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The Interaction of Strategy Use and Experience in Intuitive and Analytical Problem Solving

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Abstract

Research on dual processes in cognition has found that explicit, analytical thought is more powerful and less vulnerable to heuristics and biases than is implicit, intuitive thought. However, several studies have found that holistic, intuitive processes can outperform analytical processes, documented by the disruptive effects of hypothesis testing, think-aloud protocols, and analytical judgments. To examine the impact of intuitive versus analytical strategies and level of experience on problem solving, undergraduates solved problems dealing with college life. Results showed that strategy appropriateness depended on the problem solver's level of experience. Analysis was found to be an appropriate strategy for more-experienced individuals, whereas less-experienced participants scored best using intuition. Implications for problem solving, expertise, and dual process models are discussed.

Keywords: strategy; expertise; intuition; problem solving; decision making; dual process models

Intuitive and Analytical Problem Solving

When it comes to solving an everyday, practical problem, should the problem be approached analytically or intuitively? Much psychological research on problem solving has attempted to explain how individuals use logic and analysis to solve well-defined problems. However, many everyday, practical problems involve high stakes and are complex and ill-structured, lending themselves to a more intuitive approach. Practical problems involve the application of intuitive, tacit knowledge that has been gained through experience rather than explicit instruction (Sternberg et al., 2000). For practical problems, to what extent should we attempt analysis or rely on intuition? I argue that the appropriateness of strategy use depends on an individual's level of experience in the domain.

The constructs contrasted in this work are rooted in dual process models of cognition (e.g., Epstein, 1991; Sloman, 1996). Intuition is part of the mode characterized as holistic, automatic, effortless, affective, slow, resistant to change, context-specific, passive and preconscious, whereas analysis is part of the mode described as rational, intentional, effortful, logical, rapidly and easily changed, context-general, active and conscious.

Traditionally, the problem-solving literature has focused on how individuals solve well-defined problems using analytical processes such as means-end analysis and hypothesis testing, which rely on explicit metacognitive processes. Various studies of dual processes in higher cognition have emphasized the benefit of the analytical processing mode in overcoming the heuristic responses of the intuitive processing mode (e.g., Epstein, Pacini, Denes-Raj, & Heier, 1996; Greenwald & Banaji, 1995). Intuitive processing has been often noted as causing errors in judgment while rationality has been held up as an ideal. Intuition has generally been thought of by cognitive psychologists as synonymous with heuristic processing (e.g., Chase, Hertwig, & Gigerenzer, 1998; Tversky & Kahneman, 1974).

However, theoretical work on intuition describes two distinct definitions of the construct (Hill, 1987-88). Classical intuitionism views intuition as a holistic processing mode, whereas inferential intuitionism defines intuition as "a heuristic that represents a logical (inferential) process in which several intermediary steps have been omitted or obscured" (p. 138). This paper adopts a classical understanding of intuition. Intuitive thinking is a holistic perspective that takes into account all types of information that can often not be easily articulated explicitly. Holistic intuition is distinct from inferential (or heuristic) intuition, which has its roots in an analytical process that has become automatized. Theoretically, analysis and inferential intuition are on a continuum based on automatization, but holistic intuition is a qualitatively different process altogether.

Evidence from various literatures in psychology supports the proposal that classical, holistic intuitive processes outperform analytical processes in many cases, for example, in studies of nonverbal communication (Ambady & Rosenthal, 1992), judgment and decision-making (Wilson & Schooler, 1991), and problem solving (Berry & Broadbent, 1988; Schooler & Melcher, 1995). Such studies have shown that analytical approaches lead to misleading hypothesis testing or the neglect of relevant information, whereas intuitive approaches allow for a holistic perspective that takes into account all information, regardless of prior hypotheses or schemas. For example, Wilson and Schooler's (1991) research has shown that holistic judgments of strawberry jam are closer to expert judgments than judgments made after analyzing various features of the jams. Recent empirical and theoretical work by Dijksterhuis (2004; Dijksterhuis & Nordgren, 2006) has argued that unconscious thought (i.e., thought during a period of distraction or incubation) is superior to conscious thought (i.e., careful analysis of the problem) when the task requires the holistic processing of highly complex stimuli.

