. "We think most physicists would also agree that there are clouds on the horizon that may prove as great a threat to the extrapolated success of twentieth century physics" (Briggs, Butterfield, & Zeilinger, 2013, p. 2).

In these instances, status, cultivated and conferred by big questions, has been framed as a tool to establish or maintain a discipline's relevance, importance, and *existence*. This echoes a sentiment expressed in Hilbert's (1904) classic lecture on mathematics as a field of inquiry. Although he was not discussing status, Hilbert argued

"a lack of problems foreshadows [the] extinction [of inquiry] or the cessation of independent development" (1904, p. 407). Some of the texts in my corpus citing Hilbert interpret problems to mean something like *core* problems or big questions. Fields that lack these kinds of problems have been framed as at risk of becoming "technological initiatives whose utility will forever be in the future… [or]a set of technologies in search of questions to address" (Peterson et al., 2010, p. 159). In addition to more abstract consequences, low or no status has been described in terms of more concrete consequences, such as the ability to secure funding for research.

Many scholars discussing and debating big questions describe the relationship between big questions and status or prestige as a causal one. That is, generating and having big questions will confer status and prestige upon a field. Absent from the literature however are studies examining the validity of this position.

Has administrative ethics (Cooper, 2004; Kirlin, 2001; Neumann, 1996) become more central to public administration? Has biodiversity informatics actually taken steps towards developing a fundamental science infrastructure? Questions like these may be relevant for a field or discipline considering the potential for big questions.

This does not mean HCI research ought to wait and explore such questions before deciding to generate big questions. I see value in having big questions as a tool for reflection on what HCI research studies. In other words, big questions may be a useful tool for intellectual progress regardless of their ability to make the field more cohesive or bring status or prestige.

Intellectual Stagnation

So far I have summarized how scholars characterize the current state of their field(s) as fragmented and as having low or no status or prestige. These characterizations serve as

grounds in the argument for having big questions. There is a third characterization that rounds out the argument, and that is a state of intellectual stagnation or a lack of progress.

I use a broad definition of progress in order to capture the breadth of its use in the big questions literature. It could refer to a discipline's ability to build theory, close existing knowledge gaps and identify new ones, or to have greater impact in the professions. But progress also captures researchers' ability to think (more) effectively or strategically and to cultivate and maintain energy and enthusiasm for research. In short, progress has many different operational definitions in the literature.

In some cases, progress describes knowledge production in a discipline without concern for its application in a profession. Peterson et al. characterize biodiversity informatics as lacking "major, guiding goals that represent intellectual frontiers and challenges" (2010, p. 159). Rudd points out how "targeted, timely research," (2011, p. 477) can reduce key knowledge gaps in conservation policy and management research—gaps that *impede* knowledge advances in the field. Rohr laments how administrative ethics scholars "seem to have trouble building on one another's work" (2004, p. 408). And Hilbert characterized "a lack of problems [as foreshadowing] extinction or the cessation of independent development" (1904, p. 407). Even in HCI, DiSalvo, Sengers, & Brynjarsdóttir (2010) have observed "a need for the field to take stock of what is known and to identify major unknown questions or issues" otherwise our research is at risk of "reinventing the wheel" (2010, p. 1980). Although the authors were not writing about big questions per se, their remark could be interpreted as bolstering an argument for the potential for big questions in HCI.

Others texts reveal an interesting tension between knowledge production and progress. For instance, Watts opines that the social sciences have learned very little about real social processes in spite an "avalanche of publications" (2007, p. 489). Barabási makes a similar statement when he says of complexity science, "We learned a lot, but achieved little" (2011 p. 14). From Barabási I can only infer that learning is necessary but not sufficient criterion for achievement. However, he leaves me with the question of what constitutes achievement and how can big questions help researchers learn a lot *and* achieve a lot?

I have summarized some work that could be said to define achievement as reducing knowledge gaps, building on others' work, and identifying new intellectual pathways and challenges. All of these definitions work to counteract or protect against intellectual stagnation. Other fields characterize stagnation or a lack of progress in terms of an inability to produce applicable knowledge, which, many argue, stems from lack of big questions.

These characterizations range from abstract descriptions of disciplines as "a sterile undertaking with little relation to the world of flesh and blood" (Donaldson, 2011, p. 72) to concrete, high-stakes scenarios in which researchers "are currently faced with three questions that, until answered, will impede the development of a safe and effective AIDS vaccine" (Garber, Silvestri, & Feinberg, 2004, p. 398).

Most scholars who write about progress in terms of practical outcomes occupy a middle ground between these two more extreme positions. For instance, Rudd et al. identified "40 questions that… would advance research that has a high probability of supporting development of effective policies and management strategies..." (2011, p.

477). Fleishman et al. similarly write about how identifying "the most pressing research questions" would positively impact both the amount of policy-relevant research and practitioners' ability to predict the outcomes of different policy implementations (2011, p. 290). In HCI, this way of conceptualizing progress is perhaps most relevant to the theory-practice gap literature (Buie et al., 2013; Dalsgaard & Dindler, 2014; Lowgren, 2001; Rogers, 2012).

Intellectual stagnation means different things to different researchers. However, these different meanings are not mutually exclusive. For instance, the public administration literature includes characterizations of stagnation both in terms of cumulative knowledge building (Cooper, 2004) and impact in the professions (Rohr, 2004). Other discourses do not strike as much of a balance. Most authors call either for intellectual progress or for greater impact in the professions.

Interestingly, there were few authors that seemed to us to operationalize progress in terms of the creativity and energy with which scholars in their disciplines conduct research (Cooper, 2004; Donaldson, 2011). It seems to us that progress is itself an interesting concept for reflection and discussion in HCI. Big questions could be useful tools for framing debates about progress, which brings us to a brief summary of some of the key arguments *against* big questions.

Critiques of Big Questions

There is a lack of arguments against big questions in the literature. Phillip Ball's *Nature* feature, "What Chemists Want to Know," (2006) was the only text in my corpus that included critiques of the big questions concept. Ball argues that big questions can "[narrow] the possibilities of an inherently creative discipline," (2006, p. 502) and suggests that "the biggest breakthroughs often come from unexpected directions" (2006,

p. 502). Ball also quotes Nobel laureate Roald Hoffmann speaking against the concept of big questions on the basis of what seem to be his personal values as a scientist. Hoffmann states that his "disposition is not to work on big questions… [and that he likes working on] many detailed small problems in this wonderful [field], while keeping [his] eyes open for connections" (2006, p. 502).

There may be a nominal amount of critique relative to the amount of praise, yet critique seems imperative both in anticipation of having big questions and in debating and iterating upon them. Critique is something that could be built in to other activities undertaken to generate big questions but it is notably absent in the literature.

Study 8. The Theory-Practice Gap as a Generative Metaphor

The contemporary HCI research landscape is full of proposals and plans for "building bridges" across the theory-practice gap as evidenced by a number of CHI workshops and experience reports, such as (Buie et al., 2010; Detweiler, Pommeranz, & Stark, 2012; Judge et al., 2010; Rosner et al., 2012; Sellen et al., 2014), not to mention notes and full papers (Dalsgaard & Dindler, 2014; Goodman, Stolterman, & Wakkary, 2011; Remy, Gegenbauer, & Huang 2015; Roedl & Stolterman, 2013) and other texts (Höök & Löwgren, 2012; Löwgren, 2013; Rogers, 2012). In many cases the gap is treated as something given: an existing problem out there in the world in need of a solution. I believe it would be useful to examine this perspective by interpreting the gap as a generative metaphor, which has been done in other fields (Gallagher, 2004; Ousey & Gallagher, 2007).

Treating the gap as an obvious, given problem can be seen as problematic since things that appear obvious can be mistaken. "In order to dissolve the obviousness of the

diagnosis [of a gap] and prescription [of bridge-building] in [HCI research], we need to become aware of, and to focus attention upon, generative metaphors which underlie our problem-setting stories" (Schön, 1979, p. 148). My aim is to develop this awareness.

I propose interpreting the theory-practice gap in HCI research as a generative metaphor, which calls attention to the fact that the problem it describes is not given. It is made. This means that the theory-practice problem can be "made" differently, and that different ways of making the problem have implications for the search for solutions. For instance, theory and practice have been described using the metaphor of "uneasy bedfellows" (Obrist et al., 2013, p. 2433), which potentially points towards different questions, research projects, and possible solutions.

In this study, I write an essay using Donald Schön's concept of generative metaphor as an analytical framework to examine the theory-practice gap. I analyze (1) different ways HCI researchers have interpreted the gap, (2) reasons why researchers prioritize some problematic features of the theory-practice relationship and ignore others, (3) reasons why researchers propose certain solutions to the gap problem, and (4) the limitations of what Schön called "the problem-solving perspective" (1979, p. 144) as it manifests in theory-practice gap research.

Findings

Donald Schön coined the term "generative metaphors" to describe metaphors that "[generate] new perceptions, explanations, and inventions" (Schön, 1979, p. 142). In this section, I unpack the concept of generative metaphor, which, according to Schön,

> *"… select for attention a few salient features and relations from what would otherwise be an overwhelmingly complex reality. They give these elements a coherent organization, and they describe what is wrong with the present situation in such a way as to set the direction for its future transformation"* (1979, p. 147).

It might be helpful to unpack this definition using an example from Schön's text: the paintbrush-as-pump metaphor.

Paintbrush-as-pump: Example of Generative Metaphor

Schön described a group of researchers working on developing synthetic paintbrush bristles. The description picks up after the group has already made several failed attempts to create synthetic bristles whose function equals or improves upon natural ones. Part of their approach involves contrasting existing synthetic bristles with natural ones. Noting the differences between the two kinds of bristles yields a list of testable hypotheses that inform several different redesigns. For example, one researcher notes that natural bristles have split ends, so the team designs a synthetic bristle with split ends. But again they meet with failure.

In what seems like a moment of inspiration, another researcher says to the group, "You know, a paintbrush is a kind of pump!" (Schön, 1979, p. 140) Following a brief discussion of pumps and their key features, the team notices different parts of a paintbrush. For example, they see the spaces between bristles as *channels* through which paint flows. And bristles become the means for *pumping* paint through these *channels*.

A new set of questions arises, which focuses the team on the space between the bristles. What is "wrong with the situation," to borrow Schön's language, is now that the channels between the bristles *ineffectively* facilitate the flow of paint. Thus, a new direction is set for the transformation of the synthetic paintbrush bristles.

The paintbrush-as-pump metaphor focused the group on the space between bristles as channels through which paint flows, which, in turn, focused their attention on how bristles behave when they are pressed up against a surface. The researchers noticed

that natural bristles “curve gently” against a surface whereas synthetic ones “formed a shape more nearly an angle” (Schön, 1979, p. 140)

Could this angle actually undermine the flow of paint? The team posed new hypotheses, which we paraphrase here: (1) Varying bristle fibers could increase overall density, which would result in a more gentle curve, and (2) Fibers could be bonded together in a bristle to increase density. New synthetic bristles were created that curved gently when pressed against a surface. And as Schön writes, “Some of these [new bristles produced] a smoother flow of paint” (1979, p. 140)

Borrowing language from Schön’s definition of generative metaphor, the paintbrush-as-pump draws attention to a few features of paintbrushes and their relations. It emphasizes (1) the space between bristles as channels and (2) how pressing bristles against a surface can impede the flow of paint through these channels. Furthermore, the metaphor captures what is wrong with the current iteration of synthetic bristles: they do not curve gently when pressed against a surface and so they impede the flow of paint through the channels between bristles. It also sets the direction for the transformation of this situation: synthetic bristles ought to be made to curve gently when pressed against a surface.

The paintbrush-as-pump is a useful illustration of how a generative metaphor draws attention to a few relevant features of reality and their relations. And it helps clarify how generative metaphors organize these features and relations in a meaningful way. Generative metaphors emphasize not only the problem with the current state of things but also the direction towards possible solutions.

The paintbrush-as-pump also helps us see how making a generative metaphor is what Schön referred to as a "developmental process." The researchers were first able to see "painting as similar to pumping before they were able to say 'similar with respect to what'" (Schön, 1979, p. 142). This means that researchers first saw a strong similarity between paintbrushes and pumps *without* interpreting the spaces between bristles as channels or noticing the relationship between their curvature when pressed against a surface and the flow of paint. The researchers "[developed] an explicit account of their similarity" (Schön, 1979, p. 142) at a later stage, and this account could have gone through several iterations.

Theory-Practice Gap as Generative Metaphor

The theory-practice gap metaphor may have developed in much the same way as the paintbrush-as-pump. HCI researchers may have characterized the theory-practice relationship in terms of a gap even if they were not able to say explicitly why this characterization made sense. And as they worked with the concept they eventually developed more precise ways of explaining the relevance of the metaphor.

For example, in my discussion of related work, I summarize commonly given reasons why theory fails in its aim to serve practitioners. And each of these reasons calls attention to different features of the theory-practice gap and their relations. And once these features and relations are articulated, they can be organized in a meaningful way so as to establish a direction towards possible solutions.

The Gap as a Problem of Communication

From all of the features and relations they could consider, Roedl and Stolterman (2013) notice the relationship between framing and presenting scholarly research and its uptake

by practitioners. They summarize what is wrong with current framing and presentation practices by listing major issues, including tendencies to:

> *"[over-generalize] design situations, [fail to appreciate] the complexity of group decision making, [ignore] the burden of limited time and resources, and [prioritize] design exploration (divergence) rather than synthesis (convergence)"* (Roedl & Stolterman, 2013 p. 1954)

This list establishes directions for transforming the current state of framing and presenting HCI research aimed at supporting practitioners. By analogy, this list is akin to the paintbrush bristles that curve sharply instead of gently when pressed against a surface in that it *points towards* questions about how to achieve effective framing and presentation of research contributions, such as: How can HCI researchers avoid over-generalizing design situations? How can they appreciate the complexity of group decision-making? And how can they attend to the burden of limited time and resources in actual design practice?

The list of issues is a significant part of Roedl and Stolterman's contribution in the sense that it could motivate experiments in scholarly writing in HCI to see if one or another approach to dealing with resource constraints leads to greater uptake of theory by practitioners. In other words, the authors have established several paths towards solutions to the theory-practice gap – all rooted in scholarly writing. Moreover, they have given us some insights into their interpretation of the gap metaphor. They see it as a sort of communication gap.

