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User Psychology: Re-assessing the Boundaries of a Discipline

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Currently, efforts of psychologists to improve interactive technology have fragmented and the systemization of scientific knowledge stalled. There is no home for integrative psychological research on computer use. In this programmatic paper, we reassess three meta-scientific issues defining this discipline. As the first step, we propose to extend the subject of study from the analysis of human mind in the interaction to the broader view of human as an intentional user of interactive technology. Hence, the discipline is most aptly called user psychology. Secondly, problem-solving epistemology is advocated as an alternative to the notion from natural sciences that progress in science involves increased truth likeness of theories. We hold that implications to design is only one outcome of psychological work—user psychologists should help solving the problems of other stakeholders of technology as well. Thirdly, to help integrating fragments of research, analyses should be re-organized around explanatory frameworks that can span multiple technical application areas. An explanatory framework combines a problem domain, relevant knowledge, and the logic of scientific inference. To conclude, we argue that technology has become so pervasive an aspect of modern life that its relationship with human mind deserves the status of a basic research question and its own discipline. Psychology of the computer user should not be the handmaiden of technologists but define itself by its own terms.

Keywords: Psychology HTI User

Introduction

User psychology denotes the investigation of human use of technology by means of psychological methods, concepts, and theories. User psychologists study human action and its psychological preconditions in the setting of technology use, with an aim to contribute to pragmatic efforts in improving technology. Central in user psychological work is identification and analysis of use-related phenomena in terms of psychological theories. Deep understanding of the mental life of computer users can be useful for many stakeholders of interactive technology, including design, engineering, legislation, education, and decision-making, among other areas. In constructive projects, user psychology can help transforming intuition-based practices to evidence-based practices and thereby improve technology. This paper is about user psychology—what it has been and, more importantly, what it should be.

The goal of the paper is to solve an important dilemma characterizing the status quo. On the one hand the mode of psychological inquiry laid down for us in the eighties has been criticized numerous times as too delimited and incompatible. On the other hand, there nevertheless are active and seemingly fruitful areas of psychological inquiry in human-computer interaction (HCI), but these areas apparently do not fit in any existing meta-scientific characterization of a discipline that includes psychology. We believe it is the time to revisit the foundations of the discipline and to reconsider what it entails. A careful approach would be to update the meta-science only minimally, to the extent that these divergent areas could be subsumed. A more future-oriented way would be to update the meta-science so that its capacity to generate new perspectives and organize research was increased.

The basic idea of searching for and exploiting psychological knowledge in the development of technology has existed for a long time and exhibited different forms. Before systematic lines of inquiry can be said to have started, many pioneers were inspired by psychological concepts: Alan Turing and Douglas Engelbart by the concept of intelligence, J.R. Licklider by problem-solving, and Vannevar Bush by memory. Much of the early human factors research was also psychologically oriented (Welford, 1968). The end of the seventies and the beginning of the eighties saw systematic lines of inquiry being established to examine the use of computers. Researchers (James, 1973; Sackman, 1970; Schackel, 1959; Shneiderman, 1976; Weinberg, 1971) began to scientifically investigate human cognition in computer use and especially in the domain of programming. These studies were closely connected with the research in skills and expertise (Chase & Simon, 1973; de Groot, 1965, 1966). One illustrative finding was that programmers become better programmers by becoming better in remembering and "chunking" the parts of code that are not visible on the display (McKeithen, Reitman, Rueter, & Hirtle, 1981).

Although not the first to discuss the use of psychological knowledge in the study of computer use, Moran (1981) was the first to propose a wider description than behaviorally and cognitively oriented human factors and ergonomics. The term *user psychology* was suggested by Moran (1981) in an introduction to a special issue of *ACM Computing Surveys* entitled *The Psychology of the Computer User*. He called that special issue "the debut of user psychology." The selling point was that design processes would be based on solid psychological princeples instead of "folk psychology" (Moran, 1981). However, Moran's original formulation has been cited relatively seldom. It has not been systematically elaborated afterwards and has remained something of a curiosity. Moreover, in the subsequent book *The Psychology of Human Computer Interaction* (Card, Moran & Newell, 1983) the concept of user psychology was considerably narrowed (Clemmensen, 2006)—perhaps because the book presented the first model of the computer user, proposing a prediction-oriented simulative approach as the ideal of the new discipline. Although Card et al. did not rule out other sciences, their focus on cognition was found too limited a view to interaction. More controversial was their endorsement of a "hard science" approach, proclaiming that quantitative prediction should be the goal of research (Carroll & Campbell, 1986; Newell & Card, 1986).

As we know, not everyone felt satisfied with the original cognitive scientific description of the discipline, and the eighties and the nineties witnessed several "divorces" from the mainstream. Alternative agendas started to emerge that either defined them in terms of how they differ from the "cognitivist" orientation or were interpreted that way by others (Bødker, 1989; Carroll & Campbell, 1986; Carroll, 1991; Ellis & Nutt, 1980; Grudin, 1990; Heath & Luff, 2000; Helander, 1997; Kuutti, 1996; McCarthy & Wright, 2004; Picard, 1997; Suchman, 1987; Winograd & Flores, 1986).

Psychology of programming was deemed problematic due to its inability to derive applicable and specific enough knowledge for developers (Carroll 1991, 1997), and during the decade that followed, several important applications of psychological science emerged to address needs of practitioners: user-centered design (Norman & Draper, 1986), cognitive task analysis (Annett & Duncan 1967, Diaper & Stanton 2004, Kirwan & Ainsworth, 1992; Schraagen & Chipman, 2000), ethnography in human factors research (Blomberg, Burrell & Guest 2002) and scenario-based design (Carroll, 2000; Rosson & Caroll, 2002). Testing methods were derived for the purposes of designers, engineers, and information systems scientists (Nielsen, 1993). Usability engineers were perhaps less able to exploit psychological knowledge with the same rigor as the cognitive modeling camp and turned out to become a testing-centered practice seeking standardized procedures. These applications of psychology to both design and engineering have become somewhat detached from contemporary psychology; mainstream psychology is referred to quite rarely.

