The Conscious-Subconscious Interface: An Emerging Metaphor in HCI

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Abstract

Although there already exist traditional metaphors influencing human-computer interaction (HCI) such as the human-human interaction metaphor, some applications emerging in areas from intelligent agents to wearable and context-aware computing have prompted the authors to identify a new metaphor implicitly emerging in HCI. This will be referred to as the conscious-subconscious (C-S) metaphor. The explicit elucidation of this C-S metaphor poises HCI to speak to and leverage research in philosophy and cognitive science pertaining to consciousness and cognition.

Introduction

Although the characterization of consciousness and cognition, per se, are not the primary objectives of the applied field of human-computer interaction (HCI), the authors contend that emerging endeavours in HCI are poising it to speak, perhaps more directly than in the past, to such issues.

To address novel challenges as HCI applications have expanded and diverged, the field has developed a growing toolbox of metaphors to inform and interpret interface design. Two such, traditionally prevalent, metaphors for human-computer interaction are the human-tool interaction metaphor and human-human interaction metaphor (see Marchionini (1995) for a general overview). However, some of the applications in relatively new areas such as wearable, context-aware computing, and intelligent/autonomous agents seem to be promoting the implicit development of a new metaphor which will be referred to as the conscious-subconscious (C-S) metaphor.

In HCI, it is natural to partition computer activity into two classes: interface processes and underlying computational processes which are predominantly opaque to the interface/user. Just as much of the computation that goes on in a computer is not evident in any way through, or even to, the interface, so too, much of the computation that transpires in the mind is opaque; even to the individual's own introspection. This is evident in such activities as throwing a baseball, during which there are no conscious calculations of trajectories.

From this perspective, humans can be modelled as cognitively modular with a conscious process running concurrently with one or more subconscious processes. In some cases our conscious mind is completely unaware of the underlying computation, in other cases it is privy to the product or result of the computation, and sometimes it seems actively involved in the process. In light of it's intermittent and incomplete exposure to inner information, the conscious mind can be viewed in this regard as a form of interface itself.

The following example provides an illustration of how the C-S metaphor can be applied in HCI. The next generation of search engine interfaces will be information retrieval agents (e.g. Lieberman, 1995; Rhodes & Starner, 1996; Stenmark, 1997) which are able to proactively, that is, without an explicit query, search out and bring to the user's attention (consciousness) web documents that might be relevant in the current task context. For example, it might fetch pages on Hamlet while an individual is writing a paper on Hamlet in MS Word. In a similar spirit, subconscious memory processes proactively pop memories into mind (consciousness) that are relevant to the current context, such as when you enter a video store and spontaneously remember that your friend recommended that you should see *The Matrix*. In the sense that such interface agents perform tasks of a similar nature to those performed by human subconscious mechanisms, and exchange information with the conscious facet of the user in a similar manner, such agents could be regarded acting as supplementary or prosthetic subconscious systems.

The explicit elucidation of this C-S metaphor is significant in that, more directly than previous metaphors, it poises HCI to speak to and leverage research in philosophy and cognitive science

pertaining to consciousness and cognition.

A distinctive contribution of HCI in this regard, is that by virtue of it's agenda, it is geared toward actual operationalizations of the concepts and implementations of the processes. Such efforts yield impetus and insight towards identifying and characterising: a) information availability and internal interfacing aspects of conscious experience; and b) the underlying processes necessary to support such experience. It is beyond the scope of this paper to delve into the details of these characterizations beyond a few examples. It is hoped that the identification and systemisation of the metaphor will catalyse interdisciplinary impetus toward an integrated theoretical interpretation and framework.

Human-Computer Interaction: Catering to Consciousness

The flip side of the relevance of HCI to the characterization of consciousness, is the relevance of consciousness to the characterization of HCI. Although in cognitive models of computation, consciousness is often regarded as an aside or epiphenomenon (e.g. Jackendoff, 1987), the user's conscious experience often holds centre stage in the field of human-computer interaction. Familiar conscious experiences during computer use, such as effort, confusion, frustration and impatience are all relevant to the evaluation of an HCI design, and these are the types of experiences that HCI efforts endeavour to minimise.

