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What could abductive reasoning contribute to human computer interaction? A technology domestication view

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ABSTRACT

In recent decades, non-monotonous, informal patterns of reasoning have awakened a renewed interest among psychologists, economists and educationalists. Computer scientists and information systems professionals could also benefit from getting better acquainted with new research on how people think and act in the real world. The purpose of the paper is not to make an empirical contribution but to present a general argument in favour of a psychological approach to logic and its application to Human Computer Interaction (HCI), focusing especially on abduction. Abduction is a form of everyday reasoning that people typically use under uncertainty in a context. Abduction may help us better understand the epistemic conditions of advanced HCI – which increasingly takes place in authentic surroundings instead of in a laboratory-like setting – thus contributing to better research and design. HCI design should enhance our natural capacities and behaviour, which at the same time could mean creating new freedoms in the structures of everyday life.

Keywords: *abduction, practical reasoning, informal reasoning, logic of discovery, information systems methodology, human-computer interaction, technology design*

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1. Introduction

Deductive arguments have traditionally been regarded as the soundest basis for reasoning, especially for reasoning in science. Recently a renewed interest in practical patterns of reasoning and people's behaviour in the real world has emerged in many disciplines, including pedagogy, the cognitive sciences, psychology and economics. Instead of a consuming preoccupation with the correctness of logical forms, which has

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dominated the history of logic especially for the last hundred years or so, the issue of utility of logic is once more on the agenda. Assuming that Charles Sanders Peirce and later Wittgenstein are right about meaning being essentially a social and inferential phenomenon, a broader view on human knowledge calls for an examination of inferential practices.

Peirce's suggestion of abduction as a middle ground between induction and deduction will here be taken seriously. There are basically three research traditions on abductive logic. Two of these – abduction as hypothesis finding (and comparison) in the theory of science and abduction as logic programming – are briefly discussed but the focus will be on the third one, abduction as practical reasoning. Accordingly, the focus is on the actual abductive reasoning by people in real life.

Abduction as a form of everyday reasoning may be a central inferential mechanism at work when users act and interact with objects in an Information Society Technology (IST) context. Hence, abduction can be used for modelling what goes on "inside" the user's head. An advanced mobile computing situation especially calls for the use of abductive reasoning as the user typically is forced to come to a speedy conclusion on the spot in order to act in accordance with numerous contextual requirements of a real-life situation. From a Human Computer Interaction (HCI) design viewpoint, abduction as everyday reasoning is important because IST has to support natural social behaviour in order to become accepted by the majority of users (Abowd & Mynatt, 2000; Kleinrock, 2004; Grudin, 2002). The paper takes a stand in favour of emancipatory, domesticated technology, a kind of technology that allows the user to better control the tools he or she is using, and to comprehend the consequences of technology supported action to others and at least to the immediate environment (Keen & Mackintosh 2001; Punie, Bogdanowicz, Berg, Pauwels, & Burgelman, 2003; Patokorpi, 2006).

Pioneering work has been done for instance by Magnani and Bardone (2005a; 2005b; 2008) and Orliaguet (1999; 2000; 2001; 2002) but much more hands on deck are required to exploit the potential of abduction in the field of HCI. The sole purpose of this paper is to present a general argument in favour of applying reasoning, and especially abductive reasoning as a form of everyday, experiential, perception-based logic, to HCI. Accepting the argument means forming an alliance between logicians, psychologists and computer scientists that to some people may seem unholy (e.g. Popper, 1969).

First, abduction and its relation to the other two basic forms of logic will be explained, followed by a presentation of the three interpretational traditions of abduction. The relation of reasoning to proof and the combining of different inferential patterns in reasoned action will be illustrated in section 3. Abduction's role in discovery is then discussed, followed by a section on abduction as a potential tool for the technology domestication approach to HCI and a section on the image versus logic traditions. The last-mentioned section (section 6) tries to touch upon the parallel development of thinking styles and "thinking" machines.

