AIS Transactions on Human-Computer Interaction

Volume 2 | Issue 4 Article 2

Winter 12-31-2010

Designing and Engineering for Emergence: A Challenge for HCI Practice and Research

Steven Alter
University of San Francisco, alter@usfca.edu

AIS Transactions on Human-Computer Interaction

Transactions on Human-Computer Interaction

THCI

Research Commentary

Designing and Engineering for Emergence: A Challenge for HCI Practice and Research

Steven Alter
University of San Francisco
alter@usfca.edu

This research commentary on Future Directions for HCI Research responds to research commentaries on the same topic by Benbasat (2010) and Lyytinen (2010), and to two articles in Volume 1 of the AIS Transactions on Human-Computer Interaction (Galletta and Zhang, 2009; Zhang et al. 2009). It employs a two-dimensional framework for exploring the scope and challenges of HCI that combines a social/ technical dimension and a behavior dimension that emphasizes differences between engineered and emergent behavior in sociotechnical systems. This framework is used to reflect on possible differences between the scope of a definition of HCI in those articles and the scope of the topics identified in the extensive survey of HCI literature reported by Zhang and colleagues (2009). Implications include the possibility that future HCI research and theorizing may find significant opportunities related to "designing for emergence," or even "engineering for emergence."

WHAT IS THE SCOPE OF HCI?

This research commentary was motivated by an invitation from the *AIS Transactions on Human-Computer Interaction (THCI)* to share views on Future Directions for HCI Research. It responds to research commentaries on that topic by Benbasat (2010) and Lyytinen (2010) and to two articles in Volume 1 of the *AIS Transactions on Human-Computer Interaction*, an introduction of *THCI* as a new journal (Galletta and Zhang, 2009) and a survey of HCI research (Zhang et al., 2009). The survey examined articles in eight selected journals and in other selected sources from 1990 to 2008. It classified 693 of 2302 IS research articles in the sample as HCI articles, roughly 30% of the IS articles. If the sample of IS articles is representative, HCI research comprises around 30% of IS research.

While I never considered myself an HCI researcher, the broad definition of HCI used by Galletta and Zhang (2009) and Zhang and colleagues (2009) made me wonder about how my research fits into HCI and how HCI fits into IS in general. Galletta and Zhang (2009) said that *THCI* addresses IS issues and concerns, but with a "specific focus on the history, reference disciplines, theories, practice, methodologies and techniques, new developments, and applications of the interaction between humans, information, technologies, and tasks, especially in the business, managerial, organizational, and cultural contexts" (p. 8). That rather expansive view of HCI topics overlaps substantially with definitions of other topics related to IS in general rather than HCI in particular:

Dennis Galletta was the accepting Senior Editor. This article was submitted on 7/23/2010 and accepted on 12/20/2010. It was with the author 10 days for 2 revision.

Alter, S. (2010) "Designing and Engineering for Emergence: A Challenge for HCI Practice and Research," *AIS Transactions on Human-Computer Interaction* (2) 4, pp. 127-140.

- The definition of sociotechnical system in Lyytinen and Newman (2008) also refers to interactions: "any organizational system viewed as a multivariate system consisting of four interacting and aligned components – task, structure, actor, and technology" (p. 613).

- The nomological net for IS research proposed by Benbasat and Zmud (2003, Figure 2, p. 187) covers topics related to humans, information, technologies, and tasks in business contexts. It includes IT managerial, methodological and technological capabilities, the IT artifact, usage, impact, and IT managerial, methodological, and operational practices, where the IT artifact is "the application of IT to enable or support some task(s) embedded within a structure(s) that itself is embedded within a context(s)" (p. 186).

- Clarifying Zhang and colleagues' (2002) original definition of HCI, Zhang et al. (2005) said "HCI issues and concerns involve all possible interactions between a user and a system during its lifecycle, including the development stage, use in context, and the impact of such use on individuals, organizations, society, and future systems development" (p. 519).

- The work system method also focuses on interactions between people, information, technologies and tasks. A work system is "a system in which human participants and/or machines perform work (processes and activities) using information, technology, and other resources to produce specific products and/or services for specific internal or external customers. An IS is a work system whose processes and activities are devoted to processing information..." (Alter, 2008, p. 451). The work system life cycle model describes how work systems change over time through a combination of planned change (explicit projects with initiation, development, and implementation phases) and unplanned change (adaptations and experimentation) (Alter, 2008).

The overlap between the definition of HCI and the four statements above revolves around interactions between people, information, technology, and tasks in business and organizational contexts. Some of those interactions involve systems in operation. Others involve system life cycles. The combination of those topics probably covers much more than the 30% of IS research implied by Zhang et al.'s (2009) classification of 2,302 articles.
The lack of clarity about the boundaries between IS in general and the subfield of HCI within IS led me to try to develop a framework that would make it easier to describe the boundaries of HCI and to identify topics related to IS in operation and IS development that are and are not part of HCI. Topics near the boundary and links between topics inside and outside of the boundary might be fruitful areas for future HCI research.

Ideas from a possibly surprising source

The framework described below was inspired by recent discussions about a topic that also touches the interaction between humans, information, technologies, and tasks, but does so from a fundamentally different direction. "Organizational design and engineering" (ODE) is a subfield of IS proposed by Magalhães and Silva (2009) and is the focus of a new journal, the *International Journal of Organizational Design and Engineering (IJODE)*, first published in 2010. The *IJODE* web site defines ODE as "the application of social science, design science and computer science research and practice to the study and implementation of new organizational designs, including the integrated structuring, modeling, development and deployment of IS/IT and social processes."