This focus on phenomenology first is actually shared by an explicit methodological approach to the characterization of consciousness. It is one advocated by William James (1910) who advised that the researcher "begin with the most concrete facts, those with which he has a daily acquaintance in his own inner life".

The C-S Metaphor

Humans, as social animals, are equipped with substantial experience in interacting with each other. Designers can cater to this experience by following a human-human interaction metaphor, and attempt to make interacting with a computer resemble, in some sense, interacting with another individual. In terms of design, the practical implication was that making a better computer (interface) was synonymous with making it appear more human. This pursuit is evidenced in research involved with developing natural language interfaces, endowing computer interfaces with personality trait cues, facial expressions and imbuing them with emotions (e.g. Minsky, 1999; Picard, 1997). As users, we tend to meet the design effort halfway with our inclination to anthropomorphize.

However, some emerging applications in HCI require a phenomenological framework that does not fit well with the human-human, or other traditional interface metaphors. There is a trend for computers to become wearable and equipped with their own sensory systems, (e.g. Rhodes, 1997). They can thus be programmed to be context-aware in terms of both the task and physical environment (Dey & Abowd, 1999, is a good survey). Applications are also being programmed to absorb, and make inferences from, the behavioural patterns of their users. For example, web browsers can keep track of the URL's visited and proactively complete the URL string the user is currently typing by matching it to a habitual one. Extrapolating from the "short hand" ease of interaction enjoyed between close friends due to shared experiences, imagine the potential fluency of interaction with a context-aware, habit-aware, wearable device which could potentially accompany an individual at all times and share all "experiences". In this sense the interaction has the potential not only to be more intimate than ever before in HCI, but also in some respects more seamless than interpersonal interaction, and thus of a different, more continuous and customized character than human-human interaction paradigms could properly inform.

Although such a scenario may not be informed by interpersonal *interaction* paradigms, such an integrated, customized interface has aspects in common with the cognitive *intra*-actions that occur between the conscious and subconscious processes within an individual. Compare the experience of information retrieval from a computer search engine interface, or even by querying another person, with the spontaneous retrieval afforded by internal memory. Memories often pop into mind (consciousness) just as they are needed (Rhodes, 2000), before an explicit query need even be formulated. From the perspective of conscious experience, such retrieval is accomplished by an apparently context-aware unconscious process operating concurrently, autonomously and proactively.

In the human-human interaction metaphor for HCI, the human user is, in principle, regarded somewhat holistically. The computer (interface) is designed to simulate human interface characteristics (e.g. speech recognition, and speech output) by effectively acting as another human with "whom" the user can interact (in the spirit of the Turning Test). In contrast, in the C-S interface metaphor, the computer could be thought to be interacting in a more integrated way, simulating a service style akin to that of the user's *own* subconscious

processing. Several such subconscious systems could be simultaneously active. As with internal subconscious processes, it is not unreasonable to suppose that several could run simultaneously and have some form of intermittent 'interactions' projecting on, or guided from, the explicit stream of conscious experience. Although this is a fairly pre-theoretic model, it is at least consistent with two of the most familiar themes in cognitive science and the philosophy of mind: the modularity of mental processes (e.g. Fodor, 1983) and the introspective opacity of some processes and premises (e.g. Davidson, 1987).

The next section describes intelligent/autonomous interface agents (e.g. Lieberman, 1997) whose characteristics can be applied to C-S metaphor applications.

Intelligent Agents: Aspects of Autonomy and Implicit Interaction

Intelligent/autonomous interface agents (e.g. Liberman, 1997) are software processes/programs that can operate in parallel with the user and autonomously impact the interface. They are best described by example (as provided in the next section), but a brief prefacing discussion is appropriate to emphasise their key characteristics in the current context.