If the first two divorces were motivated by pragmatic needs (of designers and engineers) and theoretical disputes, the third "divorce" has been due to the landslide development of interactive technologies during the past two decades. Or instead of divorce, one could describe this development as "fragmentation across topics, theories, methods, and people" (Olson & Olson, 2003). Good examples of recent areas that are "psychologically loaded" include ubiquitous computing (Weiser, 1991), affective computing (Picard, 1997), ambient displays and tangible interaction (Ishii & Ullmer, 1997), attentive interfaces (Vertegaal, 2003), and mixed-initiative interfaces (Horvitz, 1999). Many of these and other emerging areas clearly touch psychological themes and needed to entice psychologists. However, research has been technologically rather than psychologically defined, and most work has been rather experimental. These circumstances are unfortunate, because they have led to a myopia which has hindered grounding the work to relevant bodies of knowledge in mother disciplines and countered the accumulation of findings and elaboration of theories.

We believe that enough criticism has been voiced and it is time to face the facts and address the problem. It is time to turn attention to the most elementary demarcations that define a discipline. The problems of the above type cannot be solved by conducting new studies; for this, foundational work is required—the analysis and critique of suppositions behind the paradigms (Saariluoma, 1997). To be constructive, we need to propose several "updates" to the meta-science of this discipline. Ultimately, in order to avoid being a slave to engineering, psychologists must start defining their work according to psychological themes rather than in respect to technological boundaries. This means re-thinking how we answer such questions as "what is the subject of psychological research in this area", "what are psychological theories about", "what kind of theory is useful," and "what is the role of psychological research in constructive efforts like design." In this paper, we address these question by considering the broadest possible terms of any discipline: subject of inquiry (the user in action), the purpose of scientific work (problem solving), and the mode of scientific inference (explanation).

Our agenda is threefold. Firstly, we propose to extend the subject of study from the interaction loop to the human as an intentional actor, human in the role of using a computer for something. Hence, we propose readopting the term *user psychology*. From this perspective, user psychology becomes in part analogous to other applied psychology disciplines that also study the human in specific activities, such as traffic psychology, aviation psychology, counseling psychology, or political psychology. However, it is evident that some revisions to the previous notions of user psychology must be introduced. We believe that areas defined around the terms "interaction" or "cognition" or "factors" are too narrow. It is important to embrace a deeper view of humans as actors rather than as factors (Bannon, 1991). Although we propose redefining the subject of inquiry, we refrain from proposing an ideal method, as history has shown such attempts to be problematic and restricting progress.

Secondly, we propose a problem-solving epistemology (Laudan, 1977; Saariluoma, 1997, 2005), the core idea of which is that progress in science is tantamount to increased ability to solve problems (Laudan, 1977). In the setting of user psychology, these problems can be empirical, conceptual, or constructive by nature. Here, scientific advancement is marked not by getting closer to "truth" but by increased problem-solving ability. This epistemology is different from the traditional epistemology coming from natural sciences, but it fits excellently to the practical nature of contemporary thinking manifested well for example in the CHI conference's (CHI Conference, 2009) requirement for authors to explicate their paper's "contribution" (to the body of knowledge) and "benefit" (for practitioners). The problem-oriented view also points out that results of user psychology should not serve exclusively designers and engineers, but any and all stakeholders of interactive technology from citizens to customers to decision-makers. We echo many before us in the ideal of applicability of work; it is important to take the pragmatic origins and ambitions of HCI seriously. Despite the apparent lack of systematic theories, HCI as a discipline has been a moderate success both in the industry and in the academia, but it could and should do even better. User psychology should not get "off the hook" as happened with software psychology (Carroll, 1997). But neither is we proposing a "light weight" version of psychology for practitioners to exploit, as that has been problematic as well.

Our third proposition is put forward in order to help reor ganizing fragments of research currently splintered across technology-defined boundaries. We believe that good research should not be like a black box that reports results from measurements, but rather entail an in-built interest for systematic development of understanding. The way to shed light on recurring practical problems is to explain things, not only describe or measure them. This way, user psychology could help research already at the outset to set its goals more ambitiously and thereby overcome the problem of locality of results. The essence of our proposition is to build a bridge between scientific problems and useful solutions via psychological knowledge. What we call an explanatory framework combines a problem, relevant knowledge, and the logic of scientific inference. How these three components go together determine the applicability, specificity, and therefore the problem-solving capacity of a theory. The goal of restructuring an area around a general explanatory framework is systemization of psychological knowledge in this area and for other areas that are analogous. Importantly, we do not propose that the boundaries of these frameworks should be defined by boundaries within general psychology. Instead, user psychological areas should be defined by boundaries inherent in the phenomenon we are addressing: human use of interactive computing. In the history and present of HCI, many good examples of explanatory frameworks can be found, from mental models to motor control. However, that kind of integrative "basic research" has almost stalled during the last decade. Our proposal is that we raise explanation to a center stage in the new user psychology.

The main ambition of the paper is to explicate and re-assess the boundaries that define our discipline, with the purpose of re-directing psychologists to contribute to the broader bodies of knowledge that surpass individual application domains. We are proposing this programmatic agenda not for engineers or designers but for psychologists already working with technology-related issues. Researchers trained in psychology and already working with technology have both the theoretical competence and substance competence to formulate research questions in a manner that the solutions sought for them would have practical importance. The user psychology we are proposing will thus be an applied discipline from two perspectives: Firstly, because it is in intellectual debt to psychology and, secondly, because its main purpose is not search for truth but problem-solving. However, technology has become so pervasive an aspect of modern life that its relationship with the human mind is regarded now as a key conceptual problem of the information age. The problem of user psychology therefore deserves the status of a basic research question within psychology. We see it necessary that psychologists start taking computer use more seriously and eventually help developers to transcend testing-based practices and address the issue in psychology's own terms and rigor.

User—The Subject of Inquiry

The motif of a human agent working with a technological artifact is at the center of disciplines involved with the use of technology, such as CSCW and Workplace Studies, CMC, HCI, Human Factors, Ergonomics, and Information Systems. It is partly due to conceptualizations of the user that the preceding versions of user psychology have been found problematic and inadequate. Some approaches have not been necessarily contradictory or complementary, but have made tacit assumptions that have limited generality. Therefore, as banal as it may sound, the term *user* deserves attention. This, after all, is the subject of inquiry in *user* psychology. For proposing a synthesis, let us examine and learn from three major conceptions of the user in contemporary research.