Part of the discussions about ODE focused on developing a framework that could help in positioning relevant topics, theories, and techniques within ODE. Since "integrated structuring, modeling, development and deployment of IS/IT and social processes" certainly includes "interaction between humans, information, technologies, and tasks," it seemed possible that some of the ideas from the ODE discussion might belong in a framework for visualizing topics, theories, and techniques in HCI, even though these subfields emphasize different sides of those issues. In other words, the surprise was that ideas for exploring the subfield of human-computer interaction, which started as the study of interfaces, might come from a discussion of organizational design and engineering, whose core topics seem to belong in a very different discourse.

Aspects of the discussion of ODE appear, but in a different form, in the *TCHI* research commentaries by Benbasat (2010) and Lyytinen (2010). Benbasat emphasized design, and said that he "strongly believe[s] that to be interesting and relevant, research in HCI should have a design component coupled with an evaluation of the design" (p. 16). He suggested approaching design in an instrumental fashion, and viewing the design of an interface as a mechanism for achieving managerial and organizational goals (e.g., related to decision making, e-commerce, and communication in virtual teams). Lyytinen emphasized topics that are distant from interfaces and less amenable to design by specific designers. He cited challenges related to current computing environments in which individuals use multiple tools and in which a computer-rich ecology of computing with many information sources involves much more than the use of individual tools. An important difference between a design emphasis and an emphasis on computing environments is related to the difficulty of designing a complex IT system or IT-reliant work system without being able to specify or control the features of many of its components.

FRAMEWORK FOR VISUALIZING THE SCOPE OF HCI

A framework for visualizing the scope of HCI should satisfy the following criteria:

- It should encompass "interaction between humans, information, technologies, and tasks" (Galletta and Zhang, 2009, p. 8), especially in business, managerial, organizational, and cultural contexts" in order to provide insight about the scope and future possibilities for HCI.
- It should be less detailed than a classification of 693 HCI articles selected from 2,302 IS articles.
- When used to position HCI-related topics, issues, theories, techniques, and tools, it should be more effective for visualization than a one sentence definition of HCI that touches a substantial part of the IS field.

Figures 1 and 2 position HCI-related topics, issues, theories, techniques, and tools in a two dimensional space built around the assumption that both human behavior and the behavior of computerized entities can be viewed as engineered, guided, or emergent. The discussion of these dimensions and use of these dimensions in Figures 1 and 2 sets the stage for Figure 3, which uses the same framework to position the categories of HCI research in the review of HCI research by Zhang et al. (2009). Tables 1 and 2 define the categories in each of the two dimensions for classifying HCI topics and issues.

Social/Technical Category

The social/technical dimension in Figures 1 and 2 positions various aggregations of people and of technologies in relation to their distance from the point of interaction between specific individuals and specific technologies. Accordingly, the human-computer interface appears in the middle of that dimension. Moving outward in the social direction, the categories focus on the activities and concerns of individuals, groups and organizations, enterprises, and society. Moving outward in the technical direction, the categories focus on specific IT artifacts (i.e., hardware and/or software), composite IT artifacts (e.g., network or software suite), and societal IT artifacts (e.g., national or global network). The social part of the dimension places more emphasis on users, usage, and other impacts. The technical part focuses more on design issues, capabilities, and interactions between IT artifacts. HCI research includes topics across this entire dimension.

The original starting point for HCI research was in the middle of this dimension, when individuals worked through human-computer interfaces using specific IT artifacts, such as specific computer programs or computerized tools. (For our purposes, IT artifact refers to specific hardware and/or software, rather than something like Kling and Scacchi's (1982) "ensemble view" of the IT artifact that Orlikowski and Iacono (2001, p. 122) favored.) The previously mentioned definition of HCI certainly applies to the social portion of the social/ technical dimension (from individual to organizational to societal). Since many impacts in business, managerial, organizational, and cultural contexts involve composite IT artifacts such as ERP suites, or even societal IT artifacts such as the Internet, HCI research might appear at any point along the technical portion of this dimension as well (provided that people, information, and tasks are considered seriously in the research).

Type of Behavior

The previously mentioned perspectives of Benbasat (2010) and Lyytinen (2010) implicitly focus on different types of behavior. Benbasat's emphasis on linking design to managerial and organizational goals is a step toward an engineering approach in which the designer specifies the desired behavior and develops artifacts that influence behavior in that direction. Lyytinen's focus on ecologies emphasizes situations in which behavior tends to emerge, and cannot be engineered due to the difficulty of coordinating and controlling the use of multiple devices in multiple work systems. In those situations, overlaps in participants, information, and work practices may change in unanticipated ways, and therefore may generate mutual benefits and/or mutual disruptions and inefficiencies that are difficult to anticipate.

The dimension representing types of behavior covers four types, each of which might apply to situations at various points along the social/technical dimension:

Engineered Behavior

Initial HCI research focused on the quality of human computer interfaces. The interactions governed by those interfaces can be described as engineered behavior, in the sense that the interface itself displays and transmits specific, predefined types of messages to and from the human user, often within a clearly defined problem domain. In relation to user interfaces, engineered behavior involves the precise details of using the interface, such as exactly which keys to press and exactly what the messages mean. In relation to business processes and activities, rather than interfaces per se, work system designers try to assure conformance to data definitions and business rules in highly structured tasks whose business outcomes call for conformance rather than flexibility. For example, according to the intentions of designers of most IT-reliant transaction processing systems, those systems are substantially comprised of engineered behavior because people who perform the transactions need to conform to business rules related to pre-defined data items whose consistency in format and meaning is essential. Research related to engineered behavior concerns whether and how designers and their clients specify the correct requirements, whether and how the requirements are translated into software, and whether and how actual work practices conform to the requirements.