They are able in principle to operate without explicit initiation by the user, and/or continually and concurrently with other explicitly interactive activities of the user. By way of contrast, in strictly turn-taking conversational interfaces, such as the familiar traditional search engine interfaces, the user and the interface take turns (inter)acting, and are dormant while awaiting the response of the other. An agent's ability to act proactively sometimes includes the potential to initiate explicit interaction with the user. For example the agent may explicitly inform the user of a something it has detected in the course of it's independent (though often context-aware) activities.

Conversational interfaces are characterized by communication which tends to be fully explicit in both directions. For intelligent interface agents, there can be explicit and implicit aspects of interaction and information gathering. Though the user may or may not be aware of the agent's activities at any given moment, an agent can be programmed to attend to the user's activities, and base it's activity on such implicitly gleaned information, rather then requiring explicit instruction.

Interface agents can have a broad range of capabilities and characteristics. As such, they are not at all tightly or necessarily coupled to the C-S metaphor. An agent could perform autonomous activity but also employ a conversational interaction style, and fit under the auspices of the human-human interface metaphor. The relevance of such agents here lies in the fact their nature *permits* them to be tailored, if desired, towards applications which do fit with the C-S metaphor. For example, they can run concurrently and invisibly in the background, implicitly ingest information, adapt to the individual, interject with task-relevant information or initiate interruptions.

Analogies between Autonomous Interface Agents and Internal Subconscious Processes

The proposal of a C-S interface metaphor for HCI has been justified by the commonalties noted between the attributes of some such interface agents and those of subconscious processes. The parallels are best exemplified in agents which actually perform similar specific functions to those provided by our own subconscious system. Examples of such agents which are likely familiar to the reader include: (1) the information retrieval agents already alluded to; (2) automatic "typo" correction 'agents' as in MS Word; and (3) automatic string completion 'agents' such as provided in browsers for automatic URL string completion.

(1) The C-S interface metaphor is particularly well suited for information retrieval (IR) applications. For the most part, these electronic IR endeavours have been guided by paradigms from the library sciences. However, a very efficient, personally customised, information retrieval system - our own memory system - provides a nearer and dearer paradigm. It is a testament to the appropriateness of the C-S metaphor that when we forget something, we often assert that "it'll come to us", implying the involvement of an agent/process other than our(conscious)selves.

There are several other phenomena in memory which speak to the conscious/unconscious interaction issue. Most of our memories are subconscious most of the time. Otherwise we would be constantly actively engaged in experiencing all our previous memories (simultaneously)! It is a common experience to have an old memory resurface (not consciously bidden) when returning to an old haunt. It is also common not to be able to remember something, such as the location of one's car keys, despite the fact that one consciously wants to. Such experiences serve to remind us that we do not remember by conscious will alone, but rather through a collaboration (interaction) of the conscious and subconscious mediated by context.

Letizia (Lieberman, 1995) is an example of an autonomous interface agent for web search (also Rhodes, 2000; Stenmark, 1997). Letizia operates in

parallel with the user's browsing activity and is always active, sifting the web space that is "nearby" (linked to) the user's current page of focus. Letizia implicitly gleans the user's current web location by monitoring the user's explicit interaction with the browser, and conducts empirical observation of the user's past and present browsing behaviour to infer aspects of interest. The user profile can be saved, so knowledge persists and accumulates across sessions. This information is used to make relevancy judgements without (prior to) explicit presentation of information to the user. Based on this implicitly acquired information, Letizia proactively displays pages in a separate right frame of the browser that it judges might be of interest. Note that Letizia's search is context driven, such that whenever the user switches pages, Leteiza's context is refocused on the new page. In terms of the user's conscious participation in the interaction, the user is free to ignore or pursue the suggestions shown subtly in a window at the edge of the screen.

(2) Word processing applications such as MS-Word can now be set to automatically correct spelling mistakes as the user types[1]. The operation is subtle and unobtrusive, and in composing this document, this author has remained largely unaware of this corrective activity (though not due to a lack of 'typos').

In a similar vein, human musicians have been observed to automatically internally correct 'musical typos' when playing off sheet music without even being consciously aware of it (Jackendoff, 1987). In both cases, there is a concurrent automatic process that is functioning like a proactive proof-reader.

