Published in final edited form as:

Proc Hum Factors Ergon Soc Annu Meet. 2008 September ; 52(20): 1645–1649. doi:

10.1177/154193120805202001

Developing a Framework for Intuitive Human-Computer Interaction

Marita A. O'Brien, Wendy A. Rogers, and Arthur D. Fisk

Georgia Institute of Technology, Atlanta, GA

Abstract

Many technology marketing materials tout the intuitive nature of products, but current human-computer interaction (HCI) guidelines provide limited methods to help designers create this experience beyond making them easy to use. This paper proposes a definition for intuitive interaction with specific attributes to allow designers to create products that elicit the target experience. Review of relevant literatures provides empirical evidence for the suggested working definition of intuitive HCI: *interactions between humans and high technology in lenient learning environments that allow the human to use a combination of prior experience and feedforward methods to achieve an individual's functional and abstract goals*. Core concepts supporting this definition were compiled into an organizational framework that includes: seeking user goals, performing well-learned behavior, determining what to do next, metacognition, knowledge in the head, and knowledge in the world. This paper describes these concepts and proposes design approaches that could facilitate intuitive behavior and suggests areas for further research.

INTRODUCTION

We frequently encounter the term “intuitive” in advertisements for high technology as marketers try to attract buyers to new products. For example, several quotations from an Internet search on April 18, 2007 illustrate representative uses of intuitive in technology descriptions:

- “MyDesignIn is an innovative, eye-catching, *intuitive* application that ...”
- “The HP MFP’s ... have a powerful combination of features ... including *intuitive* usability”
- “Mobile VoIP through one highly *intuitive*, easy-to-use interface”

These quotations imply that users will find interactions with the product to be pleasurable and very easy. The quotations do not, however, identify specific attributes of the product that might underlie this intuitive use.

Although ambiguity may be an effective marketing technique for inviting users to experience the product for themselves, the ambiguity challenges designers and developers to deliver the product and interaction described in such an advertisement. Design and computer professionals find little assistance in meeting this challenge from human computer interaction (HCI) manuals (e.g., Mayhew, 1999; Nielsen, 1994) or engineering psychology

textbooks (e.g., Salvendy, 2006; Wickens, Gordon & Liu, 1998) where neither intuitive nor its derivatives (i.e., intuition) are listed in the indices.

Rather than using guidance for intuitive design, professionals have used guidelines from these references for designing “usable” interactions. The target of usable interactions is consistent with suggestions from computer (Raskin, 1994) and design (Cooper, 1995) commentators that intuitive means “familiar”, “easy to use” or “easy to understand”. Yet, replacing the term intuitive with these synonyms in the example quotations above demonstrates that these synonyms are inadequate for describing the target experience marketers are hoping users will have. Instead, intuitive, as used in the marketing quotations, suggests it is a critical ingredient for ideal technologies. Implied is that intuitive technologies are those that not only support users in their current abilities, but also foster new abilities through discovery and experimentation. With an explicit definition for intuitive HCI, designers may be better able to develop products that meet this requirement.

An understanding of intuitive HCI could impact user-centered design in three ways. First, the designer could identify the need for intuitive and non-intuitive use within the research and needs analysis phase of product development. This paper will describe intuitive interaction to guide decisions about contexts, environments, and populations for which intuitive interaction is appropriate. Second, the designer must create stimuli, action selections, controls, etc. that elicit target usage. By proposing specific characteristics of intuitive interaction, this paper presents high-level guidance and examples that may be considered with initial design concepts. Third, designers and usability analysts must evaluate whether the designs actually induce target usage. This paper will further this goal by proposing a definition and framework for core mechanisms and attributes of intuitive interaction to allow better design and testing of intuitive systems.

REVIEW

Review of relevant literatures provides empirical evidence for the proposed definition and framework. First, prior research on intuition and intuitive behavior was systematically reviewed from general psychology, educational psychology, management, decision-making, cognitive engineering, and neuroscience literatures. The focus was on identifying prior definitions and attributes of humans’ capacity and use of intuition in general. The review particularly focused on the use of intuition in decision-making based on the observation that a user selection of an action on technology is fundamentally a decision. Second, an examination of HCI research on novice user, design best practices for consumer systems, and intuitive interactions was conducted to map attributes of intuition and intuitive decision-making identified in the prior review with findings in our domain of interest.