2. Abduction

According to Peirce, there are only three elementary forms of logic: deduction, induction and abduction (CP 8.209 [CP refers to Peirce, 1934-63]; Hoffman, 1997; Rizzi, 2004). Peirce's canonical examples of the three basic inferential forms are the following:

> Deduction
> Rule: All the beans from this bag are white.
> Case: These beans are from this bag.
> Result: These beans are white.
>
> Induction
> Case: These beans are from this bag.
> Result: These beans are white.
> Rule: All the beans from this bag are white.
>
> Abduction
> Rule: All the beans from this bag are white.
> Result: These beans are white.
> Case: These beans are from this bag (CP 2.623).

The three elementary forms of logic can be seen as complementary operations of the human mind (Rizzi, 2004): Deduction infers a result (conclusion) that is certain; induction produces a rule (conclusion) that is valid until a contrary instance is found; abduction produces a case (conclusion) that is always uncertain (i.e. merely plausible).

In order to the scientific process of inquiry to become methodologically complete, abduction (whose job is to form hypotheses to explain an observation) needs to be followed by deduction (to logically derive the consequences of the hypothesis) and induction (to empirically test the predicted consequences of the hypothesis) (CP 6.469; CP 7.220; Pückler, u/d; Pape, u/d; Hoffmann, 1997; Flach, 1996).

The phenomenon of abductive reasoning has been discussed at some length in logic and rhetoric since Aristotle's Prior Analytics (2nd Book, Ch. 25; Gabbay & Woods, 2005). In the late 19th century, it was rediscovered by Peirce, whose interpretation and development of it has set the stage for virtually all subsequent research. There are three distinct interpretational traditions related to abduction, namely, abduction as a method of or model for:

1. scientific research or inquiry (logic of discovery)
2. machine reasoning (logic programming)
3. everyday reasoning (*logica utens*)

These three fields of application have their own, partly incompatible views on abduction.

The bulk of research into abduction has so far focused on its role in scientific research or inquiry (i.e. number 1). Ideally, an inductive research approach starts with gathering data by empirical observations free from prior ideas or preferences as to how the observations should be explained. A deductive approach in turn starts with explanations, hypotheses or theories. By drawing deductive inferences from a theory, its consequences in the real world can be predicted, provided that the theory is true. The predicted (or deduced) consequences in the real world can then be tested by empirical (inductive) methods (Danermark, Ekström, Jakobsen, & Karlsson, 2001). Deduction as a method of proof preserves truth, which means that if it starts from true premises, the logical form guarantees that the conclusion will be true. True premises cannot be arrived at by deduction, though. Induction, as a method of proof, is less truth-preserving, and as a method of arriving at true premises it is as impotent as deduction. Abduction's job is to produce hypotheses (explanations, guesses), and hypotheses are always merely plausible. Hence, abduction is the starting point of the self-correcting empirical research process. Punch, Tanner, Josephson and Smith (1990) have observed that frequently in accounts of scientific reasoning the nature of the hypothesis that could explain the findings is generally very indistinct: "What counts as an explanation is not clear. It could involve accounting for (or covering) the findings to be explained, accounting with causal consistency, or maximal-plausibility coverage" (p. 38).

The role of abduction is, or should be, strong when the aim is to create something new. Secondly, the role of abduction is strong when there are not yet established theories, as abduction in tandem with induction is the means of arriving at new explanations and theories. And as was mentioned above, deduction's role is to draw the consequences of theories so that they can be put to test by induction (Kovács & Spens, 2005). As Peirce (CP 2.623; 6.469; 7.220) says, abduction describes what might be. It is thus connected to plausibility and oriented to the future (Patokorpi & Ahvenainen, 2009). Unlike deduction, it does not preserve truth.