Experience

Experience affects the organization of knowledge. Expert knowledge is organized according to highly sophisticated schemas, whereas novices lack this deep structure, organizing their knowledge on more surface features (Chi, Feltovich, & Glaser, 1981). Categorization research has found that experts use these schemas to make holistic judgments such as medical diagnoses (e.g., Eva, Norman, Neville, Wood, & Brooks, 2002). Novices are known to rely on analytical processing initially and then take a more holistic, similarity-based approach as they gain experience (Kulatunga-Moruzi, Brooks, & Norman, 2001). Use of schemas in judgment and decision-making tasks are examples of the use of inferential intuition. Such judgments rely on previously explicit knowledge that has become automatized in the form of a schema that is imposed on a new set of information.

These schemas can be contrasted with the tacit knowledge that is acquired through experience rather than direct instruction, and is thus not easily articulated (Polanyi, 1966). Whereas novices become experts by automatizing explicit knowledge into schemas that form the basis for inferential intuition, expertise in the form of tacit knowledge is theoretically never explicit and forms the basis for holistic intuition. If tacit information is to be taken into account in solving a problem, it must be made available and accessed. Therefore, if tacit knowledge is not easily amenable to explicit thought, it may be best processed in a holistic, intuitive manner.

Research on practical problem solving has provided evidence that experts may benefit from either an analytical or an intuitive problem-solving strategy. In one study, Antonakis, Hedlund, Pretz, and Sternberg (2002) proposed a model of tacit-knowledge acquisition and application that highlighted the importance of metacognitive skills in the use of tacit knowledge. The study found that military officers at higher ranks were distinguished from those at lower ranks by their ability to articulate more detailed metacognitive knowledge in an open-ended measure of tacit knowledge, suggesting that an explicit approach that emphasizes the use of metacognition may enhance practical problem solving.

However, the tacit nature of expert knowledge suggests that it may only be processed intuitively. Schön (1983) has illustrated the value of reflection and intuitive thinking in problem solving. Schön explains that leaders form intuitive, implicit, latent representations that reflect patterns of events in the environment acquired through experience. Problems are solved by responding spontaneously and intuitively to a situation by matching it to a similar pattern representation in memory. In a similar vein, recent work has conceptualized intuition as knowledge based on extensive experience (Hogarth, 2001; Klein, 1998).

Less-experienced individuals may benefit from holistic processing when solving relatively complex problems that involve tacit knowledge. Such problems may be more easily analyzed by experts who have schemas that allow them to identify relevant information in the problem.

Hypotheses

The research reviewed here indicates that neither an analytical nor an intuitive strategy will be particularly "better" than the other for solving problems. Problem-solving success is expected to depend on both the strategy approach and the experience of the problem solver. Specifically, analytical problem solving is expected to be best for experienced participants, and holistic intuitive problem solving is expected to be best for less-experienced participants. This hypothesis is tested in study 1 by manipulating strategy use through analytical and intuitive strategy instructions. Study 2 tests the same hypothesis by comparing participants based on self-reported preferred strategy.

Study 1

Method

The study employed a factorial analysis of covariance design. Independent variables included manipulated strategy instruction and level of experience. The dependent variable was practical problem solving performance. Included as covariates in the design were baseline practical problem solving ability, cognitive ability, and cognitive style. Participants were assigned to a condition based on the type of strategy instruction they received. One group of participants was taught to use an intuitive approach to problem solving, a second group, an analytical approach.

Participants Participants were 107 undergraduates (73 women, 34 men; 71 first-year students and 36 upper-level students; Mean age = 18.96, SD = 1.37). First-year students were recruited during their first two weeks on campus. Upper-level students were juniors and seniors who were trained residential advisors. These students had had at least four semesters of experience on campus and had received between 120 and 180 hours of training in confrontation, helping skills, time management, and other skills related to becoming an advisor to other students in residence halls on campus.

Practical Problem Solving Measure Problems were based on the College Student Tacit Knowledge Inventory (CSTKI; PACE Center, 2002), a 15-item measure of tacit knowledge in the domain of college life. CSTKI problems presented interpersonal and general academic issues. Brief problem scenarios were followed by a series of possible response strategies (usually approximately eight) which the participant rated in terms of their relative effectiveness on a scale ranging from 1 (extremely bad) to 7 (extremely good). In this study, two items from the CSTKI were used as a measure of baseline problem solving performance. For a sample problem, see Figure 1.

Problems were scored based on the standardized Euclidean distance of an individual's response profile from the consensus of the experts in the sample. High values on problem solving reflected greater discrepancy from the consensus.

You have decided to apply for an internship during the upcoming break, and want to ask one of your professors for a letter of recommendation. The professor you have in mind is teaching a fairly large class, and he does not know you very well. One day you run in to him in the coffee shop, where he is sitting with what you assume are his kids. Given this situation, rate the quality of the following options:

Rating scale

1	3	5	7
Extremely bad	Somewhat bad	Somewhat good	Extremely good

  2.95 a) You decide that this is a good time to talk to him about the letter.