Guided Behavior

As the range of HCI research broadened, more emphasis was placed on the way that IT artifacts might guide the behavior of human users to help them consider important issues, use appropriate categories, recognize inconsistencies, and avoid foreseeable mistakes. Decision support systems, expert systems, e-commerce web sites, and advice-giving agents fall into this category. Although the interfaces are engineered, the larger situations of use are semi-structured and cannot be described as engineered behavior. Researchers focusing on guided behavior try to understand interactions between the characteristics of the situation, the guidance (which may occur through information, web sites, models, or other means), and the decision maker(s).

Emergent Behavior

Other HCI research, such as research on computer supported cooperative work (CSCW), focuses on emergent behavior that is not guided or scripted in advance by designers and analysts, but emerges through discussion, experimentation, adaptations, and even workarounds in groups or communities of practice. At least some emergent behavior occurs in relation to most software applications as users figure out how to use those applications effectively and efficiently, sometimes through workarounds related to design flaws, mismatches of IT artifacts' features with local situations, and other unanticipated circumstances. Emergent behavior is even more prominent in the computing ecologies discussed by Lyytinen (2010), with their multiple devices, multiple sources of data, and multiple streams of tasks.

Undesirable Behavior

For completeness, it is useful to include a category of undesirable behavior. This involves interactions within or between systems of people and/or machines that generate disruptive or costly impacts that designers, owners, and other responsible stakeholders view as negative or even catastrophic. Such behavior may result in relatively minor glitches and inefficiencies, or may involve sudden, cascading technical or sociotechnical failure. A widely recognized category of undesirable behavior involves work system malfunctions while airplane autopilots are being used. In such situations, some combination of software bugs, pilot inattention, human error, and misunderstanding of the technology or of relevant recovery procedures results in dangerous conditions such as loss of control of the aircraft. A specific example of a different type of undesirable behavior is the May 6, 2010 mini crash of the stock market, in which major market indexes dropped over 7% in a 15 minute span, and in which the price of several major stocks plummeted briefly to $0.01, only to return quickly to normal price ranges. While investigations have not been completed, it is possible that risk minimization responses by managers of the algorithmic trading operations may have contributed to the mini crash. Managers in a number of firms turned off algorithmic trading to avoid excessive risk at a time of high price volatility caused by transient imbalances between supply and demand across multiple stocks markets. Turning off algorithmic trading may have exacerbated the imbalances. The circumstances of the mini crash fall under the definition of HCI, "interaction between humans, information, technologies, and tasks." Even though many, and perhaps all, individual actions of people and machines were proper, the systemic result was a frightening mini crash.

< < < ---------- Social/ Technical Category ---------- > > >	Engineered Behavior	Guided Behavior	Emergent Behavior	Undesirable Behavior
Society			• Societal change • Digital divide • Technological society • E- government	• Societal risks
Enterprise		• Sales and service through e-commerce web sites	• Organizational culture • Social infrastructure • Dynamic capabilities	• Corporate fraud
Organization or Group	• IT-reliant bureaucracies • IT-enforced business rules • Electronic sweatshops	• Human activity systems • IT-reliant work systems • Behavioral norms	• Organizational adaptations and workarounds during adoption and usage • IT-related experimentation • Social networks • Communities of practice • Diffusion of innovation	• Collusion through use of computers
Individual	• Human tasks controlled using HW/SW • Computer self-efficacy • Cognitive style	• Task/ technology fit • Trust in e-commerce • Automated advisor tools	• Individual adaptations and workarounds during adoption and usage • Impact of cognitive or personality differences • Model building	• Interface-related user errors
Human-Computer Interface	• Specific human-computer interface features • Affordances • Ergonomics			• Problematic behavior due to flaws in interfaces
Specific IT Artifact (HW/SW)	• Form and operation of specific HW/SW artifacts			• Problematic behavior due to specific HW/SW artifacts
Composite IT Artifact (network, software)	• Form and operation of specific composite artifacts		• Local IT Ecology	• Cascading IT system interactions
Societal IT Artifact	• Societal, tracking and control systems		• Internet • Wikipedia • Impacts on personal privacy	• Cascading technical failures

< < ---------- Type of Behavior ------- > > >

Figure 1: HCI Topics and Issues

< < < ---------- Social/ Technical Category ------- > > >	Engineered Behavior	Guided Behavior	Emergent Behavior	Undesirable Behavior
Society			• Societal change theory • Digital divide theory • Computing in everyday life	
Enterprise			• Theories of culture • Social infrastructure theory • Dynamic capabilities theory	
Organization or Group	• Business process • Management (BPM) • Bureaucracy theory	• Design theories • Soft system methodology • Multiview • Coordination theory • Work system method	• Structuration theory • Actor-network theory • Activity theory • Computers are social actors (CASA) • Social network theory	• Agency theory
Individual	• Theories of motivation and personality	• Task/ technology fit • Theories of motivation and personality • Theories related to trust of artifacts	• Technology acceptance model • Theory of planned behavior • Utility theory • Behavioral economics	• Agency theory
Human-Computer Interface	• Interface design theory • Ergonomics	• Cognitive theories		
Specific IT Artifact (HW/SW)	• Theories and tools of software engineering and agile development		• Theories and tools of end user development	
Composite IT Artifact (network, software)	• Theories and tools of software engineering		• Ecological theories	• Risk analysis • Simulation
Societal IT Artifact				• Risk analysis • Simulation

< < ----------- **Type of Behavior** ------- > > >

Figure 2: Examples of Theories, Techniques, and Tools in HCI

Table 1: Social/ technical categories in Figures 1, 2, and 3.