The second perspective to abduction – abduction as a model for logic programming – has likewise interests and a research tradition of its own. Josephson and Josephson (1994) have modelled computing after the abductive inference model. In syllogistic terms, abduction is a *modus ponens* turned backwards, which in the eyes of formal logic makes it into a worst kind of textbook error in logic. Abduction is a logical fallacy because even if the premises were true (e.g. "All the beans from this bag are white" and "These beans are white"), the conclusion ("These beans are from this bag") may be false (i.e. these white beans could come from somewhere else than from this bag) (Wirth, 1993; Josephson & Josephson, 1994). As a rule, the algorithms based on abduction seem to be variations of the topsy-turvy *modus ponens*. Abduction has been successfully applied to computer systems that must work with incomplete knowledge. Abductive logic is regarded as capable of making computing machines think and act more like humans do (Satoh, Inoue, Iwanuma, & Sakama, 2000).

Both in the study of scientific inquiry and logic programming abduction is usually interpreted as Inference to the Best Explanation (IBE), that is, in terms of the so-called IBE model (see e.g. Lipton 1991). The IBE model deals with the generation and assessment of hypotheses, focusing on the formal-logical accuracy rather than the actual mental process of reasoning. In other words, it is concerned with comparing guesses (hypotheses) and not with what goes on in (and outside) someone's head when drawing the actual inferences (in scientific methodology these inferences have the role of hypotheses).

The third perspective sees abduction as a form of everyday reasoning or practical reasoning. In everyday reasoning there is no escaping the use of abduction because our knowledge in rapidly changing real-life contexts rests mostly on guessing, i.e. more or less *ad hoc* hypotheses (Hoffmann, u/d). Abduction is especially suited for dealing with incomplete evidence under high uncertainty in complex real-life situations or ill-structured disciplinary fields of knowledge (e.g. medical diagnostics) (Spiro, Feltovich, Jacobson, & Coulson, 1988; Thagard, 1998; Lundberg, 2000). This may sound like a pretext for "anything goes," a recipe for anarchy. However, this is not to substitute truth with untruth but rather, as Spiro et al. put it: "the phenomena of ill-structured domains are best thought of as evincing *multiple truths*: single perspectives are not *false*, they are *inadequate*" (1988). Abduction is a practical pursuit that settles for conjecture because the search for an optimum, if not impossible, would, among other things, be too time-consuming and cognitively too demanding (Gabbay & Woods, 2005).

3. Reasoning does not equal evidence

One has to be able to say when a reasoning process is correct and when it is incorrect. Normative standards are necessary for given mental processes to count as logic (Fetzer, 1999). John Stuart Mill certainly was no stranger to the practical utility of reasoning, but he also had great concern about its correctness, which eventually led him to seek for greater certainty. He came to doubt Jeremy Bentham's facts-in-the-concrete and shifted focus in economic research from analogical (inductive) reasoning from experience to deductive (a priori) reasoning from assumptions to consequences. The latter attains greater certainty and is forward-looking, enabling prediction. In this type of a priori reasoning evidence is sharply separated from reasoning, and one starts from assumptions. Evidence enters the picture after reasoning as confirmation of predictions (Mill, 1961; De Marchi, 2002). Isolating forms of reasoning from one another and separating reasoning from evidence may give greater certainty but it is likely to steer attention away from the practical utility of logic.

In real life, forms of reasoning and evidence can be seen as essentially connected through reasoned action in the real world. Chiasson (2001) has described the use of different forms of reasoning in real life situations, demonstrating how different combinations affect our behaviour in the real world. Examples (adapted from Chiasson, 2001) of these inferential forms and their combinations are given below:

Simple abduction (guessing)

I see the dog coming into the house dripping wet. I focus on differences; and the wetness is a difference that draws my attention. What, is it raining? I give the matter no second thoughts and dry the dog.