Intuition and Intuitive Decision-Making Research

Five key factors important for intuition emerged from the literature review of intuition and intuitive decision-making. First, definitions of intuition/intuitive behavior often contrast these terms with analytic cognition/behavior and suggest that both are poles on either end of a continuum. Tools for identifying intuitive vs. analytic cognition have been created (e.g., Hammond, Hamm, Grassia, & Pearson, 1987; Kahneman & Frederick, 2002) based on

attributes like cue characteristics, task characteristics, and user disposition. This research suggests that stimuli selection based on these tools can elicit the desired cognitive mode. In addition, researchers suggest that some decisions will be more effectively made using analytic cognition. Example analytic decisions include highway and bridge engineering, areas where systematic research has created standard and auditable methods for achieving desired goals. In general, effective human cognition and behavior is based on the correct selection of intuitive, cognitive, and quasi-rational (in the middle of the continuum) techniques depending on the situation.

Second, evaluation of decision-making techniques has shown that intuitive decision-making can be as effective as analytic decision-making in reaching target accuracy in some situations (Gigerenzer & Kurz, 2001). Intuitive decision-making can also operate more quickly using less data. Third, confidence in the process and data used influences use of intuition, even when other data should be more relevant (Simmons & Nelson, 2006). Fourth, even if the user is unaware that a (or which) cue is affecting the decision, prior experience and cue exposure are implicitly used in intuitive decision-making (Bouthilet, 1948; Westcott, 1961). Finally, intuitive decision-making is similar to naturalistic decision-making techniques such as used by experienced firefighters or military commanders in which effective decision-making is based on pattern-matching and recognition, hypothesis generation, controlled experimentation, and mental simulation (Klein, 1997).

HCI Research

The HCI literature review uncovered evidence that intuitive attributes supporting general ease of use were apparent in novice interactions and consumer system best practices, but designs were limited in protecting users against serious error and frustration and in eliciting changed behavior. Two themes were consistently mentioned in the HCI research: users should feel comfortable making mistakes along their path to the goal and they should leverage prior experience/knowledge. Three other emerging themes were: re-centering (discovery learning through experimentation and exploration), expectancies (using prior experience to predict result of upcoming action for faster evaluation), and type of cue (different recommendations in studies including redundancies, causal properties, labels, differential weighting of cues).

Recommendations to facilitate design for these themes are summarized in Polson and Lewis's (1990) design principles for successful guessing, which they propose lead to easily learned interfaces (p. 214):

1. Make the repertoire of available actions salient;
2. Use identity cues between actions and user goals as much as possible;
3. Use identity cues between system responses and user goals as much as possible;
4. Provide an obvious way to undo actions;
5. Make available actions easy to discriminate;
6. Offer few alternatives;

7. Tolerate at most one hard-to-understand action in a repertoire;
8. Require as few choices as possible.

Given the type of consumer applications that novice users are typically experiencing, users are likely to find a great deal of flexibility in using the applications exactly as they choose. This mode of operation may not be beneficial, however, if exploration leads users repeatedly down the wrong path. In addition to wasting time, users may learn incorrect methods for particular actions (e.g., Singley & Anderson, 1987). Users may also develop poor system representations because their goal is to complete a task using the system, not to learn about technology in general or this system in particular (Freudenthal, 1999). This flexible interaction approach is facilitated by simple action execution and apparent progress that allow goal achievement without awareness of normal action-response cycles. This approach may be adequate in normal operation; however, experimenting with a poor system representation that is slowly updated can be extremely frustrating when users are forced to recover from errors (Jones, Farris, & Johnson, 2005). Thus, design for consumer systems may inadvertently discourage users from learning many system features.

GUIDING INTUITIVE INTERACTION

Based on synthesis of the reviews, key themes were reorganized into an organizational framework for intuitive HCI and developed a working definition. The proposed working definition of intuitive HCI is *Interaction between humans and high technology in lenient learning environments that allow the human to use a combination of prior experience and feedforward methods to achieve an individual's functional and abstract goals*. Definitional themes have been organized into a framework, shown in Figure 1.