Society	HCI topics or issues typically discussed in relation to society as a whole, rather than to enterprises, organizations, groups, or individuals.
Enterprise	HCI topics or issues typically discussed in relation to entire enterprises, rather than organizations, groups, or individuals. Within this category, the achievement of enterprise goals is viewed as more important than the details of the interfaces or the way individuals do their work.
Organization or group	HCI topics or issues typically discussed in relation to organizations within enterprises (e.g., departments) or groups of people. The main concerns within this category involve the ways in which organizations and groups apply IT while performing business tasks. At this level the achievement of process or functional goals is more important than the details of the interface.
Individual	HCI topics or issues typically discussed in relation to activities or beliefs of individuals, or impacts on individuals. The main concerns within this category involve the ways in which people use IT to perform individual tasks that may or may not be viewed as part of a larger function of a group or organization.
Human-computer interface	The point of contact between people and computerized devices. This is in the middle of the social/ technical dimension. The main concerns within this category involve the affordances and ergonomics of interfaces.
Specific IT artifact (HW/SW)	Specific hardware and/or software (HW/SW) that are used directly by end users. HCI topics within this category that were mentioned by Zhang et al. (2009) include development methods and tools, software/hardware development, and evaluation. (Note: This assumes that an IT artifact is a specific configuration of hardware and software technologies, rather than a partially social artifact containing human participants.)
Composite IT artifact	IT artifacts such as networks and large software suites that contain or integrate many individual IT artifacts that are used separately.
Societal IT artifact	IT artifacts such as the Internet that can be described as being societal resources rather than resources designed for the use of specific enterprises.

Table 2: Categories in the dimension "type of behavior" in Figures 1, 2, and 3

Engineered behavior	Behavior by people and/or machines that is designed to be performed in a specific manner. In relation to user interfaces, engineered behavior involves the precise details of using the interface, such as exactly which keys to press and exactly what the messages mean. In relation to business processes and activities, rather than interfaces per se, work system designers try to assure conformance to data definitions and business rules in highly structured tasks whose business outcomes call for conformance rather than flexibility.
Guided behavior	Behavior by people and/or machines that is designed to be performed in a flexible manner that emphasizes the exercise of judgment and creativity rather than conformance to business rules. IT artifacts designed to guide behavior rather than assure conformance provide users choices about how to proceed based on a combination of situational information, models, and personal knowledge and experience. Even when the business purpose of such an IT artifact is to support guided behavior, the details of the artifact's user interface should be unambiguous in form and should represent the intent of engineered behavior.
Emergent behavior	Behavior by people and/or machines that is not guided or scripted in advance by designers and analysts, but emerges through discussion, experimentation, adaptations, and workarounds in groups or communities of practice. Emergent behavior in relation to business processes and activities may occur even when the details of user interfaces are highly engineered. For example, by changing work practices rather than user interfaces, work system participants may create workarounds that allow them to complete tasks more efficiently than would be possible if they worked in accordance with designer's assumptions and/or intentions. On the other hand, workarounds could undermine important work system goals, such as consistency and traceability.
Undesirable behavior	Transient or persistent situations in which interactions within or between systems of people and/or machines generates disruptive or costly behavior that designers, owners, and other responsible stakeholders view as negative or even catastrophic. Such behavior may result in relatively minor glitches and inefficiencies, or may involve sudden, cascading technical or sociotechnical failure. As noted in Figure 2, agency theory is one of the theories that may be useful in analyzing undesirable behavior involving IT use, disuse, or misuse by individuals or groups (including opportunistic behavior and collusion). While the undesirable behavior is mostly about the capabilities and interactions of IT artifacts, the analysis probably requires tools and techniques such as risk analysis and simulation (in the lower right).

USING THE HCI FRAMEWORK

Figures 1 and 2 illustrate the use of two dimensions for visualizing the scope of HCI in relation to the broad scope of topics that fall within the definition of HCI used by *THCI*. As cited at the beginning of this article, that scope includes IS issues and concerns, but with a "specific focus on the history, reference disciplines, theories, practice, methodologies and techniques, new developments, and applications of the interaction between humans, information, technologies, and tasks, especially in the business, managerial, organizational, and cultural contexts" (Galletta and Zhang, 2009, p. 8). Figure 1 uses the two dimensions to position typical HCI topics and issues. Figure 2 uses the same dimensions to position HCI-related theories, techniques, and tools. Later, Figure 3 will use the same dimensions for identifying potentially fruitful areas in which less research has occurred.

Perceived center of gravity

The selection and location of all of the entries in Figures 1 and 2 are based on my view of their inclusion within the broad definition of HCI and their "center of gravity" in relation to the various aspects of HCI that they might touch. For example, Figure 1 positions "human tasks controlled using hardware/ software" as engineered behavior at the individual level. It is also possible to view many aspects of human tasks as occurring at the group or organization level. Figure 1 mentions adaptations and workarounds at both the individual level and the organization or group level because it is possible to talk about each category separately. Omitted from Figure 1 is the fact that some workarounds appear at the enterprise level, and that some generate undesirable behavior, as might happen with workarounds related to financial accounting systems in banks. Also, some topics appear in both Figure 1 and Figure 2 because it isn't obvious whether, for example, dynamic capabilities is a topic for HCI or a theory that might be used in HCI research involving IT capabilities and usage.

Other authors would likely select different entries in many of the cells in Figures 1 and 2. The purpose of these figures is to identify a selection of typical topics, issues, techniques, tools, and theories related to HCI. Far beyond this paper's scope and purpose, a much longer paper might try to enumerate most of the topics and issues that fall under the umbrella of HCI, and might provide references and explanations for each entry.