Simple induction (guessing)

The dog comes into the house dripping wet. I focus on similarities, and the last time the dog was wet my wife was in the yard with the sprinklers on. If I make no further inquiry into the matter, I may jump to the conclusion that my wife is in the yard, taking the dog's wetness as "evidence" of it.

Gradual induction (possibly seeking evidence)

The dog comes into the house dripping wet. I focus on similarities. The last time the dog was wet my wife was in the yard with the sprinklers on but last Monday when the dog was wet it was raining, and two weeks ago the dog took a dive into the pond in the backyard. I may start looking for evidence that would corroborate one and falsify other alternatives. On the other hand, I may have no incentive to do so.

Deduction combined with gradual induction (seeking evidence)

The dog comes into the house dripping wet. By gradual induction I focus on similarities, remembering that there have been several occasions on which my dog got wet. By deduction I focus on consequences, and understand that the different reasons for the dog being wet have their consequences. For instance, if the dog has been hosed down by the neighbour because it had been messing up their flower bed, I may have to face an angry neighbour. So, by using gradual induction I proceed to check the neighbour's yard, the pond, the sprinkler, and so on, seeking evidence which would corroborate one of the explanations and falsify the rest.

Abduction combined with gradual induction (seeking evidence)

The dog comes into the house dripping wet. I use abduction, which means that I focus on differences, qualitative anomalies. I discover that there is a piece of plant in the dog's fur, and venture a guess that the dog has been in the pond. I check it. It is not the pond. Because abduction dominates my thinking, I hang on to the piece of plant, trying to find another explanation for it, combining abduction with gradual induction which may lead me to check my guesses. However, because deduction is missing I am more interested in raising new questions than reaching a definite conclusion. My investigation lacks a goal.

Abduction combined with gradual induction and deduction (guessing, inferring the consequences of the guess, putting the guess to test)

The last combination adds deduction, which makes my reasoning goal-oriented. Abduction, in turn, keeps my eyes peeled for new and unexpected facts or observations, thus guiding me in the finding of hypotheses, whereas gradual induction helps me to keep score of similar events. Gradual induction may lead me to look for evidence but deduction gives me an incentive to do so.

The above examples show that all three forms of reasoning are needed for reasonable action in the real world. The three forms of logic do not have to appear in the order presented in this particular example but may of course be combined in a number of ways. Reasoning does not equal evidence, but our inferential practices are irretrievably and in numerous ways linked with experience and evidence. Admittedly, abduction does not meet the standards of deductive validity, but as Tuzet (2004, p. 276) points out, abduction is often accused of being fallacious (logically invalid) when in fact the problem is epistemic, that is, there is not enough evidence to draw the conclusion.

4. To discover and to justify

There are historical reasons for undermining informal reasoning. One reason is a sharp separation of the context of discovery and the context of justification. A modern, influential advocate of this separation is Karl Popper (1969). According to Popper, matters related to the finding of something new should be studied in psychology, sociology and history, whereas matters related to the justification (proof or evidence) of findings belong to scientific method. Popper’s view on scientific method does not recognize (epistemological) breaks in the growth of scientific knowledge as something rational. Scientific knowledge is supposed to build on previous knowledge by logical steps. Epistemological ruptures or scientific revolutions are thus things that do not belong to the logic of scientific inquiry but into historical or sociological studies of science (Bertilsson, 1978, pp. 10-14; Chauviré, 2005). For Karl Popper, logic is formal logic, and its job is to justify or prove hypotheses. If the premises of a deductive inference are true, the conclusion will also be true. If the conclusion of an inductive inference is corroborated by empirical evidence, the inference is probably true. We are justified in holding it to be (probably) true until a contrary event disproves it. This is presently the standard view on proper scientific procedure in terms of logic. An interesting consequence is that logic becomes separated from factual, experiential evidence. Evidence is not the starting-point of reasoning but may be gathered to corroborate or weaken the implicit claims made of the real world. Because logic needs to be correct or immaculate for the scientific procedure to potentially produce truth, the correctness of logic guarantees the quality of scientific propositions. So far logic has mainly focused on the correctness or immaculateness of reasoning patterns rather than their usefulness or relevance.