In this section we propose how each framework component contributes to intuitive interactions. Psychological research is cited to facilitate a concrete understanding of cognitive activities that have evolved for humans to naturally interact with their environment. With this understanding, designers will be better equipped to select features, icons, text labels, controls, etc. that appropriately simulate such aspects of the environment and elicit intuitive HCI.

The overall framework—The framework is conceptual with three “pie slices” representing a user's required cognitive activities in intuitive interactions. Bold labels for each slice summarize this cognitive activity in common language from the user's perspective. Other terms in each slice designate attributes identified in the literature review as characteristic of intuitive behavior that contribute particularly to the labeled cognitive activity. The inner and outer knowledge circles represent potential sources of information to guide the user's interaction. Bidirectional arrows between these circles and the slices represent the fact that knowledge is dynamic, with accessibility of particular knowledge elements dependent on prior activities and determining what will be subsequently available. The cognitive faculty of metacognition is proposed as a mechanism for managing these components and mediating the cognitive activities and knowledge in the head.

Seeking user goals—User behavior is oriented toward achieving goals. Goals may be concrete and functional like completing specific tasks, and knowledge of these goals guides system behavior (Polson & Lewis, 1990). Even goals that are not well defined may encourage discovery if the user is under loose cognitive control that facilitates access to peripheral cues, increasing the opportunity for discovering new directions (Bastick, 1982). Goals can also be created ad hoc by users to organize a series of options that appear together on a menu bar in the context of achieving a larger goal or learning a new activity (Barsalou, 2003). The goal-seeking process itself can help link seemingly disparate items as may be needed when users explore a system for the first time (Polson & Lewis).

In addition to functional goals, aesthetic goals such as beauty, pleasure, and truth can also guide intuitive behavior. Even in early research (e.g., Bouthilet, 1948), beauty and emotion were suggested as important factors for intuition, though aesthetic goals for HCI have only recently been explored (e.g., Overbeeke & Wensveen, 2003). Designing to support aesthetic goal achievement may be more complex than for concrete goals where user perseverance can be reinforced with visible progress toward the goal, but aesthetic goals designed into new technologies may be the most effective motivators for eliciting changed behaviors.

Performing well-learned behavior—Users select cognitively efficient, well-learned processes if they are immediately accessible and unconsciously judged to be appropriate for the current environment and context. Designing based on how users naturally operate simple tasks is challenging because users are often unaware of normal task flow or which cues allow them to execute well-learned functions easily. In fact, users may only become aware of important cues when they are not present in the environment (Gray, 2006). Gray and Boehm-Davis (2000) investigated subtle display changes and recommended that task analysis be completed at the microstrategy level to determine the best ways to facilitate behavior in system design. Otherwise, users may select a non-optimal strategy or skill as they incorporate previous knowledge with new system knowledge (Singley & Anderson, 1987). Thus, objective measures of performance with different cues should guide design decisions (Gray).

Determining what to do next—Even if available cues seem unreliable or incomplete, users can still pursue their goals intuitively for two main reasons. First, our perceptual system is accustomed to draw conclusions in environments with multiple fallible but probabilistic information sources, and relies on environmental factors like cue redundancy increase the signal and reduce the noise (Hammond, 1996). Second, the environment also includes many irrelevant cues (Westcott, 1968). The cognitive system, like other information processing systems, only needs a sufficient number of cues to discriminate between the available options.

Our cognitive system seems to have a neurological mechanism for “filling in” based on prior experience and expectancies called feedforward (e.g., Basso & Bellardinelli, 2006). Feedforward is based on a predicted future state of the environment, moving toward the goal state until a constraint or blockage is met that requires additional evaluation of available actions in the current context to select the next action (Brehmer & Hogarth, 1990). In addition, the quality of available information and context/environment regularities are also

important components of effective feedforward control as may be observed with regular driving behavior (Hollnagel, 2005). Feedforward itself is well-learned and can be done with little effort or conscious attention. Systems developers are challenged, however, to create designs that effectively guide the user in “filling in” missing information to facilitate intuitive interaction because this feedforward process develops implicitly with few constraints to make it consistent.