More about Figure 1

All of the topics and issues in Figure 1 are related to the broad view of the scope of HCI that was mentioned earlier. Many of the topics and issues in Figure 1 fit traditional views of HCI in an obvious way, for example, affordances and ergonomics related to human-computer interfaces, human tasks controlled by hardware/ software, and computer self-efficacy. Other topics, such as the digital divide, IT-reliant bureaucracies, electronic sweatshops, and the form and operation of societal tracking and control systems, seem rather distant from the central concerns of a narrow view of HCI, even though they are related to methodologies, practice, developments, and applications of the interaction between humans, information, technologies, and tasks in business or cultural environments. Whether or not such topics belong under the umbrella of HCI is basically a question of personal preference for either a narrower, more traditional definition of HCI or a broader, more expansive definition of the type proposed for *THCI* by Galletta and Zhang (2009). Yoo's (2010) call for research on computing in everyday life raises issues that span many of the cells in the framework. On the other hand, Sun and Zhang's (2008) investigation of adaptive use of features in the MS Office Suite by individuals is an example of deeper investigation within specific cells of the framework.

The association of topics with types of behavior illustrates a diverse array of concerns. Topics associated with engineered behavior include, among others, IT-reliant bureaucracies, IT enforced business rules, affordances and ergonomics of interfaces, and societal tracking and control systems. These examples represent an engineering approach of defining rules for behavior of work system participants or for automatic data collection and compilation. The topics related to guided behavior are fundamentally about situations in which designers cannot fully control the behavior of participants in specific work systems (including customers who use e-commerce web sites), but can use IT to guide participants' behavior. The topics related to emergent behavior are fundamentally about situations in which processes and IT usage patterns may be adapted or modified by work system participants, or in which unplanned interactions between technical and/or human components may generate unanticipated patterns of activity and unanticipated results. The topics associated with undesirable behavior are examples of things that can go wrong within each social/ technical category.

More about Figure 2

The theories, techniques, and tools in Figure 2 are only a subset of what might be included in a highly detailed discussion of the HCI literature. It would be interesting to see which theories are used and which have not been used in HCI. It is unfortunate that Zhang et al. (2009) did not discuss the relative prominence of different specific theories used in HCI research, though cataloguing specific theories in 693 HCI papers would have been a huge task (especially since theories might be named differently or used only implicitly or in combination with other theories).

As with Figure 1, Figure 2 raises questions about whether specific items should be included, and if so, where they should go. For example, theories and tools of software engineering are associated with engineered behavior and with specific IT artifacts and composite artifacts because the goal of most software engineering is to control behavior in a work system. On the other hand, theories and tools of end user development are associated with emergent behavior because of the iterative nature of the end user development. Cognitive theories are listed in the cell for human-computer interface and guided behavior because they are relevant to the design of interfaces, and because many of those interfaces are concerned with guiding behavior rather than enforcing engineered behavior. Despite being shown in that cell, cognitive theories could also be associated with other cells, including all of the cells related to individual behavior.

Figure 3

The goal of providing illustrative entries in Figures 1 and 2 was to set a context for using the same dimensions in Figure 3 to visualize the scope of HCI topics identified by Zhang et al. (2009) in their review of 2,302 IS papers. The categories used in that review (A01-A07 and B01-B10) are positioned in Figure 3, which shows that those categories are mostly about engineered or guided behavior by individuals using IT artifacts through human-computer interfaces. This is consistent with their finding that "618 papers (or 81.5%) addressed the individual level only, 48 papers (6.3%) the group level only, and 59 papers (7.8%) addressed both individual and group levels. That is, the majority of papers in this collection were concerned with individual level of analysis" (Zhang et al., 2009, Table 14, p. 70).

As with Figures 1 and 2, the locations of categories A01-A06 and B01-B10 in Figure 3 are an interpretation of where the categories belong. For example, A02, A07, B09, and B10 are listed at the organization or group level because those topics usually occur in group or organizational settings. All of the "B" topics straddle cells for engineered behavior and guided behavior because many of the B topics such as belief, attitude, motivation, and emotion imply applications that involve guided behavior. The location of the categories in Figure 3 shows that the HCI review focused primarily on research related to engineered or guided behavior, and seemed to contain little research related to emergent behavior, either at the individual, group, organization, or enterprise level, or at the level of emergent IT ecologies.

The three questions in the emergent behavior area of Figure 3 encompass many topics that have been the focus of some research but deserve much more. Lyytinen's (2010) comments about "richly featured computing ecologies" point to research topics up and down the social/technical dimension. Emergent behavior generated by interactions between technically complex IT systems can be viewed from a largely technical perspective, emphasizing interference or mutual synergy between co-existing technologies that are used for overlapping or unrelated purposes and that provide overlapping or non-overlapping functionalities. The same topic can be viewed through the lens of adaptive user behavior or post-implementation behavior in organizations. Those two lenses are more in line with Figure 3's other two questions related to emergent behavior: What about emergent behavior at the individual level as people learn about tools and systems, and what about emergent behavior as organizations implement and infuse technologies that affect people, information, and work. In recent research related to those topics, Sun and Zhang (2008) identified four types of adaptive use of computerized tools by individuals: trying new features, feature substitution, feature combination, and feature repurposing. They found that triggers such as novel situations, discrepancies, and deliberate initiatives were the most important antecedents of adaptive use. Sun and Zhang cite previous research by Jasperson et al. (2005) and others who pursued related topics at more of an organizational level.

Yoo's (2010) call for attention to experiential computing in everyday life adds another aspect of Lyytinen's (2010) "richly featured computing ecologies" by suggesting opportunities in three areas that can be located in the framework in Figures 1, 2, and 3. Focusing on experiential computing and digitally mediated everyday experiences, Yoo's area of theory development and testing parallels the social portion of the social/technical dimension in the Figures by identifying opportunities at the individual, group, organization, and community levels. His area of building and evaluating artifacts focuses somewhat more on the technical aspects of design, i.e., the technical portion of the social/technical dimension. His third area, infrastructure, is also in that part of the framework. All of these areas can be viewed across the horizontal dimension ranging from engineered to guided to emergent behavior.