First, the cognitivist school of HCI grounded their analytical work to Alan Turing's model of human mind that was later expanded by Newell and Simon (1972) into a model of human mentality. The point was to investigate users as information processing systems characterized by successive information manipulation operations (Anderson, 2002; Card, Moran, & Newell, 1983; Laird, Newell, & Rosenbloom, 1987; Meyer & Kieras, 1997; Gray, 2007). The most popular implementations have been based on production systems where information processing is a series of situationally triggered information manipulations guided by rules of the form: *if P* (attern) *then A*ction). In spite of the undeniable contributions of these models, some have remarked that they have little to say about emotional interaction, experience, motives, meaning, personality, or culture. Another counter-argument is that these models are mechanistic in their assumption that mental processes can be reduced to causal sequences (Dreyfus, 1992). These are not newly discovered limitations but were familiar already in the 1930s to Wittgenstein (1958) in his critical analysis of the Turing machine. For user psychology, the main problem is however whether a causalist computational language really has sufficient power of explaining intentional action (Searle, 1983). However, although there are counterarguments and limitations in the modeling approach, the core point of these models remain true: that internal mental events and properties of human mind can explain (some) observed behavior of the user.

Second, early activity theorists in HCI (Bannon & Bødker, 1991; Bødker, 1989; Kaptelinin, 1996; Kuutti, 1996; Nardi, 1996), whose rhetoric in many cases built on claimed inadequacies of the cognitive theories, drew from the Marxist pragmatic philosophy. The core idea of Marxist philosophy was that humans are what they do, *praxis* shapes them and is itself shaped by the institutions within which they function (Bernstein, 1971). Leontyev (1981), one of the founding fathers of activity theory, writes: "the human psyche's properties are determined by man's real relations with the world, which depend on the objective, historical conditions of his life" (p. 268). In present-day activity theorists' interpretation of interaction, the main unit of analysis is activity (Kuutti, 1996). Activities are driven by needs—not necessarily an individual's but an organization's—where a certain goal state is to be achieved. Activities themselves consist of actions of individuals that can be mediated by instruments or tools. Ergo, the core of being a user means utilizing a technological artifact in an activity in pursuit of a goal and satisfaction of a need. Technology is in a mediating role in human pursuits (Kuutti & Kaptelinin, 1997). While this formulation is acceptable, the most evident problem in the interpretations of contemporary activity theorists in HCI lies in their reluctance to systematically include mental aspects in their explanations of human action, although both Vygotsky (1980) and Leontyev (1981) were keenly interested in brain functions, consciousness, and cognitive capabilities (Roth & Lee, 2007). This stance closes out of discussion much of the psychological work realized and advancements achieved in psychology after the first half of the 20th century. The intuitive externalism—that is, the tendency to emphasize external dimensions of human action in constructing theory languages—has lead activity theorists to emphasize collaborative aspects of interaction, which of course is fruitful, but has largely disregarded known social psychological work on the same topics. Because of this, as activity theory is presently explicated, it does not provide a sufficiently elaborated model of user for modern user psychology. Its connection to modern empirical tradition of psychology remains shallow and it does not encourage efforts to integrate findings across disciplines. One consequence of intuitive externalism is, as Nardi (1996) observed, that the tradition is more descriptive than explanatory.

Third, phenomenology (Grossman, 1984) has provided an alternative, first-person view, to the study of user. In phenomenological accounts of human-computer interaction, the central feature of human action and experience is intentionality—being directed towards something. The philosophical roots of phenomenology involve authors such as Husserl (1913/1982), Heidegger (1927/1962), Gadamer (1960), Merleau-Ponty (1962) and Schütz (1932). *Encyclopedia of Phenomenology* (1997) distinguishes seven types of phenomenology, of which the most cited type within HCI has been Martin Heidegger's (1927，1962). Heidegger held that our activities are always "in the world" and we must not study these activities by bracketing the world, but by looking to the contextual relations that our activities and meanings have in the world. However, the concept of world does never in phenomenology refer to the naïve material world but it entails all our experiences and meanings. Phenomenologists take meaning and experiences of meanings central in their analyses of human-computer interaction. Dourish (2001) has opened up these notions for HCI by the terms intentionality, ontology, and intersubjectivity. Intentionality means the directness of actions and the intended effects of those actions, ontology concerns the ways in which we come to understand the computational world, and intersubjectivity reflects sharing of the world with other individuals. Importantly, these are not creations of the mind, but achieved in interaction with the material, social, cultural, and historical conditions of the world. Being a user boils down to one's experiences and meanings of "being in the world" achieved by using one's body to interact through technological artifacts. This characterization highlights the constructive relationship between the user's felt experience and intentions on the one hand and the material-social-cultural-historical conditions on the other. This approach brings about many sophisticated conceptual distinctions which are more or less absent both in cognitive and activity research. We agree with the claim that interaction is to be understood in terms of how people act *through* technology, not *on* it (Dourish 2001). Similarly to Winograd and Flores (1986), Dourish (2001) expands, for example, on Heidegger's idea of a tool being either "ready-to-hand" or "present-at-hand." The experience of objects depends on our actions and intentions—one and the same computer is seen as a different object by programmers, information systems scientists and secretaries, because their stances differ as a consequence of their work. If one admits that psychology is the study of mental processes and human behavior, there is no *a priori* reason to rule out phenomenological analyses from interaction discussions. Simulative cognitive science does not really capture experience by its concepts and consequently it remains silent on this phenomenon. Activity theorists do not refer to subjective or internalist conceptualizations and therefore they also have had little to say about felt experience. Phenomenologists are right in that experience exists and they have done an important service to the community by taking it under scrutiny. Methodologically and theoretically, however, phenomenologically oriented work has remained far from the main body of psychology. Phenomenologically oriented researchers have done relatively little experimental work; instead, they have made conceptual analyses and proffered folk psychological considerations on interaction (Svanaes, 2001). There is, of course, no apriori obstacle for experimentation as mode of inquiry among others. Moreover, among many other findings on experience, psychology has demonstrated that experience is not an island but rises as a consequence of other mental processes. Freud was already able to argue that conscious experience is generated by the unconscious. To understand consciousness we have to understand unconscious processes and include in our explanations emotional, social, and cognitive processes also at the neural level.