One critical requirement for the use of feedforward is the presence of a lenient environment in which small errors are expected and allowed, but frequent salient feedback allows learning and progress toward the goal (Hogarth, Gibbs, McKenzie, & Marquis, 1991). Guesses do not have to be exactly correct but only sufficient for rapid hypothesis testing and online correction (Hogarth, 2001). Thus, intuitive usage with feedforward may not be exactly the same each time even for the same individual. Different users are also likely to interact in unique ways due to individual differences in collecting information and perceiving events (Hollnagel, 2002). Systems with salient constraints that guide users in knowing what will not happen may therefore be the best way for designers to minimize exploration in areas that will not support any potential user goal (Norman, 2002).

Metacognition—Metacognition is the cognitive mechanism through which humans evaluate and monitor their own thinking processes and knowledge content (Hertzog & Hultsch, 2000). The overall question in HCI is determining what action the human should or will take. One key factor influencing users' decisions about what to do next is increasing confidence (Westcott, 1961). This confidence may be based on many factors, including prior experience with the “fill-in” strategy or prior knowledge that guides hypothesis development and evaluation. This confidence seems similar to the metacognitive feeling of knowing, guiding users as they connect possible items together and determine how connections suggest a path to the goal (Bastick, 1982).

Knowledge in the head/knowledge in the world—One benefit of understanding how metacognitive judgments affect intuitive interaction may be predicting how users select knowledge to use in interactions. Norman (2002) noted that users have two major sources of knowledge: knowledge in the head encompassing prior information, implicitly and explicitly learned, and knowledge in the world encompassing system features and environmental information available for particular interactions. He proposed that designers could improve user performance by mapping knowledge in the world (determined by system design) to expected knowledge in the [user's] head. HCI guidelines suggest that consistent cue and function usage between systems allows users to access this mapping and to leverage prior knowledge (e.g., Mayhew, 1999). The value of this consistency has been identified empirically as well. In using a new digital camera, for instance, users with broad technology knowledge but limited knowledge of other digital cameras could still access many common functions quickly and with little explanation (Blackler, Popovic & Mahar, 2003). Blackler (2006) has elaborated on Norman's recommendation with a proposed intuitive continuum of knowledge in user's heads that could be leveraged by designers. Blackler's research does not identify, however, which knowledge will be retrieved if users have several potentially

valid prior experiences. Metacognitive assessment should guide retrieval, but knowledge in the world may be misinterpreted and misused if designed incorrectly.

DISCUSSION

Conclusions

From a literature review we created an organizational framework for understanding intuitive HCI with five key components. First, user behavior is oriented toward achieving functional or subjective goals, including finding coherence in a novel domain. Second, feedforward methods allow activity selection based on hypothesis-testing/fill-in strategies that progress toward goals with quick, preconscious evaluation of responses to each action and online correction. Third, well-learned activities are frequently used in intuitive interactions because they are perceived as direct and implicitly judged as appropriate for the current environment and context. Fourth, metacognitive judgments are used in lenient environments to efficiently determine how to use each component. Lastly, the judgment uses a combination of knowledge in the head and knowledge in the world based on user confidence and feelings of knowing. The framework also shows that intuitive interactions are inherently dynamic; periods of analytic activity may be found within generally intuitive interactions.

One overall finding was that though HCI guidelines included many of the intuitive attributes identified in the psychological review, the guidelines only framed general usability and ease of use. Guidelines and best practices for governing behavior in a lenient environment and for priming users to select the best options are emerging, but they do not target subjective factors of emotional involvement and confidence that may be crucial to promote exploratory behavior for new usage. Future research is needed to investigate how these factors elicit exploratory behavior.

A corollary to these recommendations for eliciting intuitive interactions is that they may not always be appropriate. Just as some engineering decisions are best made using analytic cognition, some system environments should be designed to elicit analytic interactions for consistent, correct usage every time by every user.

Practical Applications

Several immediate questions and recommendations for improved intuitive design are based on the intuitive interaction framework, including:

In what cases should people use knowledge in the world rather than knowledge in their heads?—Research suggests that individuals may fluctuate between using knowledge in the world vs. knowledge in the head depending on costs and benefits of accessing each type of information (e.g., Gray & Fu, 2004). In a system designed to be easy-to-use, for instance, users may implicitly learn aspects of system use that decrease the cost of using knowledge in the head. Users may then be unaware that information on the display has changed that should replace their use of knowledge in the head. Further research is needed to understand how design can affect knowledge selection.