For Peirce, abduction is a logic of discovery. Discovery is thus a rational process of constructing, finding and choosing hypotheses. Science, in turn, is “controlled creation” (Bertilsson, 1978, p. 76), based on abduction and confirmed by deduction and induction. Discovery and justification go more or less hand in hand. In highly formalized systems like mathematics the discovery process can be seen as an objective process circumscribed by the properties and relations of the signs of the system. To be objective means here that the (symbolic) process of discovery is virtually one with the real-life phenomena of mathematics. Reality (of mathematical things which are signs in a basically conventional formal system) and what we think of it coalesce. In ill-structured knowledge domains the objectivity of the discovery process is in turn questionable (Bertilsson, 1978, pp. 142-143).

The idea of a logic or method of discovery is not new. Greek geometricians built a conceptual model of inquiry, which they called analysis. Analysis is a heuristic method, a method of finding proofs. Abduction has a similar heuristic function as the so-called upward propositional interpretation of geometrical analysis and the analysis-of-figures interpretation of analysis that were used in Greek geometry (Niiniluoto, 1999; Hintikka & Remes, 1974; Patokorpi, 1996). Analysis was supposed to be a conscious and skilled process and therefore learnable. Three principal views on the analytic method exist. The analytic method is seen as (i) a subordinate part of the axiomatic (deductive) method, (ii) an alternative to the axiomatic method or (iii) a superordinate part whose subordinate part the axiomatic method is. The first one is related to the closed world view and the second and third to the open world view (Cellucci, 1998; 2005). The difference between a closed and an open world view corresponds to having either all information ready from the very beginning or making it up, or emerging, as one goes on. The important implication here is that abduction can be controlled and it suits especially for dealing with open systems.

5. Domesticating technology

Keen and Mackintosh (2001) and Punie, Bogdanowicz, Berg, Pauwels, and Burgelman (2003) present parallel views on technology, stressing the user's natural way of using technology in everyday life. By "natural" is meant the biologically and socio-historically conditioned behaviour of man as a tool-making, tool-using animal. Keen and Mackintosh (2001) borrow Ferdnand Braudel's maxim of technology as a means of creating freedoms in the structures of everyday life. Technology is thus seen as something which expands our natural ways of behaving in the world, and the most successful technologies are those that build on our natural interaction with the environment. Punie, Bogdanowicz, Berg, Pauwels, and Burgelman (2003) speak in favour of harnessing information technology to use by the man in the street; technology has to be domesticated. According to Punie, Bogdanowicz, Berg, Pauwels, and Burgelman (2003), human interaction with technology is a constant struggle in which technology changes us and we (as users) change technology. Technological artefacts are continuously modified, put to novel uses, and reinterpreted by the users. For example, the designers could not predict that the users would use the Short Messaging System (SMS) in the fashion they presently do. Technology in turn changes how we humans perceive, act and think. The SMS has for example changed how we make and keep appointments. Both technology and the socio-cultural aspects have to be taken into account in order to avoid both technological determinism and an oversimplified picture of user behaviour (Patokorpi, 2006). Abduction may help reaching both goals. Our abductive competence is also an essential factor in human creativity, and good design designs for change and user inventiveness (Robinson, 1993). Technology domestication is about maximizing the user's power and control over the artefact. Understanding user behaviour can hardly succeed well if our abductive processes are neglected.