In sum, all three traditions reviewed entail important but different contributive elements for understanding the user, and they also have their limits. Knowledgeable of these, it is possible to begin to sketching a new way by taking contributive elements and unifying them into a new picture of a conception of a user. We propose viewing interaction first and foremost from an intentionalist perspective, distinguishing intentionality as the primary characteristic of the user. Interaction is action and the user's intentions are the source of personal significance and the guiding principle of that action. Thus, with phenomenologists we share the idea that human intentions are vital in explaining human actions. While material objects are subject to laws of natural sciences, human actions are intentional and goal-driven. The locus of scientific explanations of human action is in the future, what the human being intended to achieve (von Wright, 1972). I use my cell phone to call my friends in order to meet them and to socialize with them. Notions like usability, errors, and task performance can only be understood against this background. However, we should accompany phenomenological theorists only this far.

In fact, we believe we must give up the first person perspective and, instead, we should look at intentions from the third-person perspective, in order to save the objectivity of science and possibility to penetrate into subconscious mechanism as well as brain-based explanations. This perspective of looking consciousness from the outside has traditionally been called heterophenomenological (Dennett, 1991). In practice, it means that we can apply such methods as interviews and protocol analysis to study conscious experience (de Groot, 1965; Ericsson & Simon 1984). Cognitive and other areas of psychology have a lot to add to the notion of intentional agent. Let us assume that a person with an intention to write LISP code forgets something as the complexity of the required representation increases (Anderson, Farrell, & Sauers, 1984). The explanation of a failure of this kind is seldom in intention, but it must rather be searched from operations and capacities of the contributing psychological mechanisms, without which complicated actions, such as finding a link on a web page, or finding a menu item, are impossible.

In a sense, there is nothing new in the intentionalist conceptualization, as we habitually talk about users' goals and needs in HCI. Nonetheless, the nature of these guiding principles has not received the importance as it should have. For example, "user needs"—such as "need to drive screws fast, faster than by hand," in the context of screwdriver design (Ulrich & Eppinger, 2003)—do not often describe psychological needs at all but a sought-for performance of an artefact. Thus, the very nature of intention in interaction should be subjected to deeper scrutiny. Essentially, intrasubjective processes should contribute to explanations of intentional action. The positive side of this take is that the intentionalist view can help us to escape the criticism that psychologists too easily view interaction mechanistically and as a closed system, or through "boxologies" that reduce personal meaning into operations in information processing. We propose raising intentionality explicitly to the subject of inquiry.

We believe that also in practical attempts at improving technology, intentional action is the natural phenomenon to be analyzed, understood, and designed for. The reason for this is logical: All technology is designed to support people in their attempts to reach their life goals, which are set in their actions. We rely on computers when we drive cars, when we use mobile phones or elevators, when communicating via computers or when using Internet services. If one takes serious the idea of the user as intentional actor, the conclusion is that user psychology cannot be defined in terms of the technical quality of the computer in question; that is, whether the computer is a computer in the Turing sense. Any interactive computer even embedded computers in cars and digital wrist watches that are computationally simple are in the domain of user psychology. Looked at from this perspective, the psychology of the human user should be one of the key topics of the sciences of the artificial (Simon, 1969).

A Problem-Solving Epistemology

"In appraising the merits of theories, it is more important to ask whether they constitute adequate solutions to significant problems than it is to ask whether they are 'true,' 'corroborated,' 'well-confirmed' or otherwise justifiable within the framework of contemporary epistemology" (Laudan, 1977).

User psychology and related disciplines are in a way difficult to locate on the map of science. On the one hand their ultimate goal of improving technology for human use makes them applied science. In user psychology, psychology is used for solving practical problems, analogous to, say, what is done in traffic psychology. Bunge (2001) defines a discipline as applied if it is in intellectual debt to another field. On the other hand, we must ask whether user psychology is really applied science, for its goal is to produce a new coherent view of the human's relationship with interactive technology. If this kind of problem that addresses the most salient characteristic of our time is not basic science then what has went wrong? In this light, the old basic–applied dichotomy is problematic.

We have to look what science is in a new way. Instead of seeing science as a set of justifiable beliefs, or improvements in "truthlikeness" of theories, we might see it as a dynamic process where our problem-solving ability is increased (Laudan, 1977). This means that scientific concepts, theories and empirical findings should be evaluated on the ground of practical advancement they allow us in developing technology or if formulated in a wider sense: how they improve the development of information society. Naturally, problem-solving capacity cannot be increased on the basis of outright false theories, so the two aspects of epistemology—truthlikeness and usefulness—are related. However, we see that the primary goal of user psychology should be not be truthfulness, as there are cautionary examples in its past (Carroll, 1991, 1997).

What does a problem mean? In his work, Laudan (1977) distinguishes two kinds of problems: empirical and conceptual. Empirical problems involve unknown phenomena, unknown factors, and unknown effects. Much of user studies and evaluative experiments fall into this category. Conceptual problems involve implausibility (to explain something within a theory/concept), inconsistency, and incompatibility. Most theory application and construction addresses this category of problems. Because Laudan was mainly interested in natural and humanistic sciences, it may have escaped his attention that there are also problems of constructive character. Three subtypes can be thought of: 1) inability to imagine a solution, 2) insufficient knowledge for implementing a solution, and 3) unavailability of resources for implementing a solution. Much of user interface design and UI software technologies work reported in academic forums like UIST address these problems, but just as well decision-making, policies, and educational programs could be thought this way. The contribution that user psychology makes toward solving these problems is that its theories and results of empirical work can provide us with ideas on how to make good constructions. The point is that work on all three types of problems is necessary. It is a form of short-sightedness to require every study to be able to contribute to constructive problems directly. In the absence of understanding, this form of problem-solving science would not carry far as it would lead to poor solutions to the problems.