Shannon's (2001) classic and simple model of communication may help illustrate this point. The model consists of three elements: a sender, a channel, and a receiver. The sender sends a message through a channel to a receiver (Figure 7). For Roedl and

Stolterman (2013), the sender is an HCI researcher, the channel is scholarly publishing, and the receiver is a practitioner.

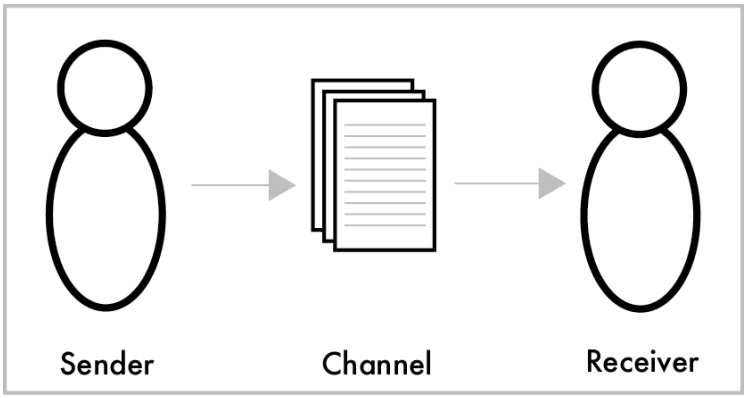

Figure 7. Sender-channel-receiver model of communication

The HCI researcher intends for their message (theory, methods, tools, etc.) to be useful and applicable to practitioners, but practitioners do not see the utility or relevance of the message. Hence, there is a communication gap, which the authors suggest can be addressed by modifying the message. But an important question remains. How will practitioners know that the message has been modified?

Prior to listing the major issues with scholarly publications, Roedl and Stolterman report the outcome of their interview study. Two key insights from this study are: (1) practitioners attend conferences associated with professional organizations like IxDA and UX Week, and (2) they tend to have a negative view of academic conferences like CHI (2013, p. 1954). Several respondents attended past CHI conferences, but, crucially, *none* expressed interest in attending in the future.

Setting the problem in terms of framing and presenting research seems like a useful approach. If the aim of HCI research is to support and improve practice, then authors could benefit from framing and presenting their contributions in ways that promote more effective communication with practitioners. But if practitioners do not

attend academic conferences or read academic publications then effective framing and presentation of research may not make much difference. This does not mean that Roedl and Stolterman are wrong in framing the problem in this way.

Rather, their framing reaffirms a key point from Schön's text. "Problems are not given. They are constructed by human beings in their attempts to make sense of complex and troubling situations" (Schön, 1979, p. 144). Roedl and Stolterman could have framed the problem as one of recruitment – *How do we increase practitioner awareness and attendance at conferences like CHI?* – or one of access – *How can practitioners access academic content stored online behind paywalls?* – but they chose to focus on scholarly writing as opposed to practitioner recruitment or access. Why?

Similar questions apply to other HCI researchers, too. For example, Rogers (2004) is aware that practitioners use some parts of theory but not others. "[Practitioners] are interested in using theory in their work, when they can" (2004, p. 126). However, just as Roedl and Stolterman attend to different features of their findings, Rogers seems to attend more so to practitioners' lack of "a good apprenticeship" to analytic frameworks developed in HCI and "the time, patience, and skill to competently carry out a detailed analysis" (2004, p. 126). It is unclear why Rogers attends to these features of reality and ignores others.

However, it seems common for HCI researchers to construct problems focused on research and/or its output. For example, Goodman, Stolterman, & Wakkary (2011) notice a lack of research with "a theoretical and methodological focus on the day-to-day, lived experience of designers" (2011, p. 1061). Remy, Gegenbauer, & Huang (2015) also focus on expanding a particular type of research: empirical examinations of theoretical

frameworks applied in practice. In addition, they identify ways for HCI researchers to strengthen the framing and presentation of their contributions. Dalsgaard & Dindler propose "bridging concepts," which is an intermediate-level knowledge object existing in "the space between theories and specific design instances" (2014, p. 1637). They – perhaps inspired by predecessors like Höök and Löwgren (2012) – see the gap as a problem of abstraction, which can be corrected by modifying knowledge production practices.

The Gap as a Problem of Abstraction

Dalsgaard & Dindler describe the relationship between theory and practice as follows:

> *"One of the persistent challenges for interaction design researchers and practitioners is that there often seems to be a gap between theory and the specific design instance; by nature, theories are abstract, since they must account for a variety of instances, and thus they can be difficult to translate and operationalize in relation to the particular design situation"* (Dalsgaard & Dindler, 2014, p. 1635).

Abstraction is thus similar to the sharply angled synthetic bristles in Schön's text. Once Dalsgaard and Dindler framed the theory-practice relationship in terms of a gap they and other HCI researchers (Bowers, 2012; Gaver, 2012; Höök & Löwgren, 2012)) noticed that general theories are abstract and that abstraction can make it difficult for design practitioners to see practical utility or applicability.

Consequently, Dalsgaard and Dindler could have explored new questions and possible solutions to this problem. What kinds of methods and tools could assist practitioners in interpreting abstract theories? Why not iterate on solutions deployed in other fields? For example, in medicine there are companies and organizations whose purpose is to translate theory into meaningful, actionable insights for practitioners. Ultimately, Dalsgaard & Dindler proposed "bridging concepts," which builds on an

existing sub-discourse of theory-practice gap literature pertaining to intermediate-level knowledge objects.

Intermediate-level knowledge refers to a type of knowledge that resides between general theory and concrete designs. In their highly cited paper proposing strong concepts, Höök and Löwgren (2012) sketch a diagram (Figure 8) to represent intermediate-level knowledge between theory and practice. This figure may help illustrate how making a generative metaphor is a developmental process.

Figure 8. Reproduction of Intermediate-level Knowledge Space (Höök & Löwgren, 2012, p. 2)

Schön wrote that the researchers in his story were able to say that paintbrushes and pumps were similar before they were able to say *how* they were similar. He also reported that the researchers were only able to develop a concrete account of similarity at a later stage in their process. But we never get the details this development and we know very little about its context. Schön described the researchers as a product-development research team, but did not describe their backgrounds or professional affiliation. And there are no field notes or other data to clarify how the metaphor may have evolved and stabilized. We can only speculate. However, with the theory-practice gap, we can lean a bit on the literature to try and make sense of why, for example, Dalsgaard & Dindler

framed the problem as one of abstraction and why they proposed an intermediate-level knowledge object as a solution.

Research Influences What Scholars Notice

A simple explanation might be that framing the theory-practice gap as a problem of abstraction and proposing an intermediate-level knowledge object as a solution reflects contemporary ways of framing the problem and devising solutions.

Dalsgaard & Dindler are not the first HCI researchers to attend to theoretical abstraction as the dominant problematic feature in the theory-practice relationship. They join several other contemporaneous researchers and groups framing the problem this way.

For instance, Obrist et al. observe "[academic] theories tend to be *abstract* and hard to understand… [which] makes it onerous for practitioners to parse and apply theory…" (2013, p. 2435). Citing Rogers (2004), Roedl and Stolterman describe "results developed by researchers [as] too *abstract*" (2013, p. 1951) to be adopted and used by designers. Goodman, Stolterman, & Wakkary (2011) also cite Rogers in their discussion of abstraction. Buie et al. characterize implications for design that appear in many academic publications as "often very *abstract*, and [thus] the transition to something actionable is too time intensive for many practitioners" (Buie et al., 2013, p. 2494). And there are other examples of HCI researchers engaging in some way with abstraction as a problematic feature of the theory-practice relationship, such as (Bowers, 2012; Gaver, 2012; Höök & Löwgren, 2012; Löwgren, 2013).

My aim here is to illustrate that, by seeing the gap as a problem of abstraction, Dalsgaard & Dindler appear to reflect the contemporary spirit of the theory-practice discourse in HCI research.

In discussing how humans construct problems, Schön illustrated how different ways of characterizing problematic situations move in and out of currency. For example, he pointed out how social policy researchers characterized the so-called urban problem "in the 1950s as 'congestion'; in the 1960s as 'poverty'; and in the 1970s as 'fiscal insolvency')" (Schön, 1979, p. 144). This does not mean that other ways of characterizing problematic situations did not exist in that field. But it does suggest that there are dominant characterizations, and it seems reasonable to suppose that abstraction is a dominant way of characterizing the theory-practice gap in HCI research.

The Problem-Solving Perspective

Many scholars working alongside Dalsgaard & Dindler characterize the problem as one of abstraction. But few of these lean on the sort of evidence that, for example, Roedl and Stolterman (2013), Rogers (2004), and Remy, Gegenbauer, & Huang (2015) provide in their work. This does not mean that these researchers have shown that there is a gap. It might be more accurate to say that they attend to their data with the gap already in mind. But they have at least grounded their interpretation of the theory-practice relationship with evidence. Several texts I read as I worked on this study seemed to treat the theory-practice gap as though it were given, which could be a manifestation of what Schön referred to in his text as the problem-solving perspective.

> *"[The problem-solving perspective] directs our attention, first of all, to the search for solutions. The problems themselves are generally assumed to be given. Thus, it is assumed that we can know or easily voice the problems… but that we cannot yet solve them. The task is to find solutions to known problems"* (Schön, 1979, p. 143).

If the theory-practice gap is a given in HCI research, then perhaps the lack of evidence for its existence in much of the literature makes sense. There is little need to provide evidence for a problem that appears to be given and easily voiced. And when problems

are treated as given, the focus can then shift to the search for solutions. As Schön wrote, "Problem-solving consists in the effort to find means for the achievement of our objectives in the face of constraints that make such achievement difficult" (1979, p. 143). This is what Schön referred to as the instrumentalist position, and it consists of goals, constraints, and means.

For example, Dalsgaard & Dindler's goal is to bridge the theory-practice gap. Their *constraints* include limited time, funding, and perhaps access to practitioners. Their *means* to achieve the goal is to generate knowledge that is more directly applicable to practitioners and designers. And in their case, the means take the form of bridging concepts. Schön also described two key issues related to the problem-solving perspective. One of these issues is that solutions often have unanticipated consequences that can turn into problems themselves.

Unanticipated Consequences Become New Problems

Schön explained how public housing, which was initially framed in the field of social policy research as a solution to the problem of "housing the temporarily poor, came later to be perceived as a concentration of social pathology" (1979, p. 144). This social pathology in turn became a new (unanticipated) problem for the field; one that developed out of a solution to a separate problem. There appear to be similar developments with respect to the theory-practice gap in HCI research.

A subset of HCI researchers have noticed that general theories are abstract and, thus, they "can be difficult to translate and operationalize in relation to the particular design situation" (Dalsgaard & Dindler, 2014, p. 1635). Intermediate-level knowledge objects have been framed as a solution to this problem in the sense that they are less

abstract than general theories, which means they are intended to be more readily translatable to particular design situations.

However, some intermediate-level knowledge objects have come to be seen as impediments to theory development. And, as such, they have become a new kind of problem motivating a new search for solutions. The question has seemingly become: How do we generate knowledge in support of design practice *and* theory development? A possible solution is to design an intermediate-level knowledge object that contributes both to theory and practice. And in fact this is how Dalsgaard & Dindler frame Bridging Concepts:

> *"Bridging concepts are a form of intermediary knowledge distinguished by their ability to facilitate exchange both ways between overarching theory and practice, rather than by being developed from theory or practice or with the specific aim of informing either theory or practice"* (Dalsgaard & Dindler, 2014, p. 1635).

What Dalsgaard & Dindler seemingly reveal in this description is the *conflict* that can arise when researchers choose different ends in response to a particular problem.

For example, following their description of Bridging Concepts as distinguishable by their accountability to theory *and* practice, Dalsgaard & Dindler explain how two other intermediate-level knowledge objects in HCI research, Conceptual Constructs (Stolterman & Wiberg, 2010) and Strong Concepts (Höök & Löwgren, 2012), are *either* accountable to theory *or* practice. The choice between these kinds of intermediate-level knowledge objects is a choice between conflicting ends.

Either a researcher can contribute to theory development (conceptual constructs) or they can contribute to design practice (strong concepts). But they cannot contribute to both, which, as Bridging Concepts makes clear, can *itself* be seen as a problem. Contributing *only* to theory development deprives design practitioners of potentially

useful knowledge, and contributing *only* to design practice deprives theory development and, thus, stunts the growth of HCI's theoretical knowledge base. And here it may be possible to see how these conflicting ends are traceable to problem setting.

Tracing Conflicting Ends Back to Problem-Setting

Schön illustrated the relationship between conflicting ends and problem setting with an example from social policy research. He reproduced verbatim two narratives written about the problem of urban housing. Former Associate Justice of the Supreme Court, William O. Douglas wrote the first narrative "on the constitutionality of the Federal Urban Renewal Program" (Schön, 1979, p. 144). Peggy Gleicher and Mark Fried – researchers working in the social policy field – wrote the second on the basis of their experience studying residents of an urban slum in Boston.

Schön pointed out that both narratives drew upon the same set of facts about the current state of urban slums in America. For example, Gleicher and Fried described some slums as "decadent and impoverished, [whose residents were] victims of cycles of decay" (Schön, 1979, p. 145) and Justice Douglas described slum conditions, such as "overcrowding of dwellings, lack of parks, the lack of adequate streets and alleys… the lack of light and air," (Schön, 1979, p. 145) among other things.

But the narratives present these facts within distinct frames such that particular facts become more or less significant. This is what Schön meant when he wrote, "Things are selected for attention and named in such a way as to fit the frame constructed [by the researchers] for the situation" (Schön, 1979, p. 146).

Generative metaphors motivate these frames. Douglas's frame constructs the slum as a disease that must be purged or cured whereas Gleicher and Fried frame slums as

natural sites in need of preservation. And these distinct ways of framing the problem point to particular solutions.

Justice Douglas described one solution as "[a redesign and rebuilding of] the whole [slum] area, under a balanced and integrated plan" (Schön, 1979, p. 145). The slum is as a diseased body part that must be removed and replaced with a kind of prosthesis that would (by design) protect against future disease. By contrast, given their framing of slums as natural spaces, Gleicher and Fried propose "to reinforce and rehabilitate them, drawing on the forces for 'unslumming' that are already inherent in them" (Schön, 1979, p. 145).

There are two noteworthy observations here. First, these solutions are incompatible; what Schön called conflicting ends. It is impossible to both demolish *and* preserve a slum. Second, these solutions stem from different ways of framing and selecting particular facts from a common set.