(3) Automatic string completion 'agents' exemplify other HCI activities that could be interpreted as serving as supplementary subconscious processes. Browsers now can be set to automatically/proactively attempt to complete the URL as the user types. Similarly, in the UNIX command-line interface shell "bash", users can type the first few letters of a filename or command and press tab to invoke the completion process (a beep will sound if there more than one possible match requiring the user to be more explicit). In the UNIX case the user has to explicitly invoke the completion process by pressing tab. In some respects, these examples could be interpreted according to the human-human interface metaphor. Conversing individuals often preemptively complete each other's sentences, and this could be considered an appropriate analogy for automatic string completion. However there are significant reasons why a C-S metaphor could be ultimately considered more appropriate. In principle, even in conversation, it is the speaker herself, not the other individual, who best knows what the correct completion will be. Thus, an intra-individual (subconscious) metaphor rather than an inter-individual metaphor is appropriate for achieving optimal performance. Furthermore, in practise, ultimately wearable computers will be privy to context and user history information on a scale that will make them more 'acquainted' with the user, in their head so to speak, than any human-human acquaintance protocol could be properly equipped to model.

[1] For example, automatically changing adn to and.

Implications for the Characterization of Consciousness and Cognition

A perspective on consciousness which revolves around the human conscious/subconscious (C-S) interface has been taken. The authors have proposed that a C-S metaphor is an emerging (though perhaps implicit) metaphor guiding HCI design. In the course of the discussion it was demonstrated that the operation of several existing autonomous interface agents, such as the type providing automatic URL string completion, can be readily interpreted according to this metaphor. However, the actual development of the existing applications was largely on a piecemeal basis and involved implicit or pre-theoretic application of the metaphor. To the authors knowledge, the C-S metaphor has not been labelled as such nor applied in a systematic manner. It lays the foundation for observing that the different disciplines of philosophy and HCI have converged to concentrate on some of the same issues, and thus are poised to mutually inform/influence each other.

There are two types of challenges inherent in implementations according to the C-S metaphor. First, it is necessary to determine and describe the exact nature of the conscious experience the interface is supposed to engender. This might include such factors as the degrees of implicit and explicit exchange, timing issues and information availability, format and salience. Then it is required to characterize and operationalize underlying computational processes to afford the desired interaction and information exchange. These two challenges are discussed in the following two sections.

Characterizing the Conscious Experience

In the human-human metaphor, much of the interaction is typically conversational and of a very explicit nature. That is, it involves direct, deliberate "communication" with the computer. The user has a conscious experience of ongoing active involvement in the interaction. This includes not only awareness of the information exchanged itself but also

(phenomenology of) intentional initiation and interpretation of exchanges. In contrast, for applications in the C-S style, the trend is towards less (experience of) explicit effort, and greater emphasis on fine tuning on the phenomenological aspects of the information availability.

The HCI endeavour of making interacting with a computer more like interaction with one's subconscious processes provides pressure to make the phenomenology of such interactions more explicit. That is, what are the various types and features of phenomenological projections of unconscious computation processes?

Phenomenology is often exemplified by reference to qualia of sensory experiences such as pain. Considerations regarding the phenomenology of interacting with our subconscious process or computers promote the characterization of a different family/modality of phenomenal experiences. These are the less sensory-centric, conscious correlates of computation and internal communication. For example, there is something it is like to consciously, with effort, conduct some reasoning, or to generate and receive explicit communication.

Some such characterizations, especially in terms of memory, have already preceded the HCI efforts. For example, meta-memory models (Kihlstrom, 1987), the feeling of knowing[2] (Hart, 1965), and tip of the tongue experiences (e.g. James and Burke, 2000). Endeavours in HCI according to the C-S metaphor may catalyse more full characterizations and/or operationalizations of such phenomenology.