What is a good solution, then? Laudan (1977) argues that progress in science is about adequate solutions to important problems. Laudan (1977) defined a good solution as having three qualities:

1. it solves a problem that is significant,
2. it has the potential to solve many new problems, and
3. it solves the problem(s) effectively.

From the perspective of the first quality, research on cognitive models of the user has been successful, because these models helped solving significant problems of the early 1980s. However, one can say that in the 21st century its challenge has been the second quality: it has not been able to solve those problems that are the most important ones (Carroll, 1991), as technology has developed and models were not updated accordingly. Moreover, even the earlier versions of GOMS (Goals, Operators, Methods, & Selection Rules; Card et al., 1983) were criticized as being too difficult to apply—in other words, too inefficient as a solution (3rd quality). However, significant progress has been made in lowering the barrier to apply these models to everyday interaction problems (John, 2004). Another good example is Fitts' (1954) law that has been applied widely to analysis and prediction of input devices. The problem of target acquisition is central to all HCI and Fitts' law offers an effective way to address it, which is why it fills two out of the three qualities of Laudan. However, the law in its original form does not really involve any explanation, rather a description of statistical relationship between three variables (movement time, target size, target distance). Without explanatory basis, its extension to new problems has mainly taken place through trial and error rather than prediction (Friedlander et al., 1998).

Importantly, the problem-solving epistemology makes it clear that prediction is only one aim in the psychology of the computer user (Card, Moran, & Newell, 1983). From the Laudanesque perspective prediction is a false a goal for epistemology. It is more essential to have psychological knowledge that is applicable (Carroll, 1991). However, it is very common for non-psychologists to believe that the existent psychological knowledge is somehow applicable as such and ready to be used, although it is often necessary to study first what the meaning of a psychological construct in a particular phenomenon of technology use, before it can really be applied in practice. Thus, identifying the most significant and practical explanatory frameworks is as important task for research as is actually elaborating them.

Thus, we believe that the core of our epistemology should not be quantitative prediction of outcomes but *explanation*. If we think of a normal engineering design, it relies heavily on the laws of nature (Pahl & Beitz, 1996). An engineer must be confident that, once built, the bridge will stand. Neither do engineers build skyscrapers by trial and error. The reason they can do this is that they know the properties of materials and the effect of forces on structures and can thus engage in *explanatory* problem solving. However, when we move to interactive technology, it is a completely different case: trial and error and reliance on intuitions in place of theory-based argumentation. This has been a necessity, because we have not been able to create a practice in which the laws and principles of modern psychology would support and guide problem-solving the way natural physical laws do in machine engineering. Getting from the intuitive to explanatory problem solving practices is a central goal for user psychology. In other words, user psychology is ideally conducted in a way where applicable solutions are sought via deepening understanding.

But whose problems are we are attempting to solve? We believe that any piece of technology ties around it a complex web of stakeholders whose problems are relevant and which we ought to be solving. There is no a priori reason to limit our work to serve designers. True, we need to aid designers to find rational ways of solving immediate interaction design problems. However, designers are not our only stakeholders (Carroll, 1991, 1997). There are also the individual end-users, or customers, whose needs and abilities we have to worry about. By informing consumer segments, user psychology can help them making informed choices and raise awareness of the consequences of poorly designed technology. But the list is much longer. In organizations, there are stakeholders from administrators to helpdesk to managers to human resources specialists. In the Internet, user communities and groups are formed that have different requirements for technology. Developers also have their constructive needs, as have designers, and service providers and commercial companies have their take and interests that are often evaluated in monetary terms. Finally, institutions like schools and societies as a whole take significant decisions on information technology, and thus their needs should also be served. Given these widening spheres of stakeholders, we believe it has become impossible to maintain that design is the main "client" of our discipline. The ultimate goal of user psychological research should be the improvement of the conditions of human life and our research should indeed be evaluated, in the end, from that point of view (Cockton, 2008; Sellen et al., 2009).

This characterization fits quite well the *de facto* practices of the HCI community. The flagship conference CHI, for example, places as the foremost demand that its papers "offer contributions that clearly and significantly advance the field of HCI." Moreover, the conference asks the authors to think "what kinds of problems might readers be facing to which your contribution could provide the solution" and tries "to make sure that the submission explains the contribution in sufficient detail for the full benefit to be extracted" (CHI Conference, 2009). In other words, CHI has already started to define itself in terms of solutions to stakeholders' problems. Previously, however, we were lacking an epistemology that would fit these aims. If user psychology wants to contribute to real-world efforts, as it should, this reformulation of its epistemology as a problem-solving epistemology is natural.

Explanatory Frameworks

Prediction is the sine non qua of engineering sciences. When engineers build a bridge or skyscrapers, they apply models derived from the laws of nature to make advance calculations. Although they also test their constructs empirically, the advance use of laws gives their work a predictive character. Of course, there is always also an element of intuition involved. The designers of the ship Estonia that sank in 1994 with 800 passengers did not have sufficiently sophisticated mathematical formulas to calculate the weight of the wave forces against the keel structures (The Joint Accident Investigation Commission of Estonia, Finland & Sweden, 1997). Save the cognitive modeling community, the predictive stance is weak or missing in areas around human-technology engineering. Usability testing is common, but it is one thing to generate and test and another to predict and test. This is why much of present-day design practices remind of medieval construction practices where, by means of trial and error, stable solutions are found and passed on from one to another.

Nevertheless, as we discussed in the previous section, we do not suggest taking prediction as the ultimate goal of this discipline. There are reasons for this. First, it may be impossible. Landauer (1997) criticized such attempts by claiming that the to-be-predicted phenomena are too complex: Any attempt at prediction is overly sensitive to differences in the starting presumptions, subject to extreme random variation, and includes variables that are impossible to know in advance. Moreover, people are not "deterministic" and thus never 100% predictable (von Wright, 1972).

We believe that the primary epistemic goal of this discipline should be explanation. By explanation it is generally meant that connections are established between previously miscellaneous items. However, explanation is not necessary for prediction—statistical prediction involves no explanation. Instead, explanation is often a sufficient condition for prediction, at least if it is not conceived narrowly as quantitative prediction. Namely, the nature of prediction can also be of a relative or nominal type: "this design will induce user error," or "design A will be better than design B." When connections are established between variables our artifacts affect, such as number of items in a menu, and variables of use, such as number of errors, an explanation will have some predictive power.