Conceptual Constructs and Strong Concepts are similarly incompatible – a point that Dalsgaard & Dindler emphasize in their text: "Stolterman and Wiberg thus differ radically from Höök and Löwgren both in terms of the approach to developing intermediary forms of knowledge and the objectives for doing so..." (2014, p. 1636).

And here there seems to be a key departure from Schön's sample narratives. Both stories seemingly share a *common objective*: solving the problem of urban slums. In my discussion of the theory-practice gap thus far I have used examples that share a common goal: to bridge the theory-practice gap. Without a common problem or goal, to what extent can there be conflicting ends? If Stolterman and Wiberg *and* Höök and Löwgren have distinct goals for developing intermediate-level knowledge objects then in what

sense do Conceptual Constructs conflict with Strong Concepts? In response to this question, framing becomes key.

The Theory-Practice Gap "Makes" Problems

Conceptual Constructs and Strong Concepts can be framed in terms of a shared goal: realizing designs and design activity as legitimate forms of knowledge and knowledge construction in HCI research.

Summarizing the problem using contemporary terminology, I might call it the problem of research through design (RtD) (Bardzell, Bardzell, & Koefoed Hansen, 2015; Bowers, 2012; Gaver, 2012). Bardzell, Bardzell, & Koefoed Hansen summarize the problem as follows, "… in order to legitimize and make use of research through design as research, HCI researchers need to explore and clarify how RtD objects contribute to knowledge" (2015, p. 2093). Clarifying the contribution of RtD objects is a useful way to make sense of the primary *goal* of Conceptual Constructs and Strong Concepts.

Stolterman and Wiberg describe problematic features of research through design presentations in HCI when they write, "In some cases… presentations [of designs of artifacts and systems] do not address, challenge, or complement the existing body of theoretical knowledge within interaction research…" (2010, p. 96). This is both a summary of their perspective on what is wrong with the current state of things and a guide towards possible solutions. For example, one can generate questions about how to forge stronger connections between designs and theoretical knowledge and then explore possible *means* for achieving this *goal*. Stolterman and Wiberg propose Conceptual Constructs as one possible *means*.

Höök and Löwgren explain that part of their aim in proposing Strong Concepts is to "discuss how [intermediate-level knowledge objects] fulfill criteria that we may have

on knowledge, such as being contestable, defensible, and substantive" (2012, p. 1). This is a concise summary of what could be wrong with the current knowledge discourse in design-oriented HCI research; there is an unclear connection between the objects RtD produces and the criteria used to evaluate knowledge contributions in the field. Clarifying the connection could thus be seen as clarifying how RtD objects constitute legitimate knowledge contributions in HCI research.

If the goal is to clarify the contribution of RtD objects, then Conceptual Constructs and Strong Concepts might not be in conflict. For example, Dalsgaard & Dindler point out how it would be possible to "theoretically substantiate" Strong Concepts and/or demonstrate how Conceptual Constructs contribute to practice even if this is not their primary purpose (2014, p. 1637).

Their conflicting ends come into focus when intermediate-level knowledge is framed through the lens of the theory-practice gap (Figure 9). Through this frame it becomes possible to see Conceptual Constructs as an application of design methods, processes, and artifacts in the service of theory development. *And* it becomes possible to see Strong Concepts as an application of these same tools and activities in the service of developing more concrete forms of knowledge for practice.

In other words, the frame constructs the dilemmatic choice between serving *either* theory *or* practice that Dalsgaard & Dindler describe in their text. And they position Bridging Concepts as an integration of these two conflicting perspectives in the sense that it restructures and coordinates them (Schön, 1979, p. 156) with the result being a knowledge object that "is accountable to both practical exemplars, the parameters that

shape the concept (articulations) and theoretical grounding" (Dalsgaard & Dindler, 2014, p. 1637).

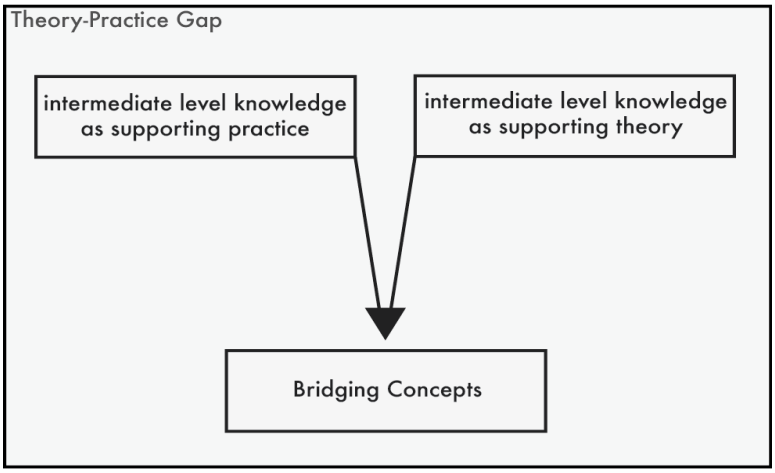

Figure 9. Bridging Concepts as an integration of conflicting perspectives in HCI Research

Framing the theory-practice gap in HCI research as a generative metaphor can itself be understood as an exercise in the use of generative metaphor since it provides a "perspective or frame, a [new] way of looking at things" (Schön, 1979, p. 137).

The paintbrush-as-pump metaphor led researchers in Schön's text to see the spaces between paintbrush bristles as channels through which paint flows, which in turn led them to new observations and new hypotheses about how to develop more effective synthetic bristles. It helped them reset the problem such that they succeeded in producing better synthetic bristles. Has the gap metaphor been similarly helpful to HCI researchers in their quest to produce theory that is used and applied by practitioners?

The gap metaphor has inspired many HCI researchers to analyze the theory-practice relationship, interpret its problematic features, and propose solutions. The extent to which these solutions are effective is unclear.

In some cases this might be because the proposed solutions are relatively new and so researchers have not yet written or published follow-up studies evaluating their

efficacy. For example, Roedl and Stolterman (2013) propose a set of guidelines for improving the framing and presentation of research findings in scholarly communication. But to my knowledge, there have not been any follow-up studies to determine whether this solution works to bridge the theory-practice gap.

One criterion to assess the efficacy of the gap metaphor is the degree to which it has provided the HCI research community with an interesting and inspiring way of seeing its relationship with practice. Many scholars in the field frame the relationship between theory and practice in terms of a gap, and this framing has led to interesting research and insights about what might be undermining efforts to produce practically useful and applicable theory. Could this mean that the value of the gap metaphor is partly in its ability to generate interesting and relevant research *as well as* its ability to generate research that solves the problem it frames? It might. However, I do not want to imply that researchers invoke the gap primarily to contextualize and demonstrate the value of their work *to the research community*.

I believe that there is genuine interest in producing theoretical knowledge that serves the needs of design practitioners, which is why evaluating the success of existing solutions is a relevant and important issue. But it is also possible and worthwhile to reflect on how researchers set the problem, since problem setting has implications for the kinds of solutions they seek. The theory-practice gap metaphor draws attention to the space between theory and practice, and it has consequently guided researchers in thinking about ways to bridge or connect this space. A possible consequence of this framing is that existing connections between theory and practice go largely unexamined.

For example, Rogers (2004) found that design practitioners use the concept of affordances, for instance, but not Gibson's whole ecological framework. And this strikes me as an important insight for HCI researchers interested in developing theory to support practitioners. The gap metaphor could be seen as sensitizing researchers to look for ways in which theory fails to connect with practice rather than ways in which it has already forged successful connections. The goal becomes understanding the qualities of theoretical knowledge objects that have been used and applied by design practitioners.

One possible means of achieving this would be making a case study out of something like affordances. I expect that affordances are not an isolated example of success and that there are other theoretical concepts or elements that have been used and applied in design practice over the years. Furthermore, by drawing researchers' attention to existing connections between theory and practice it may be possible to frame the theory-practice relationship in terms of a different generative metaphor, such as: the theory-practice network.

Generating a different metaphor (or several different metaphors) to frame the theory-practice relationship does not make the gap wrong or obsolete. But such a project may provide new perspectives and inspiration to researchers interested in cultivating a stronger relationship between theory and practice. There are many different kinds of networks (e.g. electrical circuits, natural ecosystems, and reaction networks) and many different ways of visualizing networks. And so there are many ways in which researchers could make sense of the theory-practice relationship as a network. There is a lot of room for developing this as well as other metaphors, such as: the theory-practice continuum, the theory-practice compound, or the theory-practice wave, just to name a few.

Has the gap changed at all? Has it grown wider or narrower? How has the uptake of a theoretical concept like affordances changed over time? Has it maintained its influence? Or has it waned? These are potentially interesting and important questions to contemplate in the service of forging stronger connections between theory and practice.

Reflections

One way to interpret my formative studies is as examinations of discrete but related research questions. In this way, each study can be seen to yield some interesting findings and insights. But it is also possible to see each study as contributing to the conceptual framework that undergirds the work that I did in my final study of best paper winners at CHI, and so in this section my aim is to describe that framework in more detail. In doing so, I hope to reveal some of the key values and assumptions I hold as a research which should position others to make sense of my analytic process and its outcomes.

- Different interpretations of theory may yield different insights about theory use.
- Theory as an object in scholarly publications may have a variety of scientific and *rhetorical* functions.
- Visual models of theory use in research outcomes may be useful for studying theory use and preparing intellectual contributions.
- The problem of theory use is constructed. Hence, it can be reframed.
- How scholars go about studying theory use is an interesting and important topic of study within the HCI research community.

While these eight formative studies did not lead me to recognize the need for the final study, each study contributes something to my personal theoretical framework.

Over the years, surveys of the HCI research have aimed to identify trends or themes in the community (Harrison, Sengers, & Tatar, 2007; Rogers, 2012) as well as

trends or themes that might be conspicuously absent. In one notable recent study (Liu et al., 2014), researchers used co-word analysis to examine two decades' worth of CHI publications and argued that the sample lacks motor themes. Motor themes describe mature research topics that have been the objects of significant collaborative knowledge building efforts in an intellectual community.

Explanations have been put forth as to why HCI lacks motor themes and, perhaps more broadly, why it lacks focus and cohesion (Kostakos, 2015; Oulasvirta & Hornbæk, 2016; Reeves, 2015). And there have also been forward-looking proposals that seek to achieve focus, cohesion, or unity—perhaps with the dual goal of developing motor themes and cultivating a clearer sense of identity as a discipline.

Grudin (2008) has discussed the value of historical studies of the discipline as a tool for unifying research and identifying possible paths for development. Reeves (2015) has proposed interpreting the field as a science, which brings with it host of useful tools for unification (e.g. paradigms). Oulasvirta & Hornbæk (2016) have characterized HCI as a problem-solving discipline. And at CHI2015, there was a workshop organized around the question, "What [should we] study in HCI" (Hornbæk et al., 2015).

Studying theory use could be seen as a useful complement to these efforts. A closer examination of the role and function of theory in research publications could help to (1) establish a more nuanced understanding of theory in HCI research in general and (2) potentially inform the debate around the scientificness of the discipline. In addition, a more nuanced understanding could also motivate novel, general insights about HCI as a research community. Finally, even though it has not been my primary aim, I believe that a closer examination of research publications may yield practical insights for researchers

preparing to compose or review publications. Scholarly publishing in different fields has led to a variety of accepted publication formats. The CHI format is one possible format in HCI. In the next section, I present a study of theory use in Best Paper award winners (n=90) from the past five CHI conferences.

Chapter 5. Study of Theory Use in CHI Best Papers

In this chapter, I present the approach and findings from my final study – an analysis of HCI research publications using the six models of theory use. I used the models as an *a priori* coding scheme and applied them to a set of 90 best paper award winners from the past five CHI conferences 2012-2016. The outcome of this effort is a complete list of the theories, models, and frameworks explicitly mentioned in the best papers along with their role/function. This study explores the questions: *Which theories do the best papers use? What kind(s) of theories are they? How are they used?* Furthermore, it is an attempt to reflect on the utility of the models of theory use and to raise possible connections between different empirical studies of theory use in HCI research.

The Decision to Examine Five Years of CHI Best Papers

In one of my formative studies, I examined a randomly sampled set of CHI publications (n=35) in terms of how they use theory. I viewed this formative study as a step towards clarifying and developing the notion of theory use as an object of study in HCI research and assessing the utility of my models as tools for studying theory use. In this final study I am interested in examining theory use in past Best Paper award winners from the CHI conference. CHI is the flagship conference in HCI research. Entry is highly competitive. In 2016 there were 2300+ submissions, and 23.4% of those submissions were accepted (personal communication from conference organizers). Here is how the CHI 2016 website describes the process of selecting Best Papers:

> *"The SIGCHI 'Best of CHI' awards honor exceptional submissions to SIGCHI sponsored conferences. 69 papers and notes [from CHI 2016] received Honorable Mention… The separate Best Papers committee selected the top 1% of total submissions. 20 Papers and Notes received a Best Paper award…"*

The best papers enjoy prestige in the community and potentially serve as exemplars for researchers aspiring to produce scholarship recognized by the HCI research community for its quality. I believe it is worthwhile to examine how researchers use particular theories and to try and construct a general understanding of theory use in a research community. But I think it is also important to study theory use in publications recognized for their quality and contribution. For instance, is there something different about theory use in best papers? Or do best papers follow patterns of theory use evident in other kinds of publications? To examine theory use in best papers I made the decision to sample five years' worth of best paper winners. I collected and examined 90 best papers from the past five CHI conferences (2012-2016).

Approach

In my previous examination of randomly sampled CHI full papers, I found the models to be useful in their capacity to describe different kinds of theory use in HCI. However, I was quite broad with what I counted as a theory and so in this study of Best Papers I was interested in adopting a more precise approach in line with other studies of theory use. This means that I looked for specific theories, models, or frameworks and any mention of the words 'theory' or 'model' or grammatical derivatives. If an author referred to something as a theory, theoretical underpinning, or theoretical lens, for example, I included it in my analysis. Moreover, if I found a specific theory mentioned in a citation but the name of the theory did not appear in the body of the text I included it in my analysis. This means that I include what others have called subsidiary or circumstantial theory use in my analysis.

Examining explicitly mentioned theories helps me avoid the problem of theory use being seen as a latent projective variable in a publication, which means that "the

target variable [does not] reside on the surface of the content" as much as it might in manifest content or latent pattern variables (Rourke et al., 2001, p. 15). An example of latent pattern variables is the coding of arguments. Presence of one property of an argument (e.g. a claim) "sensitizes coders to the possibility that a message could be coded as an argument" (Rourke et al., 2001, p. 15) but they must corroborate this initial recognition with other elements of an argument, such as grounds or warrant. Latent projective variables are different in that they rely much more so on interpretation.