An example of the study of everyday reasoning – although this one is not of abduction – is Gigerenzer and Hoffrage's (1995) empirical research on statistical inferences. They first carefully studied the actual reasoning processes the people used in the relevant context, then made the presentation of data more natural, which significantly improved both laymen's and professionals' estimates of probabilities and frequencies. The estimates became as good as the Bayesian ones when the data presentation suited the experimental subjects' natural way of dealing with frequencies. Unlike in the heuristics and biases programme of Tversky and Kahneman (Kahneman, 2003), the reasoning processes in the above example were not considered as more or less successful attempts, under constraints, at linear optimisation but adaptations to the environment. It is quite common in HCI that designers believe to know how the user should think: in accordance with unbounded rationality (e.g. deductive logic and Bayesian probability calculation). Thereof follows either a tendency to block avenues that do not meet the criteria of unbounded rationality – although they would be quite adequate for sensible use – or to make the inner workings of the artefact even less transparent than they already are because the users "would not understand them anyway".

6. Image and logic

Logic is usually understood in terms of order (i.e. syntax) and form. Hence meaning or content (semantics) is a matter of premises and completely isolated from logical form, which means that the existence of material inferences is not recognised. Material inferences are inferences in which the content of the concepts make them good inferences. For instance, we can infer from "John is Paul's father" to "Paul is John's son" because we understand the concepts 'father' and 'son'. On this view, grasping the conceptual content is in some sense prior to logical form, but logical (inferential) all the same (Brandom, 2000). Reasoning patterns as adaptations to the environment have a connection to experience and meaning making, but the connection itself has so far been little studied (studied though e.g. by Magnani, 2009). Abduction, as a form of perception-based reasoning, retains a connection to content or meaning because percepts make sense to us, that is, they have (iconic, indexical or/and symbolic) meaning. In other words, perception is inferential by nature. Does this holistic character of our experience set us apart from other complex systems, like machines? The issue is inherently linked to embodiment, disembodiment, situatedness and emergence which unfortunately due to limitations of space cannot be discussed here. Let us instead focus on representation (the representational side of 'experience') in humans and machines. Consider the episode in the history of physics narrated below

Peter Galison (1997, esp. p. 19) has studied two competing traditions of instrument making in physics: (i) the image tradition, based on *mimesis*, and (ii) the logic tradition, based on logical relations. The image tradition strives at representing natural processes in all their complexity through a single image. For instance, the existence of particles is demonstrated through a picture of bubbles in superheated hydrogen. The logic tradition relies not on a single event but on a large amount of data, on the basis of which one can make statistical arguments for the existence of a particle. Hence, the image tradition relies on a concrete, homomorphic representation of a single occurrence, whereas the logic tradition relies on statistically derived logical relations between circumstances that give a homologous representation of the type of event in question. The homomorphic representation seeks to register a natural occurrence without interfering with it, whereas the homologous representation entails interfering with the phenomenon through complicated data massaging. Presently, says Galison, image and logic are converging:

> The new instruments (drift chambers and time projection chambers coupled to powerful computers) had begun to meld together the data-sorting capabilities of the logic tradition with the singular detail and inclusiveness of the image tradition. So it was that in the early 1980s the two traditions fused, with the production of electronically generated, computer-synthesized images. It was just as an electronic “photograph” that heralded the discovery of the W and Z particles in 1983 – the first time a single electronic detection of an event had ever been presented to the wider physics community an compelling evidence in and of itself (1997, p. 21).

The convergence is evident also for instance in computer science which has made significant progress in approximating image by the means of logic, as the research on automated image recognition indicates.

It has to be born in mind that in Galison’s story what are converging are homologous and homomorphic *representations*. The computer-synthesized outcome is or can be seen as an image, and thus at least in a derivative sense an individual, but it may have no material (concrete) connection to the individual event or object it depicts (or simulates) (see Turoff, 1997). Simulation can produce a gestalt, a whole which is more than the sum of its parts. In the extent that distributed computing (e.g. neural networks, multi-agent systems, swarm intelligence, distributed subsumption networks) can create complete, integral wholes computers can partly do the creative, imaginative work for us. According to Peirce (CP 2.777 CP 5.171), abduction is the only form of logic that creates something new. This creative or expansive capacity is partly due to abduction’s holistic and homomorphic nature. So far, we humans have outsmarted machines in the sphere of the homomorphic (esp. abduction) whereas machines have long outperformed us in the sphere of the homologous, which traditionally has involved calculation by deduction. But now simulation and calculation seem to be coalescing. Does it mean that machines are closing upon us in areas which we regard as uniquely human?