For example, with regards to information agents, there are several relevant aspects of memory phenomenology at the level being imitated by the agent. It is necessary that the information become accessible to conscious reasoning and declaration, which falls under the auspices of Block's (1995) access consciousness. Another characteristic is that the time course of it's arrival with respect to changing context be such that it ideally arrives when it is relevant and before the user has a conscious sense of missing or wishing for it. This is a motivating premise of Rhodes' (2000) Just-In-Time information retrieval system. Also it is intended to be rendered accessible in such a way that it enters discretely onto the Cartesian stage without upstaging the focus of the current train of thought. The user is free to disregard or ignore the information. Lieberman (1997) points out the significance of this spontaneous subtle suggestion system in Letizia which avoids having the user make the "context switch" required by conversational interfaces from browsing the space of web pages to explicitly interacting with the search agent.

In some respects interaction with C-S style interface agents cannot possibly be experienced exactly like interaction with internal processes. The information from the interface agent starts out on the screen and is subject to absorption via our sensory system. But what is noteworthy is that some of the convenient and customised character is achieved nonetheless. When viewing memory phenomenology at this level, what seems to matter is that the right data be brought to mind at the right time regardless of whether it was a subconscious or sensory delivery channel.

While such input modality issues might not be brought to the fore in operationalizing the semantic access of declarative memory, such issues might become relevant in postulated cases of agents acting as artificial sensory systems. Consideration of attributes and implications of such artificial sensory agents might shed light on some important phenomenal issues and delineations. It provides a good connection point between HCI inspired insights and existing theoretical frameworks about consciousness such as the one proposed by Block (1995).

Characterizing the Underlying Computation

Determining the character and components of the desired conscious experience, which was discussed in the pervious section, might be far less than half the battle. When it comes to cognition, the portion which projects onto conscious is just the tip of the iceberg. Having established what the desired experience is like, the question becomes: how to make it like that? In order to serve as the subconscious does, it becomes necessary to operationalize the attributes and information resources of the underlying process, at least at a functional level. HCI has faithfully followed this trail far from it's initial focus on the conscious experience. Along the way, it (though perhaps inadvertently) produced computational models that act as unconscious computational processes.

The details are beyond the scope of this paper, but the crux of the matter amounts to characterizing the catch-all notion of context. A preliminary framework within HCI for such a characterization is provided by Dey and Abowd (1999). When it comes to memory, we are unaware of what contextual cues our subconscious process might be using to prompt recall. In HCI mediated memory, the nature of the contextual cues in the computational process need not be identical

[2] The feeling of knowing refers to a scenario in which, although the individual is experiencing difficulty retrieving a memory, they nonetheless feel that it is in there (their subconscious) somewhere.

to the ones leveraged by our subconscious, provided that from a functional perspective they are sufficiently correlated. For example, content stored on a computer can be tagged with time of day and date. Unconscious processes may involve some form of temporal tagging of memories, but not in the same format.

Conclusions

The authors have identified the emergence of an implicit C-S metaphor in HCI, which seems more appropriate to interpret and inform certain context-aware and autonomous agent applications than the traditional human-human interface metaphor. The C-S metaphor was inspired by the observation that, from the perspective of the conscious human experience, autonomous interface agents (e.g. Lieberman, 1997) often have attributes in common with subconscious processes. Most notably they exhibit autonomy, and the capacity for implicit interaction. Despite the existence of various applications that fit the bill, to the authors' knowledge the C-S metaphor has not been systematically identified and exploited. Remembrance Agents (Rhodes & Starner, 1996; Rhodes, 1997) were the closest encountered approximation in this regard.

In the application of the human-human metaphor to HCI, fairly operationalized models already existed on the nature of human-human interaction itself. This is not so much the case for human C-S interactions. This situation provides an opportunity for HCI and cognitive science to mutually inform and give impetus to each other on the C-S interface issue.

Probing the C-S metaphor fosters greater appreciation and awareness of the contribution and role of non-conscious processes in cognition. Newton's quote in homage to his predecessors can be aptly adapted to salute the support structure provided by actual and simulated subconscious processes.

If I have seen farther, it is because I have stood on the shoulders of giants.

-- **Sir Isaac Newton**

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