Examining explicit theory use addresses this over-reliance on interpretation, but it is not without its limitations. For instance, two of my framing assumptions are that (1) all research is theory-laden and (2) theory means different things to different researchers. This means that although a given publication may not name or reference any theories, models, or frameworks, it still makes use of theory in some capacity. Moreover, authors that do not cite or refer to theories *per se* may still see their work in terms of theory use. For example, Gaver (2012) frames a set of normative design principles as theory. Gaver's publication was not part of my corpus, but it would be important to account for his work in a study of theory use in HCI research publications.

I conducted my analysis in two stages. In the first stage, I went through each of the 90 best papers (2012-2016) identifying explicit mentions of the words of theory, model, or framework as well as any grammatical derivatives thereof (e.g. theoretical, modeling, etc.). I included all parts of a text in this exercise – the title, abstract, body, and bibliography. Then, I distinguished generic uses of these words from specific references to theory or *a* theory. For example, I excluded text in which an author refers to the theoretical implications of their work but does not name a specific theory or family of

thought. However, if an author referenced theoretical implications and then discussed implications for behavioral theory, critical theory, or specific theories within these families of thought then I included their work in my analysis.

I did not look for particular theories (e.g. activity theory) or particular kinds of theory (e.g. behavioral theory or sociological theory), and I attempted to maintain a broad understanding of what could be construed as theory. The outcome of this stage is a list of 128 explicit mentions of theories, models, or frameworks, which I summarize in the next section of this chapter. Irrespective of how many times a theory appeared in the corpus it appears only once on this list. For example, Bardzell & Bardzell (2013) mention critical theory over 300 time, but critical theory appears only once on the list of 128 theories. In the second stage of analysis, I used my six models of theory use as an exclusive coding scheme to interpret each theory, model, or framework. I present the outcome of this coding exercise in the following section.

Findings

In this section, I summarize which theories appear in 90 best papers (2012-2016) and provide sample quotes to illustrate my coding. I distinguish existing theories from new theories. A new theory could either be (1) a theory, model, or framework proposed *for the first time* to explain or describe a phenomenon or (2) an extension or revision of an existing theory. Distinguishing between new and existing theories serves a subsequent discussion about the possibility of identifying the unique qualities of HCI theories. The breakdown of different types of theory use in this study (Table 9) is consistent with my previous studies.

Type of Theory Use	Total Number Coded
Object of Study	46
Shaping Tool	0
Contextual Tool	47
Analytical Tool	12
Methodological Tool	23
No Theory	7

Table 9. Total number of codes applied to 90 CHI best papers (2012-2016)

Theory is most often used as an object of study or as a contextual tool. It is less frequently used as an analytical or methodological tool. And I found no instances of theory as a shaping tool, which could mean that this model may not be a useful representation of theory use in its current state. Finally, I coded seven instances of 'No Theory' across 90 best papers, which is a departure from previous studies. This study marks the first time I used the 'No Theory' model to categorize scholarly publications in HCI research.

Explicitly Mentioned Theory in the 2016 Best Papers

Specific Theories	Proposed (New) Theories
1. Model of Interruption	1. Model of User Burden
2. Information Foraging Theory	2. Modified Reuse Model
3. Optimal Foraging Theory	3. Color Perception Model
4. Fitts Law	4. PACE Model
5. User Interface Model	5. Gaze Model
6. Baddeley's Working Memory Model	6. Learner Cognitive Workload
7. Cognitive Load Theory	7. Partially Understood Input
8. Weave's Scripting Framework	8. Probabilistic Model of Tag State
9. Adolescent Resilience Framework	9. Theory of Variable Foraging
10. Family Systems Theory	10. Probabilistic framework for analyzing RFID.
11. Technology Acceptance Model	
12. Value-based Adoption Model	
13. Thick Description	
14. Eudemonia	
15. Hochschild's Theory of Emotions	
16. Grounded Theory	
17. Sustainability Framework	
18. Touch Input Framework	
19. Uncertain Input Framework	
20. Time-based UX Framework	
21. Reality-based Interaction	
22. Cross-divide Interaction	

Coding with the Models

Object of Study: 12 (including new proposed theories)
Shaping tool: 0
Contextual tool: 13 (includes unknowns)
Analytical tool: 3
Methodological tool: 4 (two with an asterisk)
No theory: 0

Theory	Quote	Use
Model of Interruption	*"Borst and colleagues [7] presented a **model of interruptions** with the explicit aim of reconciling earlier findings through an integrated theory."*	**Contextual**
Information Foraging Theory	*"We propose a refinement of **IFT** as a theory of variation foraging, modified to account for how people "forage" through variants…"*	**Object of study**
Optimal Foraging Theory	*"Information foraging theory (IFT), developed by Pirolli and Card [39] has been used to understand how humans search for information, and is*	**Contextual**

	*based on **optimal foraging theory**."*	
Fitts' Law	*"... problem-solving capacity can be applied to whole sub-topics also, to assess them and see opportunities to improve. Let us discuss **Fitts' law** as an example."*	**Contextual**
User Interface Model	*"A more specific sub-set of computer applications used in teaching is covered by the term intelligent tutoring systems (ITS). These systems are delineated by having knowledge of: (a) the domain by having the expert model for the subject, (b)... or (d) **user interface model** to tie all models together [33, 32].*	**Contextual**
Working Memory Model	*"The fundamental idea behind both **Baddeley's working memory model** [39] and CLT [46] is that cognitive workload is limited in its capacity to handle information."*	**Contextual**
Cognitive Load Theory	*"We now discuss the foundations of **cognitive load theory** and how this fits into our system."*	**Methodological**
Weave's Scripting Framework	*"DemoScript helps developers author and test a cross-device interaction script using interactive illustrations. It automatically analyzes a script as it is entered or modified by a developer, based on a cross-device UI framework—in our current implementation, we use the **Weave framework** proposed previously [7]."*	**Methodological**
Adolescent Resilience Theory	*"We ground this study in two theoretical frameworks that support our goals: 1) the **adolescent resilience framework** [34] and 2) family systems theory [4]. The theoretical framework of adolescent resilience was derived and validated by researchers in developmental psychology [34]."*	**Analytical**
Family Systems Theory	*"We also draw from **family systems theory** [4], which motivated the*	**Methodological**

	design of our study."	
Technology Acceptance Model	*"In addition, human behavior and decision-making theories such as the* ***Technology Acceptance Model (TAM)*** *and the Value-based Adoption Model (V AM) help us understand the behavioral aspects of technology adoption."*	**Contextual**
Value-based Adoption Model	*"In addition, human behavior and decision-making theories such as the Technology Acceptance Model (TAM) and the* ***Value-based Adoption Model (VAM)*** *help us understand the behavioral aspects of technology adoption."*	**Contextual**
Thick Description	*"Additionally, one researcher logged observations to allow us to follow an adapted version of* ***Thick Description [10]*** *where we collated observations and audio records into one document to facilitate a deeper understanding of how participants engaged with the games, and enable us to relate players' experiences to contextual factors."*	**Methodological**
Eudaimonia	*"…the present study therefore explored whether – and if so, in what ways hedonic and eudaimonic user experiences differ. We do so by first outlining the* ***theoretical content and promise of eudaimonia*** *in UX research. We then provide empirical evidence that eudaimonic experiences differ from hedonic ones in terms of ratings and content, introducing eudaimonia and its correlates…"*	**Object of study**
Hochschild's Theory of Emotions	*"For instance, Menking and Erickson [33] studied the work of women on Wikipedia, noting how 'Wikipedia's gender gap may relate to prevailing feeling rules or participation strategies; at the same time this work contributes to advancing* ***Hochschild's theory of emotions*** *work [...]' (p. 208). Some papers also*	**Contextual**

	describe implications for research methodology [4] and modeling [7,51].”	
Grounded Theory	*“We analyzed video and transcripts using a **grounded theory** approach [7] in order to reveal common associations and themes that shaped perceptions and envisioned uses of Ebb.”*	**Analytical**
Sustainability Framework	*“It is interesting to note that a **sustainability framework** developed based on literature study and expert interviews provides thorough coverage of device issues but no mention of broader infrastructure issues [12].”*	**Contextual**
Uncertain Input Framework	“Schwarz et al. proposed methods [31], frameworks [30], and an architecture [32] to handle **uncertain input** techniques…”	**Contextual**
Time-based UX Framework	*“… while hedonic quality stimulation (HQS) was related to eudaimonia and hedonia to similar degrees, hedonic quality identification (HQI) was more strongly correlated with eudaimonia. The relation between HQS and hedonia, as well as the comparably low ratings of future importance are in line with the findings of Karapanos et al. **[23]**, who found the importance of HQS to fade over time.”*	**Analytical**
Reality-based Interaction	“Such manipulation in a UI focuses on employing knowledge of the physical world to interact with the digital one **[19]**.”	**Contextual**
Shared User Modeling Framework	*“In another invention, Montague et al. introduced the **Shared User Modeling Framework** [25], an adaptive framework that aimed to improve touch accessibility across devices and applications.”*	**Contextual**

Explicitly Mentioned Theory in the 2015 Best Papers

Existing Theory	Proposed (New) Theories
1. Two Theories of Home Heat Control 2. BerkeleyLM 3. Social Learning Theory 4. Role theory 5. Theory of Social Comparison Processes 6. Renewable Energy Source Modeling and Forecasting 7. Nu-Support Vector Regression Model 8. Affordance 9. Animated Objects 10. Haptic Actuation 11. Memory for Goals Theory 12. GOMS modeling 13. Grounded Theory 14. Theory of Communicative Action 15. Computational Model of Color Perception and Color Naming 16. Cultivation Theory 17. Protective Model of Adolescent Resilience 18. Social Cognitive Theory 19. Protection Motivation Theory 20. Social Translucence Theory 21. Item Response Theory	1. (Our) language model 2. The LemonAid Framework 3. Memory-for-Problem-States 4. Stereotype Model 5. Reality Model 6. Balance Model 7. Theoretical Model of Adolescent Resilience

Coding with the Models

Object of Study: 9 (7 are proposed new theories)
Shaping Tool: 0
Contextual Tool: 10
Analytical Tool: 4
Methodological Tool: 5
No Theory: 0

Theory	Quote	Use
Two theories of Home Heat Control	*"Consistent with **theories about the construction of mental models** [7, **21**], we believe these participants extended their knowledge from a known domain (Facebook page/group) into an unknown domain (personal profile) and used the analogy between these two domains to infer the algorithm's existence in their personal profiles."*	**Analytical**

BerkeleyLM	*"We used **BerkeleyLM** [18] for language model probability lookups."*	**Methodological**
Social Learning Theory	*"Both mothers and fathers develop skills "on the job" [27] and they learn about parenting from the people around them, through their own experiences as children, and through social learning processes by observing other parents **[6]**."*	**Contextual**
Role Theory	*"Schemas can refer to stereotypes about how people behave (e.g., mothers stay home to raise children), scripts that contain a set of expectations about what will happen (e.g., parents will take their children to a restaurant and order from a children's menu), social roles (e.g., mothers feel that they should stay home to raise a child), or worldviews (e.g., families where a parent stays home to raise the child will do better at raising their children) [**8**,19,38]."*	**Contextual**
Theory of Social Comparison Processes	*"Both of these examples counter traditional norms and expectations of family life; developing search schemas for finding support might expose fathers to other fathers' struggles, validating their experiences through positive social comparisons **[15]**."*	**Analytical**
Renewable Energy Sources Modeling	*Extending weather prediction to forecast the availability of renewable energy has also been a focus of prior work [**14**, 19]—and indeed is fundamental to energy markets for balancing supply against demand.*	**Contextual**
Affordance	*"The work proposed builds on*	**Object of Study**

	*the theoretical foundations of **affordance**, animated objects, and haptic actuation of users."*	
Animated Objects	*"The work proposed builds on the theoretical foundations of affordance, **animated objects**, and haptic actuation of users."*	**Methodological**
Haptic Actuation	*"The work proposed builds on the theoretical foundations of affordance, animated objects, and **haptic actuation of users**."*	**Methodological**
Memory for Goals Theory	*"One proposal for such a theory is Altmann & Trafton's **Memory for Goals theory** [2]… In the current paper we will extend memory-for-goals – and its explanatory power – by not focusing on task goals per se, but on the contents of the problem state associated with each task."*	**Object of study**
GOMS Modeling	*"Likewise, Iqbal et al. interrupted subjects either at high or at low workload moments (determined by measuring pupil dilation [24] or by **GOMS modeling** [26]). These studies confirmed that users take less time to resume a task when interrupted at low-workload moments [25,26] (see [32] for an additional example)."*	**Contextual**
Theory of Communicative Action	*According to Habermas [**15,** 16], deliberative democracy can only exist in the public sphere, which he described as "a domain of our social life in which such a thing as public opinion can be formed".*	**Contextual**
Computational Model of Color Perception and Naming (ref)	*There have also been attempts to automatically decompose colour spaces [**15**, 22, 1] into named regions, with applications in automatic image description [17, **18**].*	**Contextual**

Cultivation Theory	*(1) "**Cultivation theory** predicts that television's portrayal of the world affects people's beliefs about reality [10,31]… **[It]** has also been found to predict how people perceive risks after experiencing them in a video game [37], and playing a sexualized female character reduces female players' feelings of self-efficacy [3]."*	**Analytical**
Protective Model of Adolescent Resilience	*"We designed our study around **a theoretical framework of adolescent resilience** that was derived and validated by researchers in developmental psychology [**34**]."*	**Methodological**
Social Cognitive Theory	*"Research that has used **Social Cognitive Theory** and Protection Motivation Theory to study adolescent online behaviors provides theoretical support for the effects of resilience on risk protection."*	**Contextual**
Protection Motivation Theory	*"Research that has used Social Cognitive Theory and **Protection Motivation Theory** to study adolescent online behaviors provides theoretical support for the effects of resilience on risk protection."*	**Contextual**
Social Translucence Theory	*"Thus, we support Yardi and Bruckman' s [40] earlier proposal to use **social translucence theory** for implementing a semi-transparent "digital window" that facilitates visibility, awareness, and accountability between parents and teens. Yet, we extend this idea by encouraging designers to also give teens access to view their own digital footprints in order to form self-awareness of their potentially risky online behaviors and patterns."*	**Analytical**