How should we work toward explanation in concrete problems of computer use? In its simplest form user psychology unifies 1) a problem with 2) the respective knowledge from a field of psychology to chart solutions through 3) scientific inference that maps the two. An explanatory framework is a psychological knowledgebase which provides us with information beneficial in solving a problem or some of its aspects (Saariluoma, 2005, Figure 1).

Problem * Scientific knowledge ➔ Solution

Figure 1.
Explanatory framework. The problem is described in a way that scientific knowledge can be brought to explain it and a solution inferred.

In the rest of this section, we examine a handful of important frameworks from the past and present lines of research: biological psychology, information processing psychology, psychology of emotions, mental contents, individual differences, groups, and socio-cultural aspects. The list is only one possible cross-section of vast volumes of work. The list is not supposed to be taken as comprehensive, it only serves to illustrate two points: 1) that there are many domains of general psychology *outside* cognitive psychology that are in fact already being applied in contemporary HCI, 2) that the internal logics of the frameworks are very different—so different that it is difficult to see how any one framework could possibly cover them all. Any concrete interaction problem is so complex that multiple explanatory frameworks must be called in. Some of these frameworks have emerged as a response to the needs of a particular application area, but have widened their scope along with research being formulated around user-related issues. For example, the recent surge of research on emotions in human-computer interaction was boosted by some seminal work on affective user interfaces. By re-thinking psychological research from the perspective of the user, user psychology may reach generality across application domains.

It is important to note that the examples presented below represent high or macro-level explanatory frameworks and define rather extensive wholes. In practice, explanations at the level of a particular study must often be much more nuanced and refer to more detailed theoretical explanations. For example, much of (but not all) information processing psychology that has been applied to HCI has utilized what could be called a macro-level explanatory framework of limited capacity. However, in a particular project one could be interested in micro-level frameworks such as, say limitations of the human working memory and its subsystems (Baddeley, 1986).

We begin with questions typical to a framework, and then look at the background theories, and finally present concrete examples of empirical work. It takes considerable time to develop a good micro-level explanatory framework for a particular problem, but in many areas that work has been done to the extent that we can start coalescing the micro-level explanations into more coherent wholes. Looking at things from this perspective forces us to address and improve the generalizability of our work.

First, the limited capacities of human information processing system is one of the classic explanatory frameworks and particularly strong in contemporary human factors (Wickens et al., 2003). Human information processing is limited in many different ways; most well-known limitations relate to perceptual discrimination (Goldstone, 1994), working memory capacity (Baddeley, 1986; Cowan, 2000), and selective attention (Pashler, 1998; Styles, 1997). These limitations have been studied for decades as explanations to performance and errors (Broadbent, 1958; Miller, 1951), and utilized in interface design to address such questions as how to construct a display that is legible, how to make warning signals discriminable, how many alternatives you can have in a menu node, how to design notifications so that they do not hamper memory, and how users search web pages. A powerful example concerns perceptual discrimination. People can visually perceive only a limited part of the electromagnetic spectrum from 380 nm to 750 (Coren, Ward, & Enns, 1999) and hearing is similarly limited, between 20 and 20 000 Hz. This means that sensation is based on a relatively narrow spectrum of physical energy. Discrimination based on the electromagnetic spectrum may be difficult because people simply cannot exceed the absolute thresholds of human sensory systems. However, discrimination depends also on the quality of background, and if the background information is too similar with the target, it also makes it difficult to perceive the object in question. Low intensity of a stimulus may refer to a target reflecting light inadequately or to a target that is not clearly discriminable against its background (Isler, Kirk, Bradford & Parker, 1997). A somewhat different set of limitations is involved in human attention (Pashler, 1998; Styles, 1997). Attention segregates the target or figure out of its background and thus organizes perceptual reality in only one of the millions of possible ways. Attention selects the messages, which are important for the ongoing action. In this way, it allows human mind to focus on relevant things. The capacity of selection is normally one unit at the time (Broadbent, 1958). It is possible to switch attention from one target to another relatively swiftly and thus follow two or even more competing messages at one time. However, this kind of performance has its costs and is risky. One of the core problems here is how we can select the target information from irrelevant background information. A key explanatory factor is discriminative cue. This means that relevant information has some property such as color, which makes it different from irrelevant information and thus is easy to pick up. Discriminative cues and selective attention are important issues in graphical interface construction. It is critical to be able to design the information to be expressed in such a way that, from the action point of view, the most important information is sufficiently discriminable. The system of discrimination to be used is often a vital issue in designing effective visualizations (Card, 2003). These examples give an idea about how capacity-based explaining is already part of user psychology. It is necessary to ensure that interaction with an interface does not surpass the available capacity. The main way of reacting is naturally to reduce the complexity, which can be done either by redesigning the interface in question or by improving the skills of the user.

Another deeply seated framework concerns mental contents of the user. Such notions as schemas and mental models have often been used to describe information in mental representations of computing systems (Carroll, 1997; Norman, 1987). What these notions share is that they involve beliefs or propositional information, properties of this information, and functional connections between content elements. The concepts of mental contents provide us with an alternative perspective to interaction compared to capacity-based explanations. The crucial limit of capacity based research is that we can fill the limited capacities with any type of information. That information can be correct, false, or irrelevant but if it does not exceed the processing capacity, there are no problems. As a metaphor, we can fill a bottle with milk, honey, poison or any substance as long as the bottle is not broken or does not overflow. This means that the capacity based language cannot express those problems which are characteristically explainable in terms of mental contents (Saariluoma, 1997). One active research area has been representations of objects of information that are not directly present but "projected" on the user interface. The feat of being cognizant or acting in the absence of instigating stimuli is of course not confined to human-computer interaction. For instance, talking about a yesterday's weather, counting time, and thinking about our political system are such activities, and in explanations of these phenomena we find links to general psychology. There are many other interesting but less researched topics concerning mental contents related to computer use, such as attitudes, values and social representations of users. Good examples are the seminal studies of Reeves and Nass (1996) that showed how users attribute humane qualities to computers and media. Key in this explanatory framework are the mental contents and inference processes that work on them that allow the user to "jump into conclusions" beyond the literal meaning of technological projections. Such inference is so basic to the construction of meaning through interaction that the topic should cover much more ground in human-computer interaction than it currently does.