And what about undesirable behavior? One might speculate about the extent to which the HCI literature addresses questions about undesirable behavior rather than desirable efforts to perform computing and business tasks consistent with the best intentions of users, managers, and organizations. The right hand side of Figure 3 contains four repetitions of a question about undesirable behavior, which can occur at levels ranging from interactions between configurations of IT artifacts to undesirable uses of IT artifacts by individuals, groups, organizations, enterprises, or society as a whole. It would be interesting to see how strongly issues related to desirable vs. undesirable behavior are addressed in the HCI literature, or alternatively, if the HCI community views that as part of a different discourse.

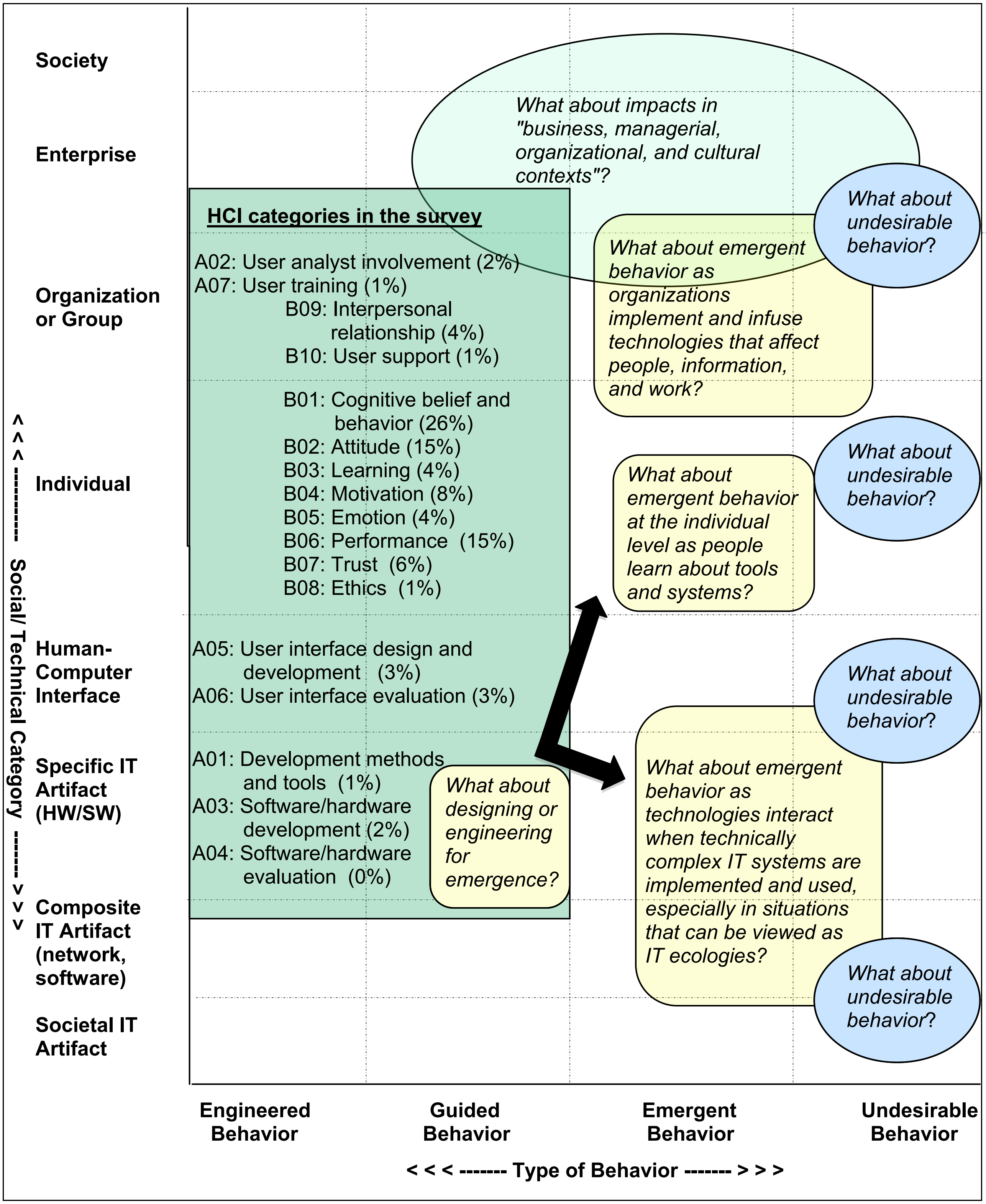

Figure 3: HCI Categories in the Classification Scheme in Zhang et al. (2009, Table 9, p. 66), with questions in some of the blank spaces (percentages are rounded)

OBSERVATIONS AND CONCLUSIONS

Consistent with *THCI*'s invitation to submit short research commentaries related to future directions of HCI, it is necessary to conclude with several brief comments that may contribute to discussions of future directions for HCI research.

New framework for visualizing the scope of HCI

The framework used in Figures 1, 2, and 3 may be useful in future discussions related to the scope of HCI and to the identification of HCI research topics. The social/technical dimension is more granular than a simple social versus technical distinction. The fact that it extends outward in two directions from the human computer interface may suggest new ways of visualizing HCI topics and research. The behavior dimension's distinction between engineered and emergent behavior may also help in visualizing HCI topics and research by pointing in directions beyond engineered and guided behavior.