Item Response Theory	*"The **construct** has been validated and widely used in social and behavioral psychology research [**13**, 36]."*	**Contextual**
Protective Model of Resilience	*"Figure 1 illustrates the generalized theory summarizing the **protective model of adolescent resilience** [34]. In the following sections, we introduce the salient constructs of our theoretical model for online risk exposure as they map to the adolescent resilience framework [34]."*	**Contextual**

Explicitly Mentioned Theory in the 2014 Best Papers

Existing Theory	Proposed (New) Theories
1. Foreground-Background Frameworks 2. Model of Open Innovation 3. Product Ecology Framework 4. Social Ecology Theory 5. Technology Acceptance Model (TAM) 6. Duality of Technology 7. Model of Adaptive Thermal Comfort 8. Hidden Markov Models 9. RDF Framework 10. Self-Regulation Theory 11. Social Cognitive Theory 12. Value Sensitive Design 13. Attention Investment Theory *14. Fitts Law* *15. Active Vision* *16. The EPIC Model* *17. GOMS* *18. The GLEAN Model* *19. MHP* *20. NGOMSL* *21. GOMSL* 22. Social signaling theory	1. A biomechanical model of the arm* 2. Model of the Value of Social Networking Attn. and Effort 3. Logistic Regression Model of Friendsourcing 4. Cognitive models of a visual search task 5. Model of Tie Strength / Site Use

Coding with the Models
Object of Study: 6 (5 of which are proposals of new theories)
Shaping Tool: 0
Contextual Tool: 10
Analytical Tool: 4
Methodological Tool: 7
No theory: 0

Theory	Quote	Use
Foreground-Background Frameworks	*"We construct a design space (Table 1) based on Falk's research on conversational linguistics [9], and Buxton's [5] and Hinckley et al.'s [14]* ***'foreground-background' frameworks."***	**Methodological**
Model of Open Innovation	*"In doing so, they introduce a* ***model of open innovation*** *not*	**Contextual**

	dissimilar from earlier generations of open source software developers."	
Product Ecology Framework	*"We then report users' initial experiences upon acquiring a Nest by re- analyzing the data originally collected for [23] from the perspective of the* ***Product Ecology Framework*** *[4]. The Product Ecology Framework allows us to more easily see changes in consumers' perception of and interaction with a novel product like the Nest, and to tease out different threads that impact the user experience."*	**Analytical**
Social Ecology Theory	*"The Product Ecology is a theoretical framework that describes social product use [4]. It is informed by* ***social ecology theory****, which is broadly concerned with the dynamic relationship between an individual and the physical and social environment."*	**Contextual**
Tech Acceptance Model	*"Numerous approaches exist for understanding how and why technological products are acquired, adopted, and used. Models such as the* ***Technology Acceptance Model*** *[22] and Orlikowski's duality of technology [16] help explain how particular features of a product or system."*	**Contextual**
Duality of Technology	*"Numerous approaches exist for understanding how and why technological products are acquired, adopted, and used. Models such as the Technology Acceptance Model [22] and Orlikowski's* ***duality of technology*** *[16] help explain how particular features of a product or system."*	**Contextual**
Model of Adaptive Thermal	*"... we are not engaging critiques*	**Contextual**

Comfort	*of the cultural construction of thermal comfort (e.g., [1]) or **models of adaptive thermal comfort** (e.g., [2]) that suggest that people can or should attain comfort through other means than mechanical heating and cooling…"*	
Hidden Markov Models	***"Hidden Markov Models** (HMMs) [26] or Support Vector Machines (SVMs) [2] are not easily applicable to classification of such motion signals."*	**Contextual**
RDF Framework	"Our main contributions can be summarized as follows: 1) a new motion sensing keyboard prototype which for the first time demonstrates both touch and hover gestures; 2) a new gesture recognition engine for robustly identifying both static and temporal gestures using a single motion signature and **RDF framework**;…"	**Methodological**
Self-Regulation Theory	*"**Self-Regulation Theory** [2] provides a framework to understand the process of how individuals use contextual information to make decisions and follow through on intentions for behavior change… (p. 2260) **Self-regulation theory** predicts that highlighting the discrepancy between the current and goal state can increase motivation. (p. 2267)"*	**Analytical**
Social Cognitive Theory	"According to **Social Cognitive Theory** (SCT), high self- efficacy is one of the most powerful predictors of behavior change, even more powerful than demographics, personal/ environmental factors, and barriers [3]."	**Analytical**
Value Sensitive Design	*"In many ways our approach echoes and is inspired by*	**Methodological**

	*Friedman and colleagues' concerns for **Value Sensitive Design (VSD)** [5, 10]."*	
Attention Investment Theory	*"Because we did not request or require that participants use the structuring supports, we were able to investigate whether their own sense of the usefulness of structuring would outweigh the time and mental effort cost of structuring (according to **Attention Investment Theory** [6], people will not invest attention in activities unless they think the benefits will outweigh the costs)."*	**Analytical**
Fitts' Law	*"The modeling work presented here, partially reported previously in [16], goes beyond previous cognitive modeling of icon search (such as [7]) by incorporating a more advanced simulation of visual perception and ocular motor processing, and stands in contrast with mathematical modeling of human performance (such as [5]) in which empirically-derived relationships such as **Fitts' Law** are used to explain features of performance data without reference to the underlying cognitive architecture mechanisms in the human user"*	**Contextual**
Active Vision	*"This paper presents recent advances in cognitive modeling which permit increasingly realistic and accurate predictions for visual human-computer interaction tasks such as icon search by incorporating an "**active vision**" approach which emphasizes eye movements to visual features based on the availability of features in relationship to the point of gaze."*	**Methodological**
The EPIC Model	*Constructing an **EPIC model** for the Williams task required a choice of (1) visual acuity*	**Object of study**

	parameters, (2) a parameter for the decay time of visual properties in the perceptual store that are no longer sensorily supported, and (3) a set of production rules that implement the visual search strategy.	
GOMS	*"A **GOMS model** of the Williams task was implemented using the GLEAN cognitive modeling system [21]."*	**Methodological**
The Glean Model	*"A GOMS model of the Williams task was implemented using the **GLEAN cognitive modeling system** [21]. GLEAN is a simulation environment similar to EPIC"*	**Methodological**
MHP	*"GLEAN is a simulation environment similar to EPIC, but with a much simpler cognitive architecture directly inspired by the Card, Moran, and Newell [4] **Model Human Processor"***	**Contextual**
NGOMSL	*"…and whose cognitive processor is directly programmed in terms of procedural GOMS models using GOMSL, a formalized version of the earlier **NGOMSL** notation…"*	**Contextual**
GOMSL	*"and whose cognitive processor is directly programmed in terms of procedural GOMS models using **GOMSL**, a formalized version of the earlier NGOMSL notation…"*	**Methodological**
Social signaling theory	*"**Social signaling theory** suggests that because the lengthier message "costs more" recipients are more likely to use it as a reliable signal of relationship worth [30,37]."*	**Contextual**

Explicitly Mentioned Theory in the 2013 Best Papers

Existing Theory	Proposed (New) Theories
1. Goffman's theatrical metaphor 2. Hogan's exhibition approach 3. Infinite Monkey Theorem 4. Panopticon 5. The AMT Model 6. Game-theoretic model of crowdsourcing systems 7. Theories of Social Change 8. Meter-based charging model 9. Solli and Lenz's Color Subjective Response Model 10. Ou et al,'s Model of Color Subjective Response 11. Valdez and Mehrabian's 3-Part Model 12. Critical theory 13. Transtheoretical model of behavior change 14. Behavioral Theory 15. Social Cognitive Theory 16. The health belief model 17. Self-efficacy theory 18. Theory of planned behavior 19. Self-determination theory 20. Goal-setting theory 21. Goffman's theory of presentation of self 22. Theory of sensemaking	1. New mixed effects models 2. Dynamic energy model (67) 3. Static Model of Perception Area 4. Dynamic Model of Perception 5. Extended Model of non-CVD subjective responses to CVD

Coding with Models

Object of Study: 14 (including the five new proposals)
Shaping Tool: 0
Contextual Tool: 5
Analytical Tool: 1
Methodological Tool: 5
No theory: 0

Theory	Quote	Use
Goffman's Theatrical Metaphor	*"Our study applied both* ***Goffman's [7] theatrical*** *and Hogan's [11] exhibition metaphor for examining the actions that users take for managing social media data over time."*	**Methodological**
Hogan's Exhibition Approach	*"Our study applied both Goffman's [7] theatrical and* ***Hogan's [11] exhibition metaphor*** *for examining the*	**Methodological**

	actions that users take for managing social media data over time."	
Infinite Monkey Theorem	*"The four topics we selected were the 1896 Olympics (easy; Example (1a)), the flag of Japan (easy), Schizophrenia (hard), and the* ***infinite monkey theorem*** *(hard; Example (1b))…"*	**Contextual**
Panopticon	*"Turkopticon is named for* ***panopticon****, a prison surveillance design most famously analyzed by Foucault. The prison is round with a guard tower in the center. The tower does not reveal whether the guard is present, so prisoners must assume they could be monitored at any moment. The possibility of surveillance, the* ***theory*** *goes, induces prisoners to discipline themselves."*	**Methodological**
The AMT Model	*"Because the* ***AMT model*** *often has workers doing HITs from a large number of employers in a session, we needed to offer workers a quick way to assess employers."*	**Contextual**
Game-theoretic model of crowdsourcing systems	*"The effect of this overhead can be better understood using a* ***game theoretic model*** *of crowdsourcing systems (Ho et. al [11])."*	**Analytical**
Theory of Social Change	*"There is a growing call within HCI to be sensitive to the broader social context* ***[19]*** *and more aware of existing energy research."*	**Contextual**
Meter-based charging model	***"Meter-based energy charging model.*** *We highlighted that the current model requires the energy supplier to send a representative to the user's home to read the meter (Figure 2)."*	**Contextual**

Solli & Lenz's Color Subjective Response Model	*"As Ou et al's [21] and Solli and Lenz's [23] models are the most recently-published colour subjective response models – and they use the CIE L*a*b* colour space, which is commonly used in recoloring tools – we employed them in the development of SPRWeb."*	**Methodological**
Ou et al.'s Model of Color Subjective Response	*"As Ou et al's [21] and Solli and Lenz's [23] models are the most recently-published colour subjective response models – and they use the CIE L*a*b* colour space, which is commonly used in recoloring tools – we employed them in the development of SPRWeb."*	**Methodological**
Valdez and Mehrabian's 3-Part Model	*"Valdez and Mehrabian [25] developed a three-part model that relates the plea- sure, arousal, and dominance of a colour to its hue, brightness and saturation."*	**Contextual**
Critical theory	*"We seek to give a sense of* ***critical theory as a holistic or synoptic framework for thought****, rather than a collection of unclearly related concepts (as they are often presented in HCI). The categories we will briefly sketch are predispositions, methods, theories and concepts, general cultural benefits, and what they offer critical design…" (p. 3301)*	**Object of Study**
Transtheoretical Model of Behavior Change	*"For example, He and Greenberg [32] used the* ***transtheoretical model*** *of behavior change as an organizing framework for persuasive eco-feedback design."*	**Object of Study**
Behavioral Theory	*"…We define core theoretical terms to create shared understanding about what theory is, discuss ways in which* ***behavioral theory*** *can be used to*	**Object of Study**

	*inform research on behavior change technologies, identify shortcomings in current **behavioral theories**, and outline ways in which HCI researchers can not only interpret and utilize **behavioral science theories** but also contribute to improving them."*	
Social Cognitive Theory	*"... we also borrow from other terms from behavioral science including: constructs, which are the fundamental components or "building blocks" of a behavioral theory, (e.g., two key constructs from **social cognitive theory** are self-efficacy and outcome expectations [5])"*	**Contextual**
The health belief model	*"One common distinction, for instance, is between behavioral theories that describe determinants of behavior (e.g., the **health belief model** [8]) versus the process of change (e.g., transtheoretical model [59]; see [66] for a discussion on this distinction)."*	**Object of Study**
Self-efficacy Theory	*"Conceptual frameworks encompass several commonly used theories including the transtheoretical model [59], **self-efficacy theory** [5], theory of planned behavior [2], health belief model [8], and self-determination theory [18]."*	**Object of Study**
Theory of planned behavior	*"Some theories focus on one behavior (e.g., smoking), others describe the specific process (e.g., relapse prevention), and still others describe dynamics between behaviors and other constructs (e.g., **theory of planned behavior** [2])"*	**Object of Study**
Self-determination theory	*"Conceptual frameworks encompass several commonly used theories including the transtheoretical model [59], self-*	**Object of Study**

	efficacy theory [5], theory of planned behavior [2], health belief model [8], and ***self-determination theory*** *[18]."*	
Goal-setting Theory	*"For example,* ***goal-setting theory*** *[47] describes the effect of different types of goals on performance, enabling HCI researchers to implement effective goals in their interventions (see, for instance, [13])."*	**Object of Study**
Goffman's Theory of Presentation of Self	*"... and a stylized display of performance, based on* ***Goffman's theory of presentation of self*** *in everyday life [31]."*	**Object of Study**
Theory of Sensemaking	*"Mamykina and colleagues [49] drew upon the construct of breakdown from the* ***theory of sensemaking*** *[19] to design MAHI, an application for patients with diabetes that supports reflection and problem-solving. The* ***theory of sensemaking*** *postulates that individuals constantly engage in drafting and redrafting of a story to understand their experiences."*	**Contextual**

Explicitly Mentioned Theory in the 2012 Best Papers

Specific Theories	Proposed (New) Theories
1. Search, Decision, Pointing (SDP) Model 2. Fitts' Law 3. Predictive Model of Human Performance with Scrolling/Hierarchical Lists 4. Predictive Model of Menu Performance 5. Gibson's Theory of Affordance 6. Gibson's Conceptual Framework 7. Ecological Theory of Perception 8. Activity Theory 9. Framework for Viewing Digital Information 10. Tangible Interaction Framework 11. Phenomenology 12. Ecological Psychology 13. Reducing the Error Offset Model	1. Two-facet Model of Instrumental Affordances 2. A framework for rhythmic interaction 3. Ethical framework for uncomfortable interactions

Coding with the Models

Object of Study: 5 (incl. new proposals not listed in the following table)
Shaping: 0
Contextual: 8
Analytical: 0
Methodological: 2
No Theory: 0

