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Prior schemata transfer as an account for assessing the intuitive use of new technology

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ABSTRACT

New devices are considered intuitive when they allow users to transfer prior knowledge. Drawing upon fundamental psychology experiments that distinguish prior knowledge transfer from new schema induction, a procedure was specified for assessing intuitive use. This procedure was tested with 31 participants who, prior to using an on-board computer prototype, studied its screenshots in reading vs. schema induction conditions. Distinct patterns of transfer or induction resulted for features of the prototype whose functions were familiar or unfamiliar, respectively. Though moderated by participants' cognitive style, these findings demonstrated a means for quantitatively assessing transfer of prior knowledge as the operation that underlies intuitive use. Implications for interface evaluation and design, as well as potential improvements to the procedure, are discussed.

1. Introduction

Intuition is a mode of effortless thinking in which pre-existing knowledge pre-empts the analysis of new situations (Hodgkinson et al., 2008; Kahneman, 2003; Klein, 1998). In this vein, devices that fit users' prior knowledge and require little effort to use are considered 'intuitive' (Blackler, 2008; Hurtienne, 2009; O'Brien et al., 2012). Currently, the means for assessing device use and intuitive use as a function of prior knowledge (a.k.a. prior experience or familiarity) consist of observational analyses of participants using a test device (e.g., a digital camera) and questionnaires to assess their familiarity with technology (for an overview, see Blackler et al., 2011). Observational analysis requires usage sessions to be recorded by video so that an experimenter may manually isolate each feature use (e.g., menu, option) and assign the corresponding performances, behaviors, and verbal protocols[1] to a set of heuristics. A feature use is considered intuitive when it displays at least two of the following heuristics: expectedness, subjective certainty of correctness, latency, (verbalized) relevant past experience, and absence of evidenced (verbalized) reasoning (Blackler, 2008; see also Blackler et al., 2010; Gudur et al., 2013; Lawry et al., 2010). Technology familiarity questionnaires assess participants' exposure to and competence with device types both similar and different to the one being tested (Blackler et al., 2010; Hurtienne et al., 2013; Langdon et al., 2007). Such assessment revealed that features whose function or appearance is familiar from other devices tended to be used correctly, rapidly, and intuitively. Notably, Blackler et al. (2010) showed that a digital camera yielded more intuitive uses from participants who had a broad familiarity with technology, yet little experience with digital cameras, than from participants who had limited familiarity with technology, yet were familiar with digital cameras. In this sense, intuitive use seems to reflect a transfer of knowledge from familiar devices and domains onto new devices (Blackler et al., 2010; Blackler and Hurtienne, 2007; Langdon et al., 2007).

The notion of transfer deserves further consideration. First, it is evident from studies of functional fixedness (Duncker, 1945), analogical reasoning (Gentner et al., 2003; Keane, 1987) and multimedia learning (Mayer, 2001) that the availability of knowledge does not imply its transfer (for a review, see Barnett and Ceci, 2002; Bracke, 1998). Thus, the way in which prior knowledge is transferred onto new devices needs to be clarified. Second, assuming that knowledge transfer is the underlying mechanism of intuitive use, it would be pertinent to assess intuitive use in terms

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[1] Verbal protocols were obtained concurrently (Blackler, 2008; Blackler et al., 2004), retrospectively (Langdon et al., 2007, 2010), or both (Lawry et al., 2010). For concurrent protocols, participants were instructed to use the device while they 'talk aloud about what they are doing' (Blackler, 2008, p. 298). For retrospective protocols, participants were asked to 'describe and explain their interpretation' of their performance while a video of their usage is played back to them (Langdon et al., 2007, p.186).

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of the transfer itself, rather than sets of other descriptors[2]. To date, intuitive use is assessed through observational analyses of participants, a method that is reportedly quite time-consuming (Blackler and Hurtienne, 2007), or through surveys of participants' impressions of a device (Ullrich and Diefenbach, 2010; Mohs et al., 2006; Hurtienne and Naumann, 2010). The major disadvantage of these approaches is their subjectivity, which justifies a search for alternatives. The present study is an effort in this direction: psychology studies are reviewed as a basis for assessing knowledge transfer quantitatively. In Section 2, we argue that transfer requires abstract representations of knowledge called schemata. In Section 3, we specify an experimental procedure, along with the factors and hypotheses for assessing schemata in terms of their operations in human computer interactions (HCI). In Section 4, we detail the experiment for verifying our hypotheses, including materials and experimental conditions. In Section 5, the results of this experiment are presented and discussed. Finally, in Sections 6 and 7, we review implications and future directions of this research.