  5.61 b) You go up and greet him, reminding him of your name and what class you are in.

  4.18 c) You greet him and then start chatting with his kids.

  3.52 d) You nod but do not talk to him.

  2.82 e) You pretend you have not seen him. He probably does not want to deal with students outside of his workplace.

  3.32 f) You ask if you can sit down with him and his kids and talk about different things.

  5.27 g) You greet him and ask for an appointment with him the following day.

  3.00 h) You greet him and offer to buy him and his kids coffee or sodas.

Figure 1: Sample practical problem with expert consensus

Analytical and Intuitive Cognitive Style Measure To control for individual preferences for strategy use, intuitiveness and analytical thinking as individual-difference, cognitive-style variables were measured using the Rational-Experiential Inventory (REI; Pacini & Epstein, 1999) The rational inventory measures an individual's preference to rely on logic and analysis in making decisions and solving problems. In contrast, the experiential inventory estimates the degree to which an individual prefers to rely on intuition or hunches when making decisions.

Procedure

  Participants were tested in groups which were randomly assigned to an experimental condition. Participants completed two practice problem-solving items and were then given the intervention instructions and asked to complete the test problems using the instructed strategy.

Analytical Strategy Instructions The experimenter gave participants in the analytical condition explicit instructions on how to use logic and analysis in approaching these practical problems using four steps: 1. Define the problem; 2. Identify the relevant pieces of information in the problem;

3. Decide how you will use your resources to solve the problem; and 4. Identify and evaluate the possible consequences of the potential solutions. The experimenter illustrated how the strategy could be implemented using two examples.

Intuitive Strategy Instructions Participants in the intuitive condition were given a set of strategies that encourage the use of intuition in problem solving. The experimenter defined holistic intuition and encouraged participants to use the following problem-solving strategies: 1. Imagine the situation vividly; 2. View the problem holistically; 3. Trust your hunches and feelings about the problem; and 4. Incubate – skip the problem and come back to it later if you get stuck. The experimenter illustrated how the strategy could be implemented using two examples.

The success of the instructional manipulations was checked via a self-report measure of strategy use.

Results and Discussion

  Self-reported strategies confirmed the success of the strategy manipulation. Participants in the Analysis condition endorsed analytical strategies (e.g., "break the problem down into steps," "carefully define the problem") more than intuitive strategies (e.g., "view the problem from a variety of perspectives," "rely on guesses, hunches, or feelings"), $F(1, 61) = 20.46$, $p < .001$. Participants in the Intuition condition reported using intuitive strategies more than analytical strategies, $F(1, 61) = 50.75$, $p < .001$.

  A 2 x 2 factorial analysis of covariance was conducted to examine the interaction of strategy use and level of experience on problem solving performance. Cognitive style scores and baseline problem solving performance were included as covariates in this analysis.

  The hypothesized interaction of condition and class year was confirmed in the repeated-measures analysis of covariance, $F(1, 56) = 7.90$, $p = .007$ (see Figure 2). The y-axis represents the distance score from the consensus on the problem-solving measure. Higher values represent greater discrepancy from the consensus, and thus less successful performance.
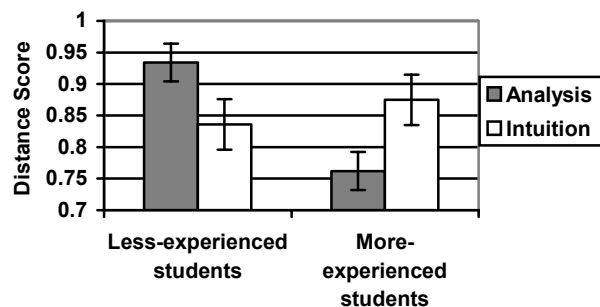

Figure 2: Problem solving performance as a function of strategy instruction and level of experience

First-year students performed better when using an intuitive strategy, and upper-level students performed better when using an analytical strategy. Simple effects analyses revealed that less-experienced students performed significantly better when using intuition than analysis, $F(1, 56) = 5.33$, $p = .025$. Among more-experienced students, the difference between the analytical and intuitive conditions was marginal, $F(1, 56) = 3.50$, $p = .067$. These results show that first-year students who tried to analyze everyday problems performed worse than those who relied on holistic intuition. In contrast, students with years of experience and hours of training tended to perform better on everyday problems when they carefully analyzed a problem than when they trusted their intuition.