Theory	Quote	Use
SDP Model	*"To formalise our analysis of the relative merits of CommandMaps, Ribbons, and menus we used the **Search, Decision, and Pointing (SDP) model** [1, 9] to make theoretical performance predictions"*	**Methodological**
Fitts' Law	*"Pointing time is commonly modeled using **Fitts' Law** [15], a logarithmic function of target width and distance from the cursor."*	**Methodological**
Predictive Model of Human Performance with Scrolling/Hierarchical Lists	*"However, hierarchical structures have been shown to be less efficient for expert users*	**Contextual**

	*(e.g., **[7]**)"*	
Predictive Model of Menu Performance	*"However, empirical evaluations demonstrate that spatial relocation can harm performance [16, 25], and **performance models** attribute this to the increased reliance on visual search rather than rapid decision **[9]**."*	**Contextual**
Gibson's Theory of Affordance	*"Such phenomena include functionality, development, motivation, communication, culture, and context (e.g., [1, 3, 16, 20, 23, 24, 26]). An underlying assumption is that **Gibson's theory of affordance** does allow for such extensions."*	**Object of study**
Gibson's Conceptual Framework	*"We argue that the notion of affordance as it was understood by Gibson has a distinct and rather limited focus, determined by the role of the notion in **Gibson's conceptual framework** as a whole."*	**Object of study**
Activity Theory	*"Adopting a more advanced notion of activity developed in **activity theory** (e.g., [4]), would mean understanding affordances as contextualized in unfolding activities and emerging in concrete interaction between the actor and the environment"*	**Contextual**
Framework for Viewing Digital Information	*"The dominating theme of these concerns is captured by Blanchette [3], who proposes **a framework** from which not to view digital information as something immaterial and independent of physical circumstances…"*	**Contextual**
Phenomenology	*"Much of the discussion of interaction with technology, in particular the values at the core of tangible interaction, has turned towards **phenomenology***	**Contextual**

	[7] and ecological psychology [24], by introducing concepts such as ready-at- hand and present-at-hand, and affordances. ***These theories*** *provide ways of understanding the use and perception of physical objects…"*	
Ecological Psychology	*"Much of the discussion of interaction with technology, in particular the values at the core of tangible interaction, has turned towards phenomenology [7] and* ***ecological psychology*** *[24], by introducing concepts such as ready-at- hand and present-at-hand, and affordances.* ***These theories*** *provide ways of understanding the use and perception of physical objects…"*	**Contextual**
Tangible Interaction Framework	*"In particular, much focus has been put into exploring how physical and bodily manifestations and actions make electronic or virtual objects 'graspable' [14] and 'tangible' [33] in the literal as well as metaphorical sense – being easy to understand and 'get a grip of'* ***[16]****."*	**Contextual**
Reducing the Error Offset Model	*"Holz and Baudisch investigated how crosshairs are targeted and present* ***a model that can reduce the error offset [6].****"*	**Contextual**

Discussion

In this section I discuss the findings from my study of best papers. I begin with general remarks about how theories are used in five years worth of best papers. Next, I examine the possibility of distinguishing HCI theories from other kinds used in the best papers – a possibility that could be a novel contribution of this analysis. Then, I reflect on the challenges and limitations of this study, which includes: (1) limits of the six models of theory use and (2) the issue of studying texts that do not explicitly name theory. Finally, I discuss new research questions and next steps for this project.

General Observations About Theory Use in the Best Papers

One way to discuss my findings is to speculate about why authors use theory in some ways more than others. For example, why do authors appear to use theory as a contextual tool and theory as an object of study more than in other ways?

Why use Theory as a Contextual Tool

I found 47 instances of theory as a contextual tool in the best papers. Using theory as a contextual tool involves situating a research question in relation to a particular discourse. Relating a research question to existing work may itself constitute a valid reason for using theory as a contextual tool since it serves as a demonstration of a question's relevance or novelty. Relatedly, theory as a contextual tool could function as a sign of a researcher's knowledge or mastery of related work. In his discussion of citation function, for example, Harwood suggests that some citations function as a display of researcher competence (2009, p. 510), which itself could be an indicator of the overall quality of the research question and approach.

There is an important precondition of using theory as a contextual tool that invites some examination. Namely, theory as a contextual tool seems to have less of an impact

on the other core elements of a research publication. Using theory to contextualize creates a frame around the research in question and shows the audience that the researchers are aware of what is done in the field.

I found that, in many cases, related work is presented as a long string of numbers pointing the reader towards the bibliography. For example, in a gloss of related work on group engagement in their best paper, Block et al. write, "Previous work in HCI research has studied group engagement around interactive tabletops in general [1, 13, 18, 27, 28, 29, 30, 31, 33, 35, 36, 37]" (2015, p. 868). These number strings seem easy to edit, by which I mean items can be added or removed ad hoc. Five of these 12 references seemingly appear only in the related work section of the paper, while one appears in the introduction and related work sections. If the only purpose were to contextualize the work and *not* to use the reference for some other purpose in a different section of the paper, then it would be safe and easy to edit this list.

But when related work plays other roles in other sections of the paper (e.g., in the research methods or discussion sections) then it becomes harder to edit since its impact on those elements seemingly grows. As theory becomes more thoroughly embedded in a paper it consequently becomes less interchangeable. And as theory becomes more embedded it arguably becomes necessary for researchers to articulate the relationship between theory and the other elements of the paper. Block et al. (2015) exemplify this quite well. Although roughly half of the references in the aforementioned quote occur only in the related work and introduction, the other half appear in the research design and other sections with text describing what elements from the theory (e.g. definitions, methods, and metrics) the authors apply in their research.

Why Use Theory as an Object of Study

I identified 46 instances of theory as an object of study, which I explain as cases where (1) theory drives the question or (2) the question is about theory itself. There are a few possible explanations as to why researchers might make more frequent use of theory as an object of study. For example, it could be seen as potentially more impactful than other kinds of theory. What is the nature of this impact and why might it be deemed valuable to researchers?

One answer to this question calls attention to the relationship between theory and the other core elements of a research publication. Theories that are internal components on the path of core elements in a text may have more impact on those elements than theories positioned as external components. Theory as contextual, methodological, and analytical tool(s) are all *external* components in the sense that they do not sit directly on the core element path in any of the six models of theory use.

By contrast, theory as an object of study sits *on* the core element path, which potentially implies a stronger connection with - and impact on – more of the other elements of the paper. Behavioral theory as an object of study influences Hekler et al.'s (2013) question, examination, and findings whereas Zhao et al.'s use of Hogan's exhibition approach may impact the examination only (2013, p. 9). Changing out contextualizing theories could have little impact on the question, examination, or findings. And while changing out theory as a methodological and/or analytical tool could have a significant impact on the paper, it might still not have the same breadth and depth of impact as changing out theory as the object of study. But determining impact may not be as simple as it seems.

For instance, a more detailed analysis of Hogan's exhibition approach in Zhao et al.'s study of social media as performance and exhibition could reveal a much more impactful use of theory than my initial results suggest. A key insight – one that did not play a role in my analysis of Hogan's exhibition approach – is that a statement about the role a theory plays in a given publication may itself be limited or inaccurate. For example, even though Zhao et al. describe their use of the exhibition approach "for examining the actions that users take for managing social media data over time," (2013, p. 9) they may not actually use it in this way. The accuracy of this statement would have to be assessed through a thorough reading of the whole text to determine if the exhibition approach could be categorized *primarily* as an instance of theory as a methodological tool or if it might be better to use a different model.

Changing out theory as an object of study is likely to have great impact on the question, examination, and findings. It may be useful because it gives direction to inquiry and helps researchers determine what is worth investigating. For example, in this dissertation I use existing research on theory use to guide my own research questions and to justify my search for answers. Arguably, none of the other kinds of theory use do this to the extent that theory as an object of study does and, in fact, a well-chosen theoretical object of study can impact most of the other kinds of theory use in a given publication.

I acknowledge that this level of impact may seem problematic for others who would deem it *too impactful*. Theory as an object of study could be seen to impose strict constraints on research. Scholars who use this kind of theory must develop an awareness of the constraints imposed on the generation of research questions, methods of examination, and analytical processes, as well as the selection of other complementary

theories and knowledge objects to use in a given publication. There must be explanations that account for using theory as an object of study even in light of these possible drawbacks. A simple explanation might be that the benefit of acquiring status or value by using a particular theory outweighs the "cost" of the limitations and work requirements imposed on the scholar.

Distinguishing HCI Theories from Other Kinds

One of my assumptions going into this final study was that researchers in HCI build knowledge additively and that this involves working with theory from other research communities. Other studies of theory use in HCI focus on theories that have been brought in from other communities, such as social science, psychology, and philosophy, among many others. Studying theory use has the potential to provide insights into the possible unique ways HCI researchers work with theory in their scholarly publications. Just as design researchers appear to manifest unique knowledge claiming practices (Beck & Stolterman, 2016), so HCI might use theory in distinct ways.

But studying theory use can also provide insight into what (if anything) could be said to distinguish HCI theories from other kinds of theories. Throughout my analysis of the best papers, I identified 17 theories, models, and frameworks that struck me as candidate HCI theories, which I define as explanations or descriptions of phenomena that are of unique interest to HCI researchers (Table 10).

Unlike Popper's famous examination of the demarcating features of scientific theories (Popper, [1963] 2002), my interest in the distinguishing HCI theories from other kinds does not derive from a belief that other kinds are masquerading as HCI theories. I am interested in building an understanding of (1) the unique theoretical knowledge over

which HCI lays claim and (2) allaying concerns that HCI is at risk of becoming theoretically inadequate by showing the potential richness of its theory development.

(HCI) Theory
User Interface Model
Touch Input Framework
Uncertain Input Framework
Time-based UX Framework
Reality-based Interaction
Cross-divide Interaction
Partially Understood Input
GOMS
Foreground-Background Frameworks
Fitts Law
Model Human Processor
Search, Decision, Pointing Model
Predictive Model of Human Performance with Scrolling…
Predictive Model of Menu Performance
Tangible Interaction Framework
Rhythmic Interaction Framework
Ethical Framework for Uncomfortable Interactions

Table 10. Possible HCI Theories in the Best Papers (2012-2016)

Limits of the Six Models of Theory Use

Using the models in this final study resulted in my considering their strengths as well as their limitations as an analytical framework. In my previous study of randomly sampled CHI publications, I found the models to be useful and did not identify any limitations or opportunities for iteration or revision. However, in this study I noted several ways in which the models could be seen as limiting my analysis as well as ways in which they could be improved upon. In particular, I will briefly discuss (1) scientific values

underlying the concept of theory as it appears in the models, and (2) the utility of the No Theory model.

In my preliminary study of theory use in design research, I define theory as an object of study as an instance where "a theory or some aspect of a theory drives the research question. This could be restated as the question is about the theory itself" (Beck & Stolterman, 2016 p. 131). Crucial words – ones that I had previously taken for granted – in this definition are "a" and "the," as in "***a*** theory" or "***the*** theory itself." One of my stated aims in that study was to adopt a broad, inclusive understanding of theory in order to account for the possible diverse ways authors might think about theory (Haynes & Carroll, 2010, p. 2).

But specifying particular theories in my description of each model makes me think that my *actual* understanding of theory could have differed from my *stated* understanding. Why might this be the case? When I started analyzing theory use, I had just completed my first study of scientific theories about designing. So, I would have potentially been influenced in my thinking about what counts as theory. And if I had been thinking about theory in a particular way then the models might also reflect this way of thinking and, thus, influence my analysis to favor scientific theories in categorizing theory as an object of study. For example, when I read Bardzell & Bardzell (2013) and Hekler et al.'s (2013) papers on critical theory and behavioral theory, respectively, I did not categorize either paper as theory as an object of study.

Hekler et al. (2013) do not aim to revise or build on behavioral theory (or specific behavioral theories) in a scientific way *even though* one of their stated goals is to identify ways HCI researchers could contribute to behavioral theory building. They do not

interrogate specific behavioral theories. Nevertheless, their research question could be framed as being about behavioral theory. By compiling and synthesizing information about behavioral theory, Hekler et al. provide an interpretation of it. They identify core scholarship and summarize key research in behavioral theory.

Theory as an object of study need not be restricted to scientific attempts to generate hypotheses about relationships between constructs and/or to falsify a theory or to expand or strengthen the explanatory power of a theory. Yet a scientific approach to working with theory may be implicit in the model, and so there has to be some revision to the model or its description so that it is not limited to scientific theories or research questions. An important question might be whether current (or future) typologies of theory use allow for diverse perspectives about what counts as theory or if underlying values and assumptions bias certain types of theory use towards scientific (or other) perspectives on theory.

Questions, Insights, and Next Steps

My study attempts to understand how theories are used in five years' worth of best paper winners at CHI. From my examination and discussion I imagine some possible implications for HCI research. These implications are meant to be relevant to the CHI community in general. While some of the implications may speak to specific research orientations (e.g. science-oriented versus design-oriented), I believe and intend them to be useful to everyone.

I focused on understanding how theory is used in best paper winners, but we did not attempt to understand its *usefulness*. It may not be possible to do this from "outside" the research process, that is, by analyzing the presentation of research in publications

without input from the authors. But it might be interesting for researchers to reflect explicitly on how and why they use particular theories or theoretical objects in their publications so that the CHI community might derive even more value from their experiences.

In an earlier section, I used the term "intentional feedback" to describe publications in which authors articulate the relationship between findings and theory, including theoretical implications and so forth. This sort of feedback could manifest as a reflection on the utility of a particular theoretical object driven by questions, such as: *In what ways was hermeneutics an effective analytical lens? What were the strengths and weaknesses of a particular ethical framework as a tool for guiding methodological decisions? Did a theory used as a shaping tool yield a more interesting, relevant research question?* I believe that publications that pose and answer questions like these are stronger than ones that do not. Answers to these kinds of questions potentially (1) contribute to the testing and building of particular theories and/or (2) provide an assessment of the usability or usefulness of theoretical objects to the benefit of other HCI researchers.

I found instances of intentional feedback to be most common when researchers were discussing the limitations of their research, such as the validity of a particular methodological or analytical tool. But I suggest that it would be beneficial to the CHI community to broaden the scope and depth of intentional feedback between findings and theory in general. For example, it would be possible to include a new, standard section in the CHI template to address theoretical implications.

One reason why intentional feedback might be limited is that there are simply too many theories or theoretical objects with which to engage. Some 'related work' sections in our corpus included a high volume of references, which carries the cost of not being able to describe in much detail the substance of each one (Weick, 1995, p. 387). But engaging with references in greater depth instead of scope could be seen as a stronger demonstration of one's ability to do impactful research—not only a sign of broad knowledge of the field. It could also potentially widen the audience for a paper. By reducing the ambiguity that can exist between research projects and their references, authors potentially expand the reach of their work to readers who might be less familiar or unfamiliar with the cited material.