Possible omissions or blind spots in HCI research

A comparison of Figures 1, 2, and 3 shows that many topics within the general definition of HCI do not fit well into the categories used by Zhang et al. (2009) in their review of HCI research. Figures 1 and 2 list a number of topics and theories that are probably not represented significantly in the 693 papers that were categorized as HCI papers. Some of those topics may prove to be important in future HCI research. For example, it appears from the categorizations in Figures 1, 2, and 3 that emergent behavior is underrepresented in the HCI research covered in this review. This is consistent with the statement that " IS scholars are mainly interested in HCI issues that are concerned with IT use and impact at the individual level in organizational and work contexts. Other topics (i.e., IT development), other contexts (e.g., social), and other analysis level (i.e., group) are gaining more attention in recent years" (Zhang et al., 2009, p. 72). Whether or not emergent behavior is underrepresented, it is certainly not absent. Topics related to emergence appear in quite different forms in papers by Tyre and Orlikowski (1994), Germonprez et al. (2007), Sun and Zhang (2008), and Yoo (2010).

Theories in HCI research

Zhang et al. (2009) did not compile a list of theories used in HCI research. It would have been interesting to discuss the relative contribution of specific theories, and then to identify theories that might contribute but have not been used extensively in HCI research. Although it is impossible to verify without the source data, it seems likely to me that identification of theories would have shown that certain aspects of HCI research were underrepresented in the survey because of the choice of which journals to include or exclude. For example, theories related to emergent behavior may be represented minimally among the 693 papers even though they have been used by many researchers to study situations involving interactions between people, computers, information, and tasks in organizational settings. Examples of such theories include:

- Structuration theory (Giddens, 1984)
- Actor network theory (Walsham, 1997)
- Activity theory (Kuutti, 1995; Kaptelinin and Nardi, 2006; Mursu et al., 2007)
- Theories related to infrastructure and ecology in organizations (Star and Ruhleder, 1996; Star and Bowker, 2002; Pipek and Wulf, 2009)
- Theories related to tailorability of technologies (Tyre and Orlikowski, 1994; Germonprez et al. 2007)

These theories and many others may provide an interesting perspective on phenomena that are distant fromthe details of human-computer interfaces but fall within the definition of HCI.

Designing and engineering for emergence

Broadening the intent of Benbasat's (2010) suggestion that "research in HCI should have a design component coupled with an evaluation of this design" (p. 16), designing and engineering for emergence presents a significant challenge for HCI research. Such research would recognize Orlikowski and Iacono's (2010, p. 131) premises about IT artifacts (in their broad sense of the term), including that "IT artifacts are neither fixed nor independent, but they emerge from ongoing social and economic practices," that IT artifacts are not static or unchanging, but dynamic," and that "IT artifacts are usually made of a multiplicity of fragile and fragmentary components, whose interconnections are often partial and provisional and which require bridging, integration, and articulation in order for them to work together."

The relative absence of HCI research in the right side of Figure 3 related to emergent behavior seems to imply that past HCI research in the spirit of Orlikowski and Iacono's premises is relatively rare. Attention to the distinction between engineered and emergent behavior may help in thinking about future HCI research that addresses emergence in the context of interactions between people, information, technologies, and tasks. Such research would provide a counterbalance to the widespread attention to precise specifications of process and information requirements (e.g., topics in typical systems analysis books and numerous articles about the quality and use of UML, BPMN, and other specification formalisms).

Attention to undesirable behavior

The right hand column of Figures 1, 2, and 3 calls attention to undesirable behavior as a possible HCI topic. The frequency of that issue in the 693 papers analyzed by Zhang et al. (2009) would be an indicator of whether the HCI literature tends to emphasize proper or desired usage and underemphasize misuse, disuse, sabotage, and other forms of undesirable behavior.

HCI in IS vs. HCI in general

One possible explanation of the blank spots in Figure 3 is that many of the articles in the sample came from journal outlets that are favored by researchers who associate themselves with the academic IS field. A broader sample might have included journals and conferences favored by computer scientists and other researchers focusing on topics such as computer-supported cooperative work (CSCW) and virtual teams. While the sample included 46 papers on GDSS and CSCW (Zhang et al., 2009, p. 80), it is possible that such topics would have received more space in other journals. Thus, it is possible that a form of academic selection bias affected the results through the omission of research by groups of researchers who have a great deal to say about HCI even though they may not be viewed as members of the academic IS community.

Characterization of unique interests of IS scholars related to HCI

Zhang et al. (2009) said, "IS/HCI researchers are not particularly interested in humans *per se*, which would be the interest of psychologists, and they are not particularly interested in artifacts *per se* either, which would engage computer scientists. IS/HCI researchers apply a unique perspective to study humans interacting with technologies in certain contexts" (p.60). Although I may be overreacting to wording that could have been chosen differently, I think it is worthwhile to close by asking whether this unique perspective really exists, especially if 30% of IS research publications seem to fall under the umbrella of HCI.

To me, the claim about "a unique perspective" of IS/HCI researchers does not ring true. The idea of a unique perspective is reminiscent of debates about whether IS needs its own theories and whether IS researchers should focus on topics within a nomological network and avoid topics outside of that network. While this is not the place to rehash that debate, a claim that IS/HCI researchers "are not particularly interested in humans *per se* or in artifacts *per se"* seems inappropriate. I think HCI should not downplay proposals like those of Lyytinen (2010), which address important topics but don't fit the claimed unique perspective because they require too much attention to capabilities and limitations of specific technologies. HCI also should not discourage potential research that falls under Orlikowski and Iacono's (2001) call for greater attention to the IT artifact in IS research.

REFERENCES

Alter, S. (2008) “Defining Information Systems as Work Systems: Implications for the IS Field.” *European Journal of Information Systems*(17) 5, pp. 448-469.

Benbasat, I. (2010) “HCI Research: Future Challenges and Directions,” *AIS Transactions on Human-Computer Interaction* (2) 2, pp. 16-21.