How can designers lead users to guess effectively?—Polson and Lewis's (1990) design principles for successful guessing provide some initial tactics. Systems may also use echoing and repetition to reinforce the task flow direction and linkage with other elements/functions for the same goal (Barsalou, 2003). If the system is analogous to another system, designers can evaluate user cues for recognizing the analogy and provide these cues to let the feeling of knowing implicitly guide users to make this connection.

How can designers guide the guessing process?—Use feedforward techniques to manage user expectations for system responses to their actions. These can be subtle so that they are used as needed, particularly with peripheral vision (Spool, 2005). For example, input fields requesting specific types of data can be accompanied by valid samples.

How can designers communicate clearly that error consequences/costs are low?—The user should be made aware that errors are not fatal and can be corrected using system feedback, i.e., a lenient, learning environment (Hogarth, 2001). One starting point for web-based systems is to recognize that the major cost is that the user will lose time from errors, so design should enable easy error recovery.

How can designers help users resolve ambiguities in data interpretation?—Users' actions and experimentation allow them to perceive knowledge even in impoverished environments (e.g., Kirlik, 1998). For systems in which users will gain significant experience with little explicit training, designers should provide users with controls that allow them to gather information in ways that make sense to them, even if based on idiosyncratic prior knowledge.

What type of feedback helps users reduce evaluation time and need for analytic processing?—Intuitive systems work well in normal operation, but they cannot manage error correction well. When errors are made, researchers recommend that feedback be frequent, fast, and diagnostic (Hogarth, 2001). Though users may temporarily use analytic processing to recover, they experience minimal time loss or frustration because they know exactly what to do.

References

- Barsalou LW. Situated simulation in the human conceptual system. *Language and Cognitive Processes*. 2003; 18:513–562.
- Basso D, Belardinelli MO. The role of the feedforward paradigm in cognitive psychology. *Cognitive Processing*. 2006; 7:73–88. [PubMed: 16683170]
- Bastick, T. *Intuition: How We Think and Act*. Chichester, England: John Wiley & Sons; 1982.
- Blackler, A. Unpublished dissertation. Queensland University of Technology; Brisbane, Australia: 2006. Intuitive interaction with complex artifacts.
- Blackler A, Popovic V, Mahar D. The nature of intuitive use of products: An experimental approach. *Design Studies*. 2003; 24:491–506.
- Bouthilet, L. Unpublished Dissertation. University of Chicago; Chicago: 1948. The measurement of intuitive thinking.
- Brehmer, B.; Hogarth, RM. Strategies in real-time, dynamic decision making. In: Hogarth, RM., editor. *Insights in decision making: A tribute to Hillel J. Einhorn*. Chicago: University of Chicago Press; 1990. p. 262-279.

