

RATIONAL, INTUITION, AND INSIGHT: THREE
PHENOMENOLOGICALLY DISTINCT
MODES OF DECISION MAKING

by

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ABSTRACT

This research was conducted in order to uncover the characteristics of, and factors related to, the emergence of the three phenomenologically distinct modes of rational, intuitional and insightful decision making. The theoretical foundation for these three distinct modes was crafted from the theoretical domains of Social Psychology, Gestalt, Creativity, Insightful, and Biofunctional theory.

The study involved the use of two sampling groups. Sample 1 consisted of 68 undergraduate students, and Sample 2 consisted of 98 undergraduate students. Participants' problem solving performance was examined with a series of time-limited novel and non-novel word puzzles, in which a set of three clue words was presented. There were two phases of problem solving, with an incubation period between phases. These problem outcomes were examined against problem difficulty, current affect, personality preferences for rationality and intuition, solution cues in the environment during incubation, problem novelty status, and intelligence.

The data revealed a strong bias for insight for solved novel problems, while a strong bias for rationality was found for novel problems that participants failed to solve. As problem difficulty increased, participants used rationality proportionally more often to solve problems. When current affect was higher, participants were more likely to use insight for solved novel problems, and when current affect was lower, rational solutions were more likely. Intelligence was found to increase the number of problems solved and problem solving speed. The findings

provided evidence for three distinct problem-solving modes. Rational problem solving was slowest and least frequently used to solve novel or non-novel problems. Insightful novel solutions took half the time of rational solutions. Insight is affectively informed sudden knowing, and was the predominant novel problem solution mode. Intuition is also affectively informed sudden knowing. Intuition was found to be the fastest and most successful solution mode for non-novel problems.

This research provided empirical evidence to counteract the common conflation of intuition and insight. It illustrated the distinctiveness of the rational, insightful and intuitional modes of decision making and produced evidence of the relationship between each mode and the factors commonly considered to influence decision making.

DEDICATION

To my family, for your patience, love, and encouragement. Without you, this would not be worthwhile or possible.

LIST OF ABBREVIATIONS AND SYMBOLS

a	Cronbach's index of internal consistency
b	Beta; probability of a Type II error
d	Cohens' measure of effect size
df	Degrees of freedom: number of values free to vary after certain restrictions have been placed on the data
F	Fisher's F ratio: A ratio of two differences
M	Mean: the sum of a set of measurements divided by the set's number of measurements
Mdn	Median: The middle value of an ordered set of values
N	Total number in a sample
n	Number in a subsample
p	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
r	Pearson product-moment correlation
R^2	Multiple correlation squared; Measure of strength of a relationship
SD	Standard Deviation
t	Computed value of t test
$<$	Less than
$=$	Equal to
ϕ	Phi: Measure of statistical power
χ^2	Computed value of a chi-square test

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CHAPTER 1

INTRODUCTION

Decision making is the universal human ability that enables people to make choices, solve problems, and select a course of action (Wenke & Frensch, 2003). Whether the decision requires the person to answer a math problem or select the proper temperature to cook a meal, much of human activity may be thought of as an ongoing series of large and small decisions. Each problem encountered during daily life may be solved with a different strategy or mode. The mode that one uses depends on a number of factors. Some of these factors, such as personality-based preferences, one's overall attentional focus, and current mood are internal to the person (Allinson & Hayes, 1996; Elsbach & Barr, 1999; Hunt, Krzystofiak, Meindl, & Yousry, 1989; Seifert, Meyer, Davidson, Patalano, & Yaniv, 1995). Past experience, novelty of the problem, problem difficulty, and depth and breadth of one's domain knowledge also play a role in the mode one chooses to use (Denes-Raj & Epstein, 1994; Weisberg & Alba, 1981a; Wiley, 1998).

Research across the theoretical domains of Gestalt theory, creativity, social psychology, insight, and Biofunctional theory has addressed the processes and cognitive mechanisms by which people make decisions. Interestingly, most of these theories propose a dual-process system, with similarities and differences between the theories. This research compares these theoretical domains and unifies the disparate theories. It brings to light the phenomenon of three

distinct decision-making modes, where each mode emerges under unique circumstances with unique decision-making abilities.

Gestalt theory's view of problem solving acknowledges a distinction between doing something old and something new. When confronted with a decision situation, the solver first attempts to discover a *stereotypical* successful mode of response (Maier, 1940) that has been successfully used in the past. Failing this, a novel solution may arise by seeing something new, or achieving *illumination*. This is considered a more natural decision-making process based on a new association of ideas resulting from automatic mental processes (Wallas, 1926).

The literature of creativity research shares a great deal with Gestalt theory. Creativity literature envisions decision making as either reproducing old solutions or producing new ones. The application of some previously acquired knowledge to a problem results in *reproductive* solutions, while novel problems require a restructuring of the problem, which produces insightful *productive* solutions (Dominowski, 1995; Weisberg, 1995, 1999).