The third widely utilized mode of explanation concerns individual differences. This macro-level framework subsumes multiple middle-level frameworks from skills to age to gender to personality. The issue of individual differences has been recognized since the very first experimental studies in HCI (Sackman, 1970) and is today reflected in popular agendas such as Universal Access and Design for All. Since we cannot possibly cover all relevant frameworks, we briefly visit the issue of user personality as an example. The best known of feature approaches to personality is most likely the so-called BIG 5 theory which focuses on five basic personality traits. These are extraversion, agreeableness, conscientiousness, stability, and openness to experience (McCrae & Costa, 1997; Wiggins, 1996). A typical problem could deal with the question of how a user's commitment to a device might depend on a number of personality features and the symbolical and identity values provided by the product (Aaker, 1997). Another often used view to individual differences is age (Hawthorn, 2000). Czaja and colleagues (Czaja *et al.*, 2006), for example, analyzed the connection of intelligence and anxiety to older peoples' use of computer technology. Similar to all sub-frameworks is the idea that users are unique and idiosyncratic characteristics must be taken into account when analyzing interaction.

Fourth, a recent surge in the study of emotions in interaction has opened up a very different system of explanatory grounds. Emotions define our subjectively felt personal positions towards events and objects (Jordan, 1998; Norman, 2004; Power & Dalgleish, 2007). Such categories of contemporary ICT research as user acceptance and user experience are essentially emotional issues. Of particular relevance among emotional phenomena are, at least, the contents of emotions and their connections to cognition and action. Emotions can be understood as reactions and preparations to prevailing situations, but before we know what a situation is we have to make a cognitive analysis (Power & Dalgleish, 1997). Emotions are activated with appraisal, the cognitive analysis of the situation which in user psychology involves a computer technology. Therefore, the designers' route to influencing user experience by means of design is via cognitions (Beck, 1976). Emotions are also important, because they can convey information about our needs. Naturally, these connections have an important role in motivating our immediate actions. Finally, emotions are always important in experiencing the world in interaction with computers. They bring some self-perspective to experience. They also tell the "goodness" of the experience to the experiencing person. We can also speak about a "felt" experience, which opens a different perspective to interaction when compared to performance (McCarthy & Wright, 2004). There are questions which can be answered on emotional grounds only and for this reason it makes sense to take emotions as an independent explanatory framework.

Fifth, the recent "Decade of the brain" has brought about a general movement toward biological psychology, also within the HCI community (Parasuraman & Rizzo, 2007) that did not recognize this area before the turn of the millenium (Landauer, Helander, & Prabhu's, 1997 handbook did not have a chapter about it). The basic form of argumentation is familiar to us, going from biologically determined properties of human performance to explain why some design alternatives are preferable to others. Human motor performance is a prime example of linking performance to properties of human nervous system (Rizzo, Robinson & Neale, 2006). The size of hand and fingers, muscle power, limb and joint movement, the speed of neural signals, and physical limits of transduction are variables that are crucial in designing low-level interaction. The harmony between movements and input devices is a critical issue and many types of problems require signal processing analyses in a peripheral and central level. Recently, neuroergonomics has extended the application of biological psychology from "low-level" issues such as sensation, perception, and motor control to problems related to higher-level cognitive concepts such as vigilance and attention and memory capacity. It has also been applied to register physiological states of users, such as stress, emotional states, and mental workload. Arguably, neuroergonomics should be as important a part of user psychology as neural theories are for understanding mind and it can provide deeper understanding of user performance with pointing devices than statistical models such as the Fitts' law (Fitts, 1954). As a philosophy of science, however, biological psychology may at first blush appear too strict in its reductionism—a position that has been criticized numerous times. It may seem that in many important design solutions, there is no additional value that can be achieved by biological explanations, but this is not always true. There are indisputable cases in which neuroergonomics can be of real and non-replaceable use in HCI. On the other hand much of the research is still in a very early stage compared to the cognitive paradigms.

Sixth, the development of information and communication technologies—first groupware and now especially web and recently mobile technologies—have opened new forms of communication and collaboration between people. On an elementary level one may focus on the effects of group parameters such as size when performing a basic interaction task such as searching information from a display. Forlines and colleagues (2006), for example, noticed that groups may be slower in searching information from a display but they are 10-15% more accurate than individuals. On a higher level it is possible to investigate motivational and dynamic factors for users interacting in groups (Backstrom et al., 2006; Beenen et al., 2004; Malone & Crowston, 1994). Sociometric analyses (Lindzey & Borgatta, 1954) and many other ways of studying groups have been taken in use again. In general, group-level concepts can be used both in analyzing interaction phenomena as well as in explaining the forms they get. In a narrow sense, interaction means immediate interaction with a screen and controls, but, in a wider sense, it is essential to analyze also how groups of people organize their actions when mediated by technology (Grudin, 1994).

Seventh, beyond the group level, cultural issues are on the radar of user psychology as well. Humans are essentially cultural creatures. There are numerous questions in computer use that must be resolved by referring to culture, such as values, communication practices, and cultural norms. We have to be able to discriminate important subcultures and the ways they see computer use, to be able to serve all segments of users. Women, for example, form their own subcultural group in web cultures (Frieze, Hazzan, Blum, & Dias, 2006). One additional resource can be provided by cross-cultural psychology with its long tradition of conceptual and empirical analyses of human cultures (Cole, 1991; Ekman, 2003; Hofstede, 1984; Matsumoto, 1996). There are much fewer obstacles now for communication between people of different countries and districts than there have been during previous centuries. This means that there are new ways of group formation in society and one can participate with very different types of groups. Choi et al. (2005), for example, reported a comparative crosscultural investigation concerning design norms for mobile data services. In-depth interviews were conducted in Korea, Japan, and Finland, to find a number of culturally explainable differences between users. The most important of the differences were found in uncertainty avoidance, individualism vs. collectivism, and context, which could be linked with such usability features as variety of options, contents, the use of colors, and iconic style. Wider reference groups that are characterized by such attributes as nationality, ethnicity, values, beliefs, living conditions, social order, or religious group will also become important in user psychological analyses. Bourges-Waldegg and Scrivener (1998) investigated multicultural CSCW and noticed that understanding differences in representations forms a major design challenge. They very justly called attention to analysis of meanings underlying cultural representations. One can also find numerous subcultures within one's own society. Age, work organization, profession, wealth or education differences can culturally divide people. Even a larger context for socio-cultural human-technology interaction is proposed by Rauterberg (2006), who sees socio-cultural computing as the new paradigm emerging amongst the traditional personal and cooperative computing.