Study 2

Study 1 demonstrated that an experimental manipulation of strategy use influenced practical problem solving performance differentially for participants of varying levels of experience. However, does this effect occur when participants are not instructed with a given strategy? Are highly intuitive first-year students better problem solvers than their highly analytical classmates? Are highly intuitive upper-level students likely to score worse than their analytical classmates?

In Study 2, I addressed these questions by examining problem solving performance among participants who solved problems using their own preferred strategy rather than an instructed one. I hypothesize that the interaction of strategy use and expertise will be apparent even in the absence of an experimental manipulation.

Method

Participants Forty-four undergraduates (29 female, 15 male, 29 first-year, 15 upper-level; Mean age = 18.91, $SD = 1.39$) participated in this study.

Procedure The procedure was identical to that of Study 1 with one exception: participants did not receive an instructional strategy manipulation. High analytical strategy preference was operationally defined as scores above the median on the REI rational scale, and high intuitive strategy preference was operationally defined as scores above the median on the REI experiential scale.

Results and Discussion

A 2 x 2 factorial analysis of covariance was conducted for each dichotomized cognitive style variable to examine the effects of strategy preference and expertise on problem solving score. Each analysis included baseline problem solving score as a covariate.

The hypothesized interaction of analytical strategy preference and experience was significant, $F(1, 39) = 6.77$, $p = .013$ (see Figure 3). First-year students who reported a more analytical cognitive style scored marginally significantly lower than those who were less analytical, $F(1,$

$39) = 3.52$, $p = .068$. In contrast, more experienced participants with a more analytical cognitive style performed slightly better than those who preferred intuition, $F(1, 39) = 3.62$, $p = .064$.
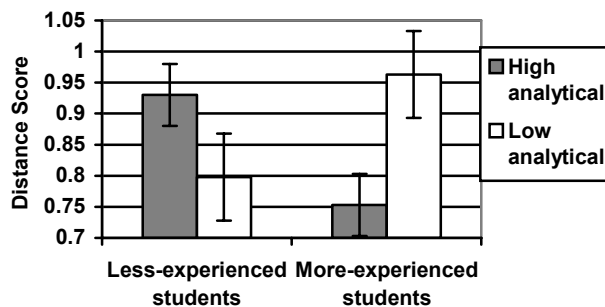

Figure 3: Problem solving performance as a function of analytical strategy preference and level of experience

The hypothesized interaction of intuitive strategy preference and experience did not reach significance, $F(1, 39) = 2.00$, $p = .165$. However, the pattern of means showed that less-experienced participants who were low on intuition performed poorly relative to the highly intuitive students with equal experience (see Figure 4). In fact, highly intuitive students with little experience scored as well as the trained and highly-experienced participants.
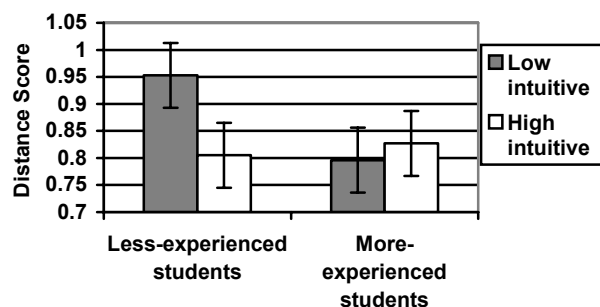

Figure 4: Problem solving performance as a function of intuitive strategy preference and level of experience

Although these results did not reveal as strong a pattern as those of Study 1, they added support for the hypothesis. A comparison of high intuitive / low analytical with high analytical / low intuitive participants may have revealed a clearer interaction, but the small sample size did not permit such an analysis. Overall, these findings showed that self-reported preference for intuitive or analytical thought affected practical problem-solving performance in the absence of an instructional manipulation.

General Discussion

These two studies provide converging evidence for the primary hypothesis. When strategy was manipulated or measured, its interactive effect with experience was detected. Less-experienced individuals performed best when

using an intuitive strategy, and more-experienced individuals were more successful when using the instructed analytical strategy than the intuitive one. Furthermore, analysis resulted in worse performance among first-year students relative to trained upper-level students.

In order to explain this interaction, one must consider that these problems are relatively complex and involve the application of tacit knowledge that is difficult to articulate. Therefore, intuition is a useful strategy for bringing to mind all the relevant information about a problem situation, especially for novices. Among more-experienced individuals, analysis aids practical problem solving because it focuses the problem solver on the information that he or she knows is key to the solution of the problem. When individuals with little experience attempt analysis, their performance suffers because they are likely to rely on irrelevant information during problem solving. When experienced individuals rely on intuition, they are distracted from that which is known to be relevant. Overall, the data from Study 1 and Study 2 provide support for the hypothesis.