The social psychology literature, typified by the research of Seymour Epstein, imagines decision making as the interaction and joint operation of a cognitive and an experiential mode of functioning (Epstein, 2006). The verbally oriented and relatively affect-free *cognitive* system is the source of human rationality, operating at the conscious level according to a person's understanding of evidence and rules of logic. Intuition, however, arises from the automatic and preconscious *experiential* system, which works through the accumulation of tacit information automatically acquired from experience. In the experiential system, associations triggered by recognition of past experiences are rapidly recalled and applied, without cognitive effort or ability to justify the feeling of knowing (Sloman, 1996).

A collection of literature on the topic of insight has produced a somewhat different dual-mode system containing *insight* and *noninsight* problem solving. When problems are solved in the *insight* mode, there are sudden realizations (*Aha!* experiences) about a perplexing problem, often after reaching an impasse (Bowden & Jung-Beeman, 2003a; Hodgkinson, Langan-Fox, & Sadler-Smith, 2008). The source of the impasse is often due to being misled by ambiguous information in the problem (Dominowski & Dallob, 1995). Problem solvers are frequently unable to describe the mental processing that enables them to overcome an impasse with an insightful solution (Gick & Lockhart, 1995; Schooler & Melcher, 1995), and when the solution appears, it is sudden and surprising (Davidson, 1995; Schooler, Ohlsson, & Brooks, 1993). In contrast, *noninsight* problem solving is likely to involve *approach-execution*, a rational process involving the selection and execution of the necessary operations to achieve a solution (Bowden & Jung-Beeman, 2003a; Kounios et al., 2008; Schooler & Melcher, 1995). Those solving problems with an analytic, noninsight strategy tend to have a greater focus of attention (Kounios et al., 2008), and typically can report increasing “warmth” (nearness to a solution) as they get closer to a solution (Bowden, Jung-Beeman, Fleck, & Kounios, 2005).

Through the brain-mind cycle of reflection, Biofunctional theory provides three pairs of dispositional modes of brain functioning. These pairs of modes, habitual & creative, active & dynamic, and constructive & unconstructive provide the basis of a symbol/ground navigation system of human functioning (Iran-Nejad & Gregg, 2001). When these modes are applied to the dual-mode systems mentioned earlier, they provide functional insights into all three of the decision-making modes that become evident when the theories are taken together.

Emerging from a combined view of the dual-process systems and Biofunctional theory is evidence of three distinct modes of decision making as illustrated in Table 1.

Table 1.1

Dual-process and Biofunctional Theories of Decision Making

Theory	<u>Mode</u>		
	Rational	Intuition	Insight
Gestalt	-----	Stereotype	Illumination
Creativity	-----	Reproductive	Productive
Social Psychology	Cognitive	Experiential	-----
Insight	Noninsight	-----	Insight
Biofunctional	----- Active Unconstructive	Habitual Dynamic -----	Creative Dynamic Constructive

Three Phenomenological Modes of Decision making

Despite the obvious lack of overall uniformity or consensus across these literatures, taken holistically there is evidence that supports the existence of three phenomenologically distinct modes of decision making: Rational, Intuition, and Insightful. The *rational* mode, is where known objectives lead to the selection of an optimal solution from among a set of known solutions (Eisenhardt & Zbaracki, 1992). This approach is mental energy demanding, verbally mediated, deliberative, and primarily conscious. This active mode of self-regulation (Iran-Nejad, 2000), which was long considered to produce superior decisions (Dewey, 1910/1933), functions through a person's understanding of established rules of logic and evidence (Denes-Raj & Epstein, 1994). Simon's (1965) three steps (Identification, Development and Selection), and Cyert & March's (1963) Bounded Rationality are variations of this basic rational mode of decision making. A person using an analytical problem-solving technique is likely to use a

stepwise set of logical arguments that incrementally build on the previous ones, leading to a solution (Dominowski, 1995). Many rational decisions are chosen in order to maximize the payoff of different outcome choices (Allison, 1969; Eisenhardt & Zbaracki, 1992; Simon, 1965).

The *intuitional* mode is typically considered to be experienced-based knowing (Fredrickson, 1985). This is in contrast to Haidt and Joseph's (2004) theory of innately prepared intuitions that are thought to arise from the human mind that has been shaped by evolution. Intuition is an affectively informed feeling of knowing (Duncan & Barrett, 2007) without being able to justify the feeling (Epstein, 2006). This habitual mode of dynamic self-regulation conserves mental energy (Iran-Nejad & Gregg, 2001). This mode is automated expertise (Miller & Ireland, 2005) that enables decision makers to *reproductively* (Maier, 1940) use their experience or expertise (Wiley, 1998) to make rapid decisions through the retrieval or recall of solutions learned through experience (Dominowski & Dallob, 1995). This experiential mode operates in a manner that is unconscious, rapid, effortless, and associative (