2. A schema-transfer account of intuitive use

2.1. Knowledge transfer

Knowledge transfer is a composite phenomenon. Of the various existing transfer mechanisms, two are directly relevant to the understanding of intuitive use: near transfer and far transfer. These mechanisms have been conceptualized in the field of analogical reasoning by means of a two-stage procedure in which participants study a source problem and its solution, and then solve a target problem. Source and target problems are formulated so as to be similar in terms of surface (near transfer) and/or means-goal structure (far transfer). Transfer is demonstrated if participants, without being told this similarity, spontaneously reuse the source to solve the target. Near transfer has been demonstrated to occur robustly. For example, participants presented with a source problem about a doctor who treats a cerebral tumor by converging low-intensity X-rays were able to transfer this convergence solution to the X-ray treatment of a stomach tumor (Gick and Holyoak, 1980). Transfer even occurred between outwardly similar yet structurally incompatible problems: participants drew superficial analogies that did not result in a conceptually relevant solution, and they repeatedly attempted to reuse the source rather than analyze the target (Holyoak and Koh, 1987; Novick, 1988). Conversely, far transfer could not be obtained between analogous problems in which structure is similar, yet surface attributes differ. For example, consider the above tumor problem presented after a source problem in which a military general converges his troops to attack a fortress (Gick and Holyoak, 1980). In such cases, even when made to summarize, memorize, or recall the source while solving the target, participants did not reuse the convergence solution, instead analyzing alternative solutions to the target (Gick and Holyoak, 1983; Spencer and Weisberg, 1986).

The fact that outward similarity promotes transfer and prevents analysis upholds design strategies that consist of replicating the appearance attributes of familiar devices and domains (see Blackler and Hurtienne, 2007). Yet as surface dissimilarity disrupts transfer, it is unclear how devices that depart from replication and skeuomorphism (for reasons of style revitalization, trademarked property, etc.) can still be intuitive. This issue of far transfer was resolved by Gick and Holyoak (1983) with a study in which participants compared, in writing, two problem instantiations of the convergence solution (e.g., the fortress problem and an analogous parade problem) before solving the tumor problem. The tumor problem was solved through transfer by nearly 90% of participants who emphasized the convergence solution in their comparisons, but by none of the participants who focused on details of the source stories in their comparisons. This finding was attributed to the induction of a schema. Schema induction requires that structure common to several instances be encoded as constant and differing attributes be encoded as variables (Gentner et al., 2003). The resulting representation (schema) can be assigned optional values and transferred to instances that are new as well as superficially different (Reeves and Weiberg, 1994).

Comparison of just two instances suffices for a new schema to be induced. Even if instances are not fully understood, knowledge gained from one aids in understanding the other (Gentner et al., 2003). Without comparison, exposure to several instances results in the formation of representations that are specific, in that they support near transfer but not far transfer (Catrambone and Holyoak, 1989; Cummins, 1992; Hintzman, 1986; Spencer and Weisberg, 1986). It takes many instances for a schema to be 'abstracted' without comparison. Since Reber (1969), it is known that participants who study many character strings from an artificial grammar become able to classify new target strings based on this grammar. The knowledge hence acquired is implicit, as participants fail to explain their judgments or recognize previously studied source strings. Debate occurred as to whether such transfer was due to a schema being abstracted (Reber, 1989; Reber and Allen, 1978) or fragments of the source strings being memorized. Compelling evidence in favor of schema abstraction includes demonstrations of far transfer whereby participants classified strings composed of new letters, and even new stimuli such as aural tones, based on the grammar (Altmann et al., 1995; Gomez, 1997; Kürten et al., 2012; Reber, 1969). Studies from analogical reasoning and implicit learning established the key role of schemata in the transfer of knowledge from known contexts and domains to new ones. Likewise, we posit that schemata mediate the transfer of knowledge onto devices that are new-to-innovative.

2.2. Revisiting previous accounts of intuitive use

Many aspects of intuitive use resemble the schema construct. Intuitive use has been described as an application of well-learned knowledge or existing skills that result in chunking, grouping of actions, or automated procedures (Langdon et al., 2007; Lawry et al., 2010; Raskin, 1994). Psychological accounts of expert thinking have established that schemata result in a chunking of information that working memory processes automatically and effortlessly (Chase and Simon, 1973; Chi et al., 1981, 1982; Ericsson and Kintsch, 1995; Gobet et al., 2001; Larkin et al., 1980; Saling and Phillips, 2007; Shiffrin and Schneider, 1977). Intuitive use has also been described as the unconscious application or transfer of knowledge across devices and domains (Blackler et al., 2010; Langdon et al., 2007; Raskin, 1994). In psychological accounts of reasoning, schemata designate abstract knowledge structures that mediate far transfer and allow the unconscious anticipation of an indefinitely large number of situations (Gentner et al., 2003; Gick and Holyoak, 1983; Neisser, 1976).

Some accounts of intuitive use have attempted to connect the application of knowledge across devices to either transfer or

[2] Examples of these sets: Evalint questionnaire (perceived effortlessness, perceived error rate, perceived achievement of goals, and perceived effort of learning; Mohs et al., 2006); QUESI questionnaire (low subjective mental workload, high perceived achievement of goals, low perceived effort of learning, high familiarity, and low perceived rate of errors; Hurtienne and Naumann, 2010); INTUI questionnaire (magical experience, effortlessness, gut feeling, and verbalizity; Ullrich and Diefenbach, 2010); and coding heuristics (expectedness, subjective certainty of correctness, latency, relevant past experience, and absence of evidenced reasoning; Blackler, 2008).