Notably, these studies revealed no main effects of instructed strategy or strategy preference. Neither analysis nor intuition was an optimal strategy for solving. Strategy success could only be determined by considering experience level and strategy use simultaneously.

Strengths, Limitations, and Implications

The results of these studies may be easily generalized to actual problem-solving behavior among undergraduates, and potentially individuals in other populations due to the high ecological validity of the materials. The problems used in this study refer to real-life problems encountered by a typical college student, and the instructional interventions were grounded in the context of everyday problem solving. The results of this study have implications for research on problem solving, expertise, and dual processes.

Problem Solving Researchers who aim to enhance practical problem solving and the acquisition of tacit knowledge needed for such tasks must consider that level of experience will influence the type of training that will most benefit problem solvers. Research designs that can detect main effects alone may neglect to find meaningful interaction effects such as those found in this study. Other intervention studies seeking to teach problem-solving strategies or enhance decision-making should include a holistic, intuitive approach for novices, but emphasize analytical strategies for individuals with more experience.

Expertise Expertise can be viewed as tacit knowledge that is inherently intuitive in nature, or as a set of automatized schemas that were once explicit. Recently, researchers have argued that expertise is intuitive in nature (Hogarth, 2001; Klein, 1998). However, these studies found that novices performed better when using intuition and that experts actually benefited from an analytical approach.

There are two points to be made with respect to this apparent inconsistency. First, the definition of intuition must be clarified. Hill (1987-88) has made a distinction between classical (holistic) and inferential (heuristic) intuition. The novices in Study 1 were instructed to use holistic intuition. In contrast, expert intuition is often considered a result of an automatization of previously-explicit processes, precisely the kind of intuition that is inferential. The instructions to use holistic intuition used in this study may not have benefited experts whose intuitions are inferential in nature. The data from Study 2 provide preliminary support for this hypothesis. Highly intuitive experts did not perform worse than those who were less intuitive, suggesting that some kind of intuition may be a valid and useful strategy for experienced participants. Further study must be done to determine if this self-reported intuition in fact corresponds to the inferential nature of intuition.

Second, it is arguable that the experts in these studies, the experienced and trained college juniors and seniors are not actually experts by the definition of the field. While their scores are better than those of first-year students, the main effect of expertise was merely marginal in Study 1 and non-significant in Study 2. In fact, it is difficult to determine who would qualify as an expert in the college life experience on any particular campus. Expertise is said to be achieved generally after ten years of experience in the domain, yet this level of experience is rarely achieved by Residential Life staff members let alone student Resident Assistants. Future work should attempt to replicate these findings in a sample for which clear experts and novices can be identified.

If the upper-level students in these samples are not considered experts, then they may have a kind of intermediate expertise as compared to first-year students. One theoretical model of the development of expertise can be used to explain the current pattern of results. Baylor's (2001) U-shaped model of expertise and intuition proposes that intuition is used by both novices and experts, but that intermediate experts use a more analytical strategy. In Study 1, I found that holistic intuition helped novices solve complex problems involving the use of tacit knowledge. As these novices gain knowledge in the domain, they will become better able to articulate their knowledge, and as they become intermediate experts who see the structure and logic of problems, they will benefit from an analytical strategy. As this knowledge becomes part of an automatized expert schema, they become true experts who can rely on inferential intuition to make decisions and solve problems. The sample used in these studies was limited in its range of expertise. Future work should include participants with very little knowledge and participants with highly automatized schemas. Using such a sample, the distinction between holistic and inferential intuition as well as the U-shaped model can be tested.

Dual Process Models This theoretical distinction between holistic and inferential intuition has implications for dual

process models. Most researchers emphasize the limitations of the intuitive system, yet these studies highlight the benefits of intuitive processing. Previous work has criticized solely the heuristic nature of intuition. It is the holistic nature of intuition which has strong advantages over analytical processing, especially when tasks are so complex that analysis leads to neglect of important information, where the whole is greater than the sum of its parts. Future studies in the dual process framework should attempt to distinguish between these two types of intuition and their influence on problem-solving and decision-making tasks.

Conclusions

Practical problems are often ill-structured and involve high stakes. This study has demonstrated that the approach to solving such problems depends on the experience of the problem solver. Analysis is a good strategy to the extent that an individual can see the structure of a problem and identify the relevant pieces of information necessary for solution. However, more inexperienced individuals may benefit from a holistic, intuitive approach to problem solving.

Acknowledgements

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