As we humans are increasingly becoming cyborgs – meaning that our environment, social practices and bodies are merged with machines and artefacts – the line between human and nonhuman is eroding. However, our abductive competence is still among the toughest things to simulate by computers, mostly because abductive reasoning is focused on differences and conveys things as concrete individuals (as wholes). What will be our "natural" behaviour in the future remains to be seen. Presently, it seems reasonable to call such behavioural patterns natural which are firmly anchored especially in the most formative period of our human evolution, namely that of hunter-gatherers. Abduction certainly still is a central mechanism to us humans (as animals), which shows in the easy, rapid and mostly unconscious way we use it.

7. Conclusion

Abductive inferences are only plausible, and thus not, unlike deduction, truth-preserving. Abduction as everyday reasoning differs from the standard view of abduction as Inference to the Best Explanation, the latter being more focused on abduction's role in scientific method. Incomplete information, time pressure and a changing environment compel to the use of abduction. In real life we use different forms of reasoning in tandem in order to take reasonable action. In order to become a sensible guide to reasonable or reasoned action abduction requires support from deduction and induction as well as a close connection to the seeking of evidence. Abduction is a logic of discovery, that is, a means of finding something new. Abductive reasoning takes a holistic view of facts or observations, focusing on details which lead to individuals (i.e. individuals as wholes). It is thus typically oriented towards homomorphic representations and analogue knowledge, which means that images (iconic signs) dominate abductive thinking. More precisely, abduction is typically oriented towards experiential gestalts of sounds, odours, feelings, tastes, and so forth. Lessons drawn from the study of abductive reasoning in real life should be readily applicable especially in interface design. Logic programming in terms of everyday abduction instead of the IBE model is a tougher challenge.

Firstly, abduction is a form of logic and therefore a sharp, analytic tool that should meet the rigorous requirements of technologically oriented HCI researchers. Abduction is also a form of qualitative, everyday reasoning, connected to our bodily interaction with the world. Therefore it should be rich and broad enough for socio-culturally oriented HCI researchers (Patokorpi, 2006). Secondly, because the creation and sharing of knowledge is in many ways anchored in real-world environments and social practices, the study of knowledge practices ought also to pay attention to reasoning patterns as specialized ways of an organism to adapt to the environment (see e.g. Gigerenzer, 2008; Gigerenzer, Hoffrage & Goldstein, 2008). In addition to abductive practices, deductive, inductive and other reasoning practices need to be re-examined (e.g. Chiasson u/d; 2001). There is a wealth of valuable insights into reasoning, classification, perception and so forth, by writers like for instance Gigerenzer (e.g. 2008), Rosch (1975), Landa & Ghiselin (1999), Magnani (e.g. 2004) and Orliaguet (e.g. 2000) that are yet largely untapped by the HCI community.

Finally, insofar as our inherited forms of reasoning and behaviour in general help us to interact with new technology as well as better understand the impact of our technology enhanced action to others and the environment, it makes sense to exploit knowledge of our natural ways of interaction when designing technology. Although the fairly recent developments in the history of logic (e.g. Boole's laws of thought) coupled with the invention and diffusion of computing machines effectively divorced logic from psychology, it certainly is legitimate to study logic in terms of adaptations to the environment (ecological rationality) and in terms of inferential practices that cannot be reduced to their pure logical form (inferentialism). It is legitimate because without a connection to the environment there would be neither reasoning nor rationality. Psychology has here a great deal to contribute to logic and the kind of practically oriented logical study advocated in this paper has a great deal to contribute to human technology interaction.

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