Authors can also benefit from considering the ways in which theory, as a core element of a research publication, interacts with the other core elements of a research publication. This consideration could enable researchers to make practical decisions about what theories to use, how to use them, and, perhaps importantly, *when* to use them. It would be potentially useful to explore which theories in particular are used in HCI research publications and how they are used.

While Rogers (2004; 2012) provides expansive coverage of theory use in our field, it could be argued that this work focuses on what could be called revolutionary theories in the field—those theories that seem to exemplify paradigm shifts and other major research trends—to the detriment of a host of other theories. In this study, I provide a more comprehensive list of theory used in HCI research. My goal is not to summarize the revolutionary theories but to complement such a summary with a richer description of the theories appearing in contemporary CHI publications without regard

for the overall breadth and depth of their use in the HCI research community. It may be the case that some of the theories I present in my findings, such as the proposed new theories, have only appeared in a single publication and, thus, have had limited impact. In addition, I distinguish possible HCI theories as a means of encouraging inquiry into the new and unique theoretical knowledge of which HCI is *generative*.

When I have presented my models and findings to other researchers in informal settings, I have observed spontaneous discussions and insightful personal reflections on the structure and presentation of research in scholarly publications. It would be interesting to explore the models of theory use themselves as practical tools for inspiring or prescribing the planning and writing processes as well as the review and editorial processes. I believe that my examination and findings demonstrate value in paying attention to theory as a functional tool in scholarly publications.

Finally, my examination could be a step towards a more conscious, intentional inquiry into research practice in HCI. I would welcome multiple approaches and perspectives scrutinizing the way HCI scholars present their research, such as: full papers, notes, videos, and pictorials. Scholarly publishing in different fields has led to a variety of accepted publication formats. The CHI format is one possible format in HCI, and I have not yet applied the models to others. But I believe that a more robust examination of scholarly publishing in HCI could lead to a more reflective stance towards publications in general and perhaps even an openness to novel formats.

Chapter 6. Discussion

Surveying five years' worth of CHI Best Paper award winners in terms of theory use provides a rich picture of the diversity of theories being used at HCI's flagship conference. Not only is there a healthy representation of theories from other research communities, but there are theories that could be unique to HCI research, which I present as an indication that concerns over a lessening or lack of attention to developing such theories might be misplaced. Using the models of theory use developed in my previous studies also yields possible novel insights into theory use that enrich existing perspectives proposed Rogers (2012) Clemmensen, Kaptelinin, & Nardi (2016) and Velt, Benford, and Reeves (2017).

However, the empirical work in my studies is not meant to challenge or replace the ways theory use has been understood by others. My findings complement and enrich existing, empirically grounded understandings of theory use in HCI research, and they provide an opportunity to construct a different frame on the research community. Toward this end, I summarize the following three insights: (1) it is possible to study theory use by examining scholarly publications, (2) models of theory use could be useful tools for future research, and (3) it is possible to strengthen intentional theory use in HCI research publications.

It is Possible to Study Theory Use by Studying Research Outcomes

In HCI and in other disciplines, textual analysis seems to be a dominant approach to studying theory use. This involves generating a corpus of publications and applying some sort of content analytic techniques resulting in a taxonomy or typology of theory use. Findings range from lists of reference disciplines from which theories are borrowed to characterizations of which research paradigms match with which kinds of theory use. In

many cases, the authors of these studies synthesize their findings with a brief summary of different kinds of theory use. For example, Clemmensen, Kaptelinin, & Nardi (2016) describe theory functioning as:

1. **Object of Analysis** "Identified unique features and principles, as well as problematic aspects of the theory and compared it to other 'contextual' theories in HCI" (2016, p. 630)
2. **Tool for New Analytical Tool Development** "Identified the needs and requirements for new theoretical tools and employed [AT] to inform and guide the development of such tools" (2016, p. 630)
3. **Conceptual Analysis and Development Tool** "Applied the theory to address central issues and challenges in HCI" (2016, p. 630)
4. **Empirical Analytic Tool** "Key theoretical constructs [were used] to identify and categorize specific empirical phenomena." (2016, pgs. 630-631)
5. **Framework for Design** "The theory [guides] the iterative design process, or [helps] develop claims about the nature of the design process. (2016, p. 631)

Similar lists can be found in many other sources and so it seems as though textual analysis has proven to be useful and valuable to a scholars working in a variety of research communities. Studying theory use by studying scholarly publications is one way to study theory use. However, there are other approaches.

For example, Haynes and Carroll (2010) conduct an interview study with 68 design researchers in order to understand how theory functions *during* the design process. The authors state that their focus "is on how theories are used in design research to motivate and inform the particulars of designed artifacts and design methods" (Haynes and Carroll, 2010 p. 1). And there seems to be a tacit assumption that it is impossible (or at least difficult) to ascertain theory use during the design process by examining its outcomes. In other words, designed artifacts (e.g. a reading application, or a multi-touch tablet) do not lay bare theory use during *design* research in the same way that scholarly publications (are expected to) describe theory use during research. The ubiquity of textual analyses in the literature suggests at least a shared assumption among scholars that

publications are valid objects of analysis for studying theory use in research. But there are important limitations.

The accepted approach to studying theory use in publications seems to be either (1) to choose a specific theory (i.e. something with the words 'theory,' 'model,' or 'framework' in its name like 'Activity Theory') and then search for instances of it in a publication or (2) look for instances of any named theories, models, or frameworks in a publication and analyze them in terms of theory use. Only a handful of authors deviate from these approaches. But deviation seems to involve expanding the notion of what counts as theory *just enough* so that a "set of constructs and relationships in a body of conceptual argumentation delineated by diagrams [or] words" (Hannay, Sjoberg, & Dyba, 2007 p. 93) can be counted as theory even if the words theory, model, or framework are nowhere to be found in the text.

This expansion does not mean that *anything* counts as theory even though it is accepted that scholars refer to theories in publications as "concepts, ideas, and perspectives" and some design researchers count things like "phenomenology" and "design patterns" as theory. If textual analysis continues to serve as a useful technique for studying theory use, then perhaps scholars undertaking such work ought to involve the authors of the papers. Involving authors may also clarify where authors perceive theory use in the absence of any explicit mention of theory.

Seven papers out of 90 did not name any theories, models, or frameworks. If it is true that all observation is theory-laden, then even where there is a lack of explicit naming there must be some kind of theory use. It becomes important to consider ways to examine such papers in terms of theory use. Ignoring these papers deprives HCI research

of a richer understanding of how scholars in the community use theory in their publications. Moreover, it reveals a possible limitation of taking a content analytic approach where theory has to be explicitly shown in some way.

To examine texts for explicit mentions of theory and/or clear descriptions of theoretical constructs and their interrelationships is one way to study theory use. But taking such an approach by its nature excludes texts that leave theory unnamed and texts that relegate theory to the bibliography. In my analysis, I focused primarily on explicit mentions of theory. However, I also included in-text citations that point to theories named in the bibliography. For example, Semaan et al. (2015) name Habermas but do not name the Theory of Communicative Action in the body of his text. They write,

> *"According to Habermas [**15,** 16], deliberative democracy can only exist in the public sphere, which he described as 'a domain of our social life in which such a thing as public opinion can be formed'"* (2015, p. 3168).

An analyst studying explicit mentions of theory use may still include this theory *if* they judge the quoted text to be a description of "constructs and relationships in a body of conceptual argumentation" (Hannay, Sjoberg, & Dyba, 2007, p. 93). Are deliberative democracy and the public sphere constructs? Is describing the existence of one as a necessity for the other sufficient to count as a relationship?

This instance of Habermas's Theory of Communicative Action might be excluded from analyses of explicit theory use because it is not named in the body of the text and, hence, it may be considered an instance of circumstantial theory use. Circumstantial theory use refers to cases where an author names a theory *but* refrains from engaging with it in depth. But is it reasonable to exclude such cases? What does it mean to engage with a theory in depth? Is it possible that Habermas's Theory of Communicative Action

is significant to Semaan et al.'s paper even though they do not engage with it in depth? How could this significance be determined? By including the Habermas's theory in my analysis I hope to promote discussion about the distinction between significant and circumstantial theory use. A useful way to advance this discussion could be to involve authors in future studies of theory use.

So far none of the textual analyses of theory use I have examined involve the publications' authors. Yet involving the authors could be useful way to enrich our understanding of the "diversity of thinking about what counts as a theory" (Haynes and Carroll, 2010 p. 2) and strengthen validity claims about the results of textual analysis. Involving authors addresses the question of whether authorial intention aligns with reader interpretation. For instance, Krippendorff disagrees that his collaborative study on identifying design moves (Perry & Krippendorff, 2013) constitutes an example of theory as a shaping tool (Krippendorff, personal communication). But I think this position can be framed as an opportunity for clarifying and expanding my analysis and thus enriching my contribution rather than as an invalidation of my findings.

Interviewing or surveying authors as part of a study of theory use also potentially creates an opportunity to examine *implicit theory use*, by which I mean theory use in publications that do not name theories, models, frameworks, or other theoretical devices. Other scholars who contribute to the discourse on theory use observe "all [science education researchers] use [theoretical lenses and theoretical frameworks] because research is necessarily theory driven" (El-Khalick & Akerson, 2007 p. 189). If these statements are true – and I believe they are – then it does not make sense to exclude publications that do not name theories or theoretical devices *explicitly* from a study of

theory use. If there is any chance of approaching a more general theory of theory use then there must be ways to assess theory use even when it is implicit.

Models could be Useful Tools for Future Studies of Theory Use

In other studies of theory use, it is common for researchers to synthesize their findings as taxonomies or typologies – lists of different types of theory use coupled with a short description of that type. It is also common to illustrate the different types of theory use with an illustrative quote as I did in the previous chapter of this dissertation. However, to my knowledge there have not been attempts to model theory use in the same way that I modeled it in my analysis of design research publications.

I created models to try and account for the interaction between theory and three other key elements of a research publication, which I listed as (1) the research question, (2) examination, and (3) findings. It would have been possible to describe theory use without creating models. Most other studies do this, and they do it well. But the models helped me to think about whether there might be patterns of theory use in the overall structure of a publication. And to some extent they amplify an assumption in other studies of theory use; that the location of theory use in a publication is interesting and potentially important.

For example, Pettigrew & McKechnie (2001, p. 67) and McKechnie & Pettigrew (2002, p. 413) examine where theories appeared in a text. “Theories were mentioned in article titles about 10 percent of the time, in abstracts about 20 percent of the time, and almost always in the [body] text of an articles” (2002, p. 412). And they clarify an assumption that the location of a theory tells readers something about its significance for the overall text. In other words, a theory appearing in a title or abstract is of more significance to the publication than a theory appearing only in the body text. Models may

help clarify this significance by facilitating examinations of the impact and influence of theory on other elements of a publication.

For example, following my analysis of design research publications I used the models as a framework for explaining why authors use theory in some ways more than others. They helped me to articulate the relationship between a type of theory use and its overall influence on the other key elements of a publication. For instance, I suggested that *theory as an object of study* influences the question, examination, and findings in a publication. In other words, it influences the overall structure of the publication. By contrast, I explored the possibility that *theory as a contextual tool* may not influence the structure in a significant way, and, crucially, I used the location of theory as partial grounds for this claim:

> *"Contextualizing theories are externally positioned [in the model] relative to the other key elements in a text, and they are also (arguably) more flexible than other types of theory. They can be added and removed ad hoc with seemingly little consequence for other key elements. Unlike adding a note to a melody or adding a patch of color to a painting, citing an additional piece of literature seemingly does little to change the whole text in an obvious way especially if the citation amounts to little more than a name or number in a long sequence of citations. It is even possible to imagine cases where contextualizing theories are added to publications days before submission deadlines with no consideration given to how these late additions impact the other key elements"* (Beck and Stolterman, 2016a p. 138).

The key idea here is that the external positioning on the model illustrates the lack of impact on the overall text. Theories that occupy central locations like the title or abstract are assumed to have influence over the other key elements of a publication, including but not limited to research questions, examinations, and findings. Theories that appear only in the body text somewhere are assumed – rightly in my view – to have less impact on the overall structure of the text.

The notion of a generic overall structure brings to mind another potential benefit of modeling theory use in research publications. Model building lays bare the assumptions about what constitutes a research publication and, thus, opens up the possibility of discussing theory use in alterative formats, too. For example, what if a publication only poses a question, as is the case with some CHI extended abstracts? What if it presents *only* findings as, for example, some editorials on preparing manuscripts for journal publication do? And what if the research contribution manifests as a designed artifact rather than a full paper or CHI note?

It Is Possible to Strengthen Intentional Theory Use

When I claim that it is possible to strengthen intentional theory use, I do not mean to imply that intentional theory use is weak. Nor do I mean to call for more of a particular kind of theory use. For instance, I do not mean that there ought to be more theory as an object of study or more theory as an analytical tool. I mean that it is possible to improve upon current theory use practices in HCI research by becoming more deliberate in the selection and application of theories in research publications. So far I have studied and examined which theories are used and how they are used but I have not taken the additional step of examining the utility of theories in research publications. For example, is the product ecology framework a useful analytical tool? Is value sensitive design a useful methodological tool? Questions like these could support researchers deciding which theories to use, how to use them, and, importantly, *where* to use them in a publication.

A deeper understanding of how theory functions in research publications can lead to more intentional theory use. And more intentional theory use could potentially lead to greater systematicity and avoidance of pitfalls in at least three different ways. First,

researchers can be more systematic in their evaluation, selection and application of particular theories. Some theories may be better suited for certain functions than others. Second, researchers can avoid treating contextualizing theories with less care and attention simply because they appear to have less overall impact on the text. Finally, more intentional theory use in part involves attending to the way in which findings talk back to theory – an issue that has been overlooked in many studies of theory use. Part of the value of the models could be their emphasis of unrealized connections between key elements of research and theory.

The models of theory use are imperfect, and they ought to be developed further. But even in their current state, they reveal opportunities for reflecting on the intellectual utility of theory that seem rare in the publications I have studied. For example, when Durant, Kirk, and Reeves (2014, p. 2687) use value sensitive design as analytical tool they do not reflect on its utility or value *as an analytical tool*. Models of theory use could facilitate this sort of thinking during the writing process so that reflection on intellectual utility becomes a natural, central part of writing. While there are valuable resources for planning and writing academic texts (Booth et al., 2003; Turabian, 2013) these resources tend not to call out theory as a core element in a publication let alone identify opportunities for discussing the utility or value of theory as an analytical or methodological tool.

Chapter 7. Conclusion

In her highly cited book, *HCI Theory* (2012), Yvonne Rogers describes HCI as a research community undergoing rapid expansion. She observes that it is challenging to pin down the nature of the HCI research community. Is it a science or a design discipline? Or is it something different altogether? What distinguishes HCI research from other intellectual communities? Rogers invokes a metaphor of adolescence to characterize HCI, but she does not examine the metaphor in much depth.

Metaphors are packed with information, and they do not necessarily require explication in order for their meaning to come across. For example, I could interpret Rogers' adolescence metaphor to mean that HCI research explores many different topics and questions as an adolescent might explore different kinds of music or styles of dress in an effort to find ones that fit and express their personality. But the metaphor may have negative connotations as well. For instance, it could capture insecurity over an inability to make concrete identity claims about HCI as a research community.

Rogers does not examine the metaphor in much depth. This is not her purpose. However, some additional exploration could prove useful since it could shed light on other issues examined in the text.

Consider the concerns Rogers expresses over so-called "weakening theoretical adequacy" in HCI research. By "theoretical adequacy," Rogers means the degree to which HCI develops theories that explain or describe its core objects of study (2012, p. 18). The notion of weakening theoretical adequacy tells the story of a research community whose theory is less and less effective at explaining or describing core objects of study in a scientific way. Whether one uses the publication of the first HCI

paper or the establishment of the first HCI academic department or special interest group to mark the beginning of HCI research, the community seems young.

I do not mean to suggest that it is unreasonable for a young research community to aspire toward theoretical adequacy or that it is impossible to be theoretically adequate at such a young age. But in Rogers' text I read a tone of concern and warning; the kind of tone a parent might take when painting a grim future for a rebellious high school student who hasn't yet picked a career path or a college. Theoretical adequacy might not be the right path for HCI research, but, if it is, I believe that the community may get there by embracing the qualities (e.g. exploration, expansion, and diversity) that have led Rogers to warn of a looming identity crisis.

In my analysis of big questions literature, I found that researchers from diverse disciplines describe their intellectual communities in terms of (1) fragmentation and disunity, (2) low/no intellectual status, and (3) a lack of progress. However, I believe it is important to recognize that these descriptions are not disinterested summaries of facts. They are interpretations of facts. In other words, they are ways of framing facts. For example, Rogers writes that in HCI research "there is no longer a coherent set of aims or goals" (2012, p. xii). It is possible to frame a lack of coherence in terms of a "worrying lack of direction" (Rogers, 2012, p. 1) or fragmentation, but it is also possible to frame it in terms of exploration, experimentation, or diversity.

Reframing Fragmentation as Diversity

There are several examples of HCI scholarship that call attention to fragmentation or disunity as a characteristic of the discipline. For example, Hornbæk et al. suggest that

"HCI seems to have no consensus on what we need to study," (2015, p. 2387) which they acknowledge might be positive *or* negative.

While Liu et al. offer empirical support for the claim that "HCI is becoming increasingly cohesive" (2014, p. 3560) they also point out "a recent explosion in the number of specific [research] topics or keywords" (2014, p. 3560). And Carroll characterizes HCI as an "increasingly fragmented and complex" (2010, p. 4) field and has suggested that there is "no single disciplinary problem or specified set of practices, and certainly no single conception of effectiveness" (Carroll, 2010, p. 11). But he resists framing fragmentation as problematic.

It is clear that some HCI scholarship describes the discipline in ways that resonate with the concept of fragmentation. But others adopt a more balanced perspective, and, in some cases, there are some who describe HCI in ways that eschew fragmentation in favor of language with more positive connotations. For example, in their examination of the literature on sustainability in HCI, DiSalvo, Sengers, & Brynjarsdóttir (2010) describe a "remarkable *heterogeneity* of methods, orientations, and approaches, which have contributed to the rubric of sustainable HCI" (2010, p. 1975).

Framing the community in terms of heterogeneity, diversity, or complexity could lead to different ways of grappling with disciplinary identity and maturity since these frames capture the same variety of research questions and approaches *without* the negative connotations that accompany words like fragmentation. Complexity, diversity, and heterogeneity may still need to be addressed in some way, but it seems obvious that addressing complexity can be very different from addressing fragmentation.

Reframing Stagnation as Exploration

The concepts of status and progress seem to be complementary in the sense that if/when a discipline achieves status it also probably has a way of assessing progress. In my corpus of big questions texts, many authors wrote about how big questions are one way to facilitate progress in an intellectually stagnant discipline. Do HCI researchers talk about how the discipline is intellectually stagnant or lacking progress?

For example, in discussing the ways in which theory in HCI has been adapted to include a variety of scholarly functions, Rogers observes that "the downside of such [eclectic theory use] is a weakening of [the discipline's] theoretical adequacy, i.e. being certain that an account is representative of the state of affairs" (Rogers, 2012, p. 18).

From this perspective, a discipline making progress should become *more* certain that its theories adequately represent its objects of study. However, what Rogers categorizes as a downside is only a downside if research is understood and assessed on scientific terms. But even this statement takes a particular position on science and scientific research that is not shared by *all* scientists. Nobel laureate Roald Hoffmann, a chemist, speaking against the concept of big questions, states that his "disposition is not to work on big questions… [and that he likes working on] many detailed small problems, while keeping [his] eyes open for connections" (Ball, 2006, p. 502). The downside of eclectic theory use resonates with what could be characterized as a traditional perspective on scientific research and cumulative knowledge growth (Lakatos, 1970; Popper, 2005), which is a topic that has been written about in HCI by Kostakos (2015) and others (Carroll, 2014; Liu et al., 2014; Reeves, 2015).

There may be evidence of scholars expressing concern over HCI's intellectual progress. However, it is clear that there are different measures of progress. It may be the

case that HCI research – in its youth – explores many small intellectual problems without regard for the ways they complement and inform one another. If it is reasonable to reframe what some might call intellectual stagnation as exploration, then what would this mean for the community? For one thing, it might prompt researchers to abandon efforts to jumpstart a stagnating community and consider ways to cultivate new ways of doing research and sharing research outcomes. In this way, different ways of using theory and the variety of theories being could be framed as core objects of interest. Moreover, it becomes possible to take the position that there is no weakening theoretical adequacy in HCI research. A good question to ask now would be how new proposed theories evolve in the HCI research community. There are many examples of theories whose history is traceable through the body of scholarly communication in the field. But what gets done with newer theories? How is it that some become dominant while others fade into obscurity?

The Strengths of Being an Adolescent Research Community

HCI research may not have an agreed upon set of big questions or grand challenges, and it may not recognize a set of core objects of study. Should it?

I recently spoke with colleagues in an informal setting about the possibility of assembling a reading list of canonical HCI texts. It may be the case that a list of canonical texts is something of a myth; that it simply creates a cohesive historical development narrative for the field. But such an image could be precisely what an adolescent craves since a canon could provide much needed stability and identity for HCI researchers; as a field of inquiry, we want to know where we come from, where we are, and maybe even where we (could be) going.

The world can seem complex and overwhelming without the presence of a few useful frames to make sense of it all. And when it all comes at you so fast and in such high volume, one response would be to retreat. But things only seem/appear/feel dim if we focus on the parts of the metaphor that Rogers' brings into focus. Rogers' use of phrases like "worrying lack of direction" (2012, p. 1) and "weakening theoretical adequacy" (2012, p. 18) frame HCI as a collection of problematic qualities that prime her readers to look in certain directions for possible solutions to the problems.

For example, it might be reasonable to respond to a lack of direction by providing a sense of direction in the form of big questions or grand challenges. And it might seem reasonable to respond to potential "weakening theoretical adequacy" by strengthening scientific theory-building efforts. But one cost of pursuing these solutions is a lack of time spent examining the problems themselves.

My aim is not to question whether the problems in Rogers's text are real problems. Instead, it is to point out that there are different ways of making sense of HCI research. For example, rather than try to solve the problem of fragmentation, it would be possible to figure out how to cultivate more creative ways of exploring and diversifying research questions and approaches. Instead framing HCI research in terms of a weakening theoretical adequacy it would be possible to bolster efforts to understand how different interpretations and applications of theory complement one another.

There is interesting theory work happening in HCI research. Scholars in the community are appropriating and developing theories from other fields and developing their own. And, although I disagree with Rogers's framing HCI research in terms of weakening theoretical adequacy, I can understand why she might choose to frame it that

way. But adolescence brings with it enough anxiety. Framing the field in terms of weaknesses and limitations may undermine its constituents' ability to do good work

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Zuger, A. (2003). A big study yields big questions. *New England Journal of Medicine*, *349*(3), 213–214.

Jordan Beck

EDUCATION

Indiana University, Bloomington, IN — September 2017
PhD: Informatics (Human-computer Interaction design)
Minor: Qualitative Inquiry Methodology

University of Chicago, Chicago, IL — June 2009
Master of Arts in Humanities

Columbia College, Chicago, IL — May 2007
Bachelor of Arts in Film Production (with honors)

Professional Experience

Associate Instructor — August 2012 – May 2017
Indiana University, Bloomington, IN

- Teach advanced graduate courses in design theory, master's thesis/capstone, rapid design for slow change, and undergraduate courses in HCI
- Create and revise course syllabi, lesson plans, assignment specs, and grading rubrics

Lead Instructional Designer — October 2011 – July 2012
Embanet+Compass (now Pearson), Chicago, IL

- Managed program development for the University of Southern California's online Master of Public Administration (MPA) and Executive Master of Health Administration (EMHA)
- Led a ten-person instructional design team in the development of new, revamp, and revision courses in accordance with partner needs and program standards

Instructional Designer — August 2010 – October 2011
Embanet+Compass (now Pearson), Chicago, IL

- Collaborated with faculty to design innovative, interactive online courses for graduate programs in business, economics, finance, education, and communications
- Collaborated with information architects on the design of program-specific learning management systems

English and Film Studies Teacher — July 2009 – August 2010
Carmen High School of Science and Technology, Milwaukee, WI

- Designed and taught intensive, year-long ESL curriculum to 50 students
- Designed and taught three sections of film theory and production to 60 students

PUBLICATIONS

Journal Articles

- Beck, J. and Chiapello, L. (accepted) Schön's Intellectual Legacy: A Citation Analysis of DRS Publications (2012-2016). *Design Studies*
- Beck, J., and Stolterman, E. (2017) Examining knowledge claims made in design research. *She Ji: The Journal of Design, Economics, and Innovation,* 2(3), 199-214

- Beck, J. and Stolterman, E. (2016) Examining practical, everyday theory use in design research. *She Ji: The Journal of Design, Economics, and Innovation,* 2(2), 125-140

Peer-reviewed Conference Papers

- Beck, J., and Stolterman, E. (2017) Reviewing the big questions literature; or, should HCI have big questions? *ACM Designing Interactive Systems (DIS)* 2017. Edinburgh, SCT
- Beck, J. and Chiapello, L. (2016) Schön's legacy: Examining contemporary citation practices in DRS publications. *DRS 2016: Future-focused Thinking*, Brighton, England
- Beck, J. and Stolterman, E. (2015) Can there be scientific theories of design that do not scientize design? *European Academy of Design 11: The Value of Design Research*, Paris, France.
- Sosa-Tsec, O., Beck, J., Siegel, M.A. (2013) Building the narrative cloud. *DRS//CUMULUS 2013: 2nd International Conference for Design Education Researchers*, Oslo, Norway.

Magazine Articles

- Siegel, M.A., and Beck, J. (2014) Slow change interaction design: A theoretical sketch. *ACM Interactions*. *21*, 28-35.

PRESENTATIONS

Research Talks

- 2016, June. Schön's legacy: Examining contemporary citation practices in DRS publications. *Design Research Society: Future-focused Thinking.* (University of Brighton, Brighton, UK)
- 2015, June. Can there be scientific theories of design that do not scientize design? *European Academy of Design: The Value of Design Research.* (Paris-Descartes University, Paris, France)
- 2014, June. Slow change interaction design: Current and future trends. *Design Research Society: The Big Debates.* (Umea Institute of Design, Umea, SE)
- 2013, May. Storytelling as a pedagogical tool for teaching design. *DRS//CUMULUS 2nd International Conference for Design Education Researchers.* (Akershus University, Oslo, NO)

Guest Lectures

- 2016, October. Scientific theories about designing. *I604: Design Theory.* (Indiana University, Bloomington, IN)
- 2016, September. Synthesizing Design Insights from Fieldwork. *I604: Design Theory.* (Indiana University, Bloomington, IN)
- 2016, March. Sketching: Overcoming roadblocks*. I694. HCI/d MS Thesis Course.* (Indiana University, Bloomington, IN)
- 2015, October. Making sense of different design theories. *I604: Design Theory.* (Indiana University, Bloomington, IN)
- 2014, May. Conducting ethnographic research in virtual worlds. *I502: Human-centered Research Methods.* (Indiana University, Bloomington, IN)
- 2013, October. What is slow change interaction design? *I690: Rapid Design for Slow Change.* (Indiana University, Bloomington, IN)

SERVICE

Advising and Leadership

- 2016-Current. Advise undergraduate honors student through research design and writing process, culminating in publishable ACM conference papers
- 2014-Current. Edit and provide critical comments and guidance to colleagues preparing dissertations and other manuscripts for publication
- 2014-2016. Co-led and advised a research group with three undergraduate and one graduate student researching and writing papers about interactivity clutter
- 2013-2015. Mentored 40+ second-year masters students completing design practicum and capstone projects

Peer Review

- 2017 Reviewer for Computer-Human Interaction (CHI) Conference
- 2017 Reviewer for INTERACT Conference
- 2017 Reviewer for Designing Interactive Systems (DIS) Conference
- 2016 Reviewer for Interactive Surfaces and Spaces (ISS) Conference
- 2015 Reviewer for Designing Interactive Systems (DIS) Conference
- 2015 Reviewer for Computer-Human Interaction (CHI) Conference
- 2015 Reviewer for Design Research Society (DRS) Conference
- 2014 Reviewer for Designing Interactive Systems (DIS) Conference
- 2014 Reviewer for Design Research Society (DRS) Conference

PROFESSIONAL AFFILIATIONS

- Association for Computing Machinery (ACM)
- Design Research Society (DRS)