- Cooper, A. *About Face: The Essentials of User Interface Design*. Foster City, CA: IDG Books Worldwide; 1995.
- Freudenthal, A. *The Design of Home Appliances for Young and Old Consumers*. Vol. 2. Delft, The Netherlands: Delft University Press; 1999.
- Gigerenzer, G.; Kurz, EM. Vicarious functioning reconsidered: A fast and frugal lens model. In: Hammond, K.; Steward, T., editors. *The Essential Brunswik: Beginnings, Expectations, Explications*. Oxford, England: University Press; 2001. p. 342-347.
- Gray, WD. The emerging rapprochement between cognitive and ecological analyses. In: Kirlik, A., editor. *Adaptive Perspectives on Human-Technology Interaction: Methods and Models for Cognitive Engineering and Human-Computer Interaction*. Oxford, England: Oxford University Press; 2006. p. 230-246.
- Gray WD, Boehm-Davis DA. Milliseconds matter: An introduction to microstrategies and to their use in describing and predicting interactive behavior. *Journal of Experimental Psychology: Applied*. 2000; 6:322-335. [PubMed: 11218341]
- Gray WD, Fu WT. Soft constraints in interactive behavior: The case of ignoring perfect knowledge in-the-world for imperfect knowledge in-the-head. *Cognitive Science*. 2004; 28:359-382.
- Hammond, KR. Human judgment and social policy: Irreducible uncertainty, inevitable error, unavoidable justice. New York: Oxford University Press; 1996. *Coping with uncertainty: The rivalry between intuition and analysis*; p. 60-93.
- Hammond KR, Hamm RM, Grassia J, Pearson T. Direct comparison of the efficacy of intuitive and analytical cognition in expert judgment. *IEEE Transactions on Systems, Man, & Cybernetics*. 1987; 17:753-770.
- Hertzog, C.; Hultsch, DF. Metacognition in adulthood and old age. In: Craik, FI.; Salthouse, TA., editors. *Handbook of Aging and Cognition*. Mahwah, NJ: Lawrence Erlbaum Associates; 2000. p. 417-466.
- Hogarth, RM. *Educating Intuition*. Chicago: University of Chicago Press; 2001.
- Hogarth RM, Gibbs BJ, McKenzie CR, Marquis MA. Learning from feedback: Exactingness and incentives. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 1991; 17:734-752.
- Hollnagel E. Time and time again. *Theoretical Issues in Ergonomics Science*. 2002; 3:143-158.
- Hollnagel, E. Extended Control Model (ECOM). 2005. Retrieved 2/28/2007, from www.ida.liu.se/~eriho/ECOM_M.htm
- Jones KS, Farris JS, Johnson BR. Why does the negative impact of inconsistent knowledge on web navigation persist? *International Journal of Human-Computer Interaction*. 2005; 19:201-221.
- Kahneman, D.; Frederick, S. Representativeness revisited: Attributed substitution in intuitive judgment. In: Gilovich, T.; Griffin, D.; Kahneman, D., editors. *Heuristics and Biases: The psychology of intuitive judgment*. Cambridge, UK: Cambridge University Press; 2002. p. 49-81.
- Kirlik, A. The ecological expert: Acting to create information to guide action. Paper presented at the Conference on Human Interaction with Complex Systems (HICS '98); Piscataway, NJ. 1998.
- Klein, G. The recognition-primed decision (RPD) model: Looking back, looking forward. In: Zsombok, CE.; Klein, G., editors. *Naturalistic Decision-Making*. Mahwah, NJ: Lawrence Erlbaum Publishers; 1997. p. 285-292.
- Mayhew, DJ. *The Usability Engineering Lifecycle: A Practitioner's Handbook for User Interface Design*. San Francisco, CA: Morgan Kaufmann Publishers Inc; 1999.
- Nielsen, J. *Usability Engineering*. Boston: AP Professional; 1994.
- Norman, DA. *The design of everyday things*. New York: Basic Books; 2002.
- Overbeeke, CJ.; Wensveen, SAG. From perception to experience: From affordances to irresistibles. Paper presented at the Proceedings of the 2003 international conference on Designing pleasurable products and interfaces; Pittsburgh, PA. 2003.
- Polson PG, Lewis CH. Theory-based design for easily learned interfaces. *Human-Computer Interaction*. 1990; 5:191-220.
- Raskin J. Viewpoint: Intuitive equals familiar. *Communications of the ACM*. 1994; 37:17-18.

- Salvendy, G., editor. Handbook of Human Factors and Ergonomics. 3. New York: John Wiley & Sons, Inc; 2006.
- Simmons JP, Nelson LD. Intuitive confidence: Choosing between intuitive and nonintuitive alternatives. *Journal of Experimental Psychology: General*. 2006; 135:409–428. [PubMed: 16846272]
- Singley MK, Anderson JR. A keystroke analysis of learning and transfer in text editing. *Human-Computer Interaction*. 1987; 3:223.
- Spool, J. What makes a design seem “intuitive”? 2005. [Electronic Version]. Retrieved 7/17/07 from http://ui-e.com/articles/design_intuitive
- Westcott MR. On the measurement of intuitive leaps. *Psychological Reports*. 1961; 9:267–274.
- Westcott, MR. Toward a contemporary psychology of intuition: A historical, theoretical, and empirical inquiry. New York: Rinehard & Winston; 1968.
- Wickens, CD.; Gordon, SE.; Liu, Y. *An Introduction to Human Factors Engineering*. New York: Addison Wesley Longman, Inc; 1998.

Figure 1.
Proposed organizational framework for intuitive human-computer interaction.