We have presented existent and emerging explanatory frameworks referring to such subdisciplines as cognitive psychology, neuroscience, personality, social psychology, and (cross cultural psychology. Today we have a wealth of knowledge about basic psychological phenomena, and the mission of user psychology is to organize and translate the various types of knowledge into coherent wholes that can work as a reference in solving problems. Alas, we do not yet have a unified psychology, and psychological research areas are very different from each other. For example, the limited capacity of working memory can be used to solve some interaction questions, while the psychology of emotions is applicable to very different types of problems. It is true that these fields have some connection points such as the Yerkes-Dodson's law, but still the two frameworks can and should be used in solving very different types of problems. Consequently, it would be self-handicapping to adopt as the main goal a *unified* theory of user psychology. User psychological explanatory frameworks must be and are being built on the basis of *many* types of psychological knowledge.

Conclusion: The New Role of Psychology in ICT

The sheer scale of technological development over the millennia has been astonishing. Once-innovative technologies became either obsolete or mundane elements of everyday contemporary life as human societies progressed. The technological developments of especially the last decade have dramatically altered most humans' way of life. Interaction with objects and people is not direct anymore, if it ever was, but increasingly requires interaction with computers manifested as hardware of all kinds and, more recently, software. It would not be an exaggeration to view humans as standing at the cusp of profound social changes that are in line with those following the invention of writing or the steam engine. Therefore, now is a good time to stop for a moment and ponder the forces that make such new developments possible.

For decades it has been sufficient to intuitively imagine human interaction with new services. Today, however, it is necessary to admit that mere intuitions have not given us a sufficiently deep enough understanding of the human mind and social roles to enable us to design really good technical products for people. Scientists working with the human mind and society have naturally known for a long time that simple intuitions and lay science do not provide technologists with an accurate understanding of people. This is why psychology, sociology, anthropology, and other human sciences have developed sophisticated observations, concepts, and theories that make it easier for specialists to understand better human being.

We have proposed user psychology as an explanatory problem-solving science contributing to the development and societal use of interactive technology. A hundred and fifty years of scientific psychology has developed a deep understanding of the regularities and principles of human mind. We understand much about emotions, motives, thinking, psychology of language and social processes. To an outsider, it may seem unproblematic to expect that psychological knowledge in all of its breadth and depth should form a basis for modern information technology and that interaction should be designed on the ground of professional psychology. Nevertheless, the difficulties in applying psychology in industry have been known for a long time. The links between psychological knowledge and constructive processes have not met each other in an ideal manner (Carroll, 1991, 1997). The purpose of this paper has been to search for solutions to some foundational issues that we think underlie these problems. We have repurposed the classic concept of user psychology, suggesting a number of new elaborations to it (Moran, 1981).

The need to reformulate user psychology has arisen, because original formulations have been found limited and no comprehensive alternatives have been proposed. The information processing model of human cognition is mechanical, because it assumes that each act is a consequence of the prevailing states and state histories. The activity theory and related ideas have not been able to host contemporary psychological work due to their unwillingness to accept internal mechanisms of mind as the explanatory base. Building on earlier mainstream ontologies, we have taken the human being as an intentional creature to the subject of inquiry in this discipline. Instead of activity, we talk about intentional action with interactive technology.

By doing this, we have tried to address two unfortunate consequences of the previous formulations of psychological research in this area. First, it has been recognized that psychological research has fragmented into niches that—notwithstanding few promising exceptions—have been defined by technological boundaries (Carroll, 1997; Olson & Olson, 2003). User psychology should be formulated around psychological questions so that we can merge these fragments over artificial boundaries. This is the essence of what "putting the user first" means for a scientist. Secondly, user psychology is needed for replacing the folk-psychological thinking by scientific psychology and its principles. Current folk-psychological practice simply does not accumulate—the same things are being repeated in a frustrating cycle. Explanatory practices should replace seat-of-the-pants thinking. However, finding explanations to particular problems can also be regarded as search for the most suitable form of psychological knowledge.

Thus far, the development of technology has belonged to engineers and computer scientists, who relatively seldom have in-depth knowledge of psychological phenomena and knowledge. Consequently, psychological knowledge has been brought to the picture only after devices or platforms have already been built. The question is if we could do better. We expect user psychology to contribute to earlier stages of development. For example, usability research with its interest in immediate suitability of technology for human action is ultimately a conservative form of possible psychological perspectives. What we could do is to turn this thinking upside-down by first designing human actions and after that asking what kinds of technologies would be useful. At first blush, this does not sound like news to researchers trained in user-centered design—it is known that the earlier psychological knowledge can be taken as a part of action analysis, the better human requirements can be implemented to interaction. However, we claim that user psychology can a) do this work more systematically than approaches that rely on folk psychology and b) it can help us systematically examine the very premise that technology is needed in the first place.

However, we do not expect user psychology to be easy. In the short term, it is time-consuming to deal with psychological knowledge compared to running a simple study. But this is the only way out of the method of trial and error. Moreover, getting psychologists interested in "applied psychology" may be difficult. Relatively few psychologists are seriously interested in "technical issues" as they have hands full with traditional problems within departmental focus areas, such as education, mental illnesses, family violence etc. However, we see the possible rewards motivating enough that solutions can be found. Technology has become so pervasive an aspect of modern life that its relationship with human mind deserves the status of a basic research question and its own discipline. Psychology of computer use should not be the handmaiden of technologists but define itself by its own terms.

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