Benbasat, I and R. W. Zmud (2003) "The Identity Crisis within the IS Discipline: Defining and Communicating the Discipline's Core Properties," *Management Information Systems Quarterly* (27) 2, pp.183-194

Galletta, D. and P. Zhang (2009) “Introducing AIS Transactions on Human-Computer Interaction,” *AIS Transactions on Human-Computer Interaction* (1) 1, pp. 7-12

Germonprez, M. D. Hovorka, and F. Collopy (2007), "A Theory of Tailorable Design," *Journal of the Association for Information Systems*(8) 6:2, pp. 351-367.

Giddens, A. (1984). *The Constitution of Society*, Berkeley, CA: University of California Press.

Jasperson, J.S., P.E. Carter, and R.W. Zmud (2005) "A comprehensive conceptualization of the post-adoptive behaviors associated with IT-enabled work systems," *MIS Quarterly* (29) 3, September, pp 525-557.

Kaptelinin, V. and B. A. Nardi (2006) *Acting with Technology: Activity Theory and Interaction Design*, Cambridge, MA: The MIT Press.

Kling, R. and W. Scacchi (1982) "The web of computing: Computer technology as socialorganization," *Advances in Computing* (21) pp. 1-90.

Kuutti, K. (1995) "Activity Theory as a potential framework for human-computer interaction research," pp. 17-44 in B. Nardi, *Context and Consciousness: Activity Theory and Human Computer Interaction,* Cambridge, MA: The MIT Press.

Lyytinen, K (2010) "Human-computer Interaction Research: Future Directions that Matter," *AIS Transactions on Human-Computer Interaction*(2) 2, pp. 22-25.

Lyytinen, K. and M. Newman (2008) "Explaining information system change: a punctuated socio-technical change model," *European Journal of Information Systems* (17), pp. 589-613.

Magalhães, R. and A. R. Silva (2009) "Organizational Design and Engineering (ODE)," Working Paper No. 1, Version #4, Centre for Organization Design and Engineering, Lisboa, Portugal.

Mursu, A., I. Luukkonen, M. Toivanen, M. Korpela (2007). Activity theory in information systems research and practice - theoretical underpinnings for an information systems development model *Information Research* (12)3, paper 311, Retrieved Dec. 22, 2010 from http://InformationR.net/ir/12-3/paper311.html

Orlikowski, W.J. and C. S. Iacono (2001) "Research Commentary: Desperately Seeking the "IT" in IT Research - A Call to Theorizing the IT Artifact," *Information Systems Research*(12)2, pp. 121-134.

Pipek, V. and V. Wulf (2009) "Infrastructure: Toward an Integrated Perspectice on the Design and Use of Information Technology," *Journal of the Association for Information Systems*(10) 5:6, pp. 447-473.

Star, S. L. and G. C. Bowker (2002) "How to infrastructure," in L. A. Lievrouw and S. Livingstone, (Eds.) *Handbook of New Media - Social Shaping and Consequences of ICT*s, London, UK: SAGE Pub., pp. 151-162.

Star, S.L. and K. Ruhleder (1996), "Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces," *Information Systems Research* (7)1, pp. 111-134.

Sun, H. and P. Zhang (2008) "Adaptive system use: An investigation at the system feature level." International Conference on Information Systems (ICIS), Paris, France, 2008.

Tyre, M.J. and W.J. Orlikowski (1994) "Windows of Opportunity: Temporal patterns of technological adaptation in organizations," *Organization Science*(5)1, pp. 98-118.

Walsham, G. (1997) "Actor-Network Theory and IS Research: Current Status and Future Prospects," in A.S. Lee, J. Liebenau, and J.I. DeGross, *Information Systems and Qualitative Research*, Proceedings of IFIP Working Group 8.2 Conference, London,UK: Chapman and Hall, pp. 469- 480, Philadelphia, PA, May 31- June 3, 1997.

Yoo, Y. (2010) "Computing in Everyday Life: A Call for Research on Experiential Computing," *MIS Quarterly*(34) 2, pp. 213-231.

Zhang, P., I. Benbasat, J. Carey, F. Davis, D. Galletta and D. Strong (2002) "Human-Computer Interaction Research in the MIS Discipline," *Communications of the Association for Information Systems* (9) 20, pp. 334-355.

Zhang, P., J. Carey, D. Te'eni, and M. Tremaine (2005) "Integrating Human-Computer Interaction Development into the Systems Development Life Cycle: A Methodology," *Communications of the Association for Information Systems* (15) 29, pp. 512-543.

Zhang, P, N. Li, M. J. Scialdone, and J. Carey (2009) "The Intellectual Advancement of Human-Computer Interaction Research: A Critical Assessment of the MIS Literature (1990-2008)," *AIS Transactions on Human-Computer Interaction*(1) 3, pp. 55-107.

ABOUT THE AUTHOR

Steven Alter is Professor of Information Systems at the University of San Francisco. He earned a Ph.D. from MIT and extended his thesis into one of the first books on decision support systems. He served for eight years as Vice President of Consilium, a manufacturing software firm that went public and later was acquired by Applied Materials. His research for the last decade has concerned developing systems analysis concepts and methods that can be used by typical business professionals and can support communication with IT professionals. His 2006 book, *The Work System Method: Connecting People, Processes, and IT for Business Results*, is a distillation and extension of ideas in 1992, 1996, 1999, and 2002 editions of his information system textbook, which raised awareness of the essential role of IT in work systems in organizations. His articles have been published in *Harvard Business Review, Sloan Management Review, MIS Quarterly, IBM Systems Journal, European Journal of Information Systems, Decision Support Systems, Interfaces, Communications of the ACM, Communications of the AIS*, *CIO Insight*, *MIS Review, Journal of Relationship Marketing, International Journal of Organisational Design and Engineering* and many refereed conference proceedings.

ISSN: 1944-3900

Transactions on Human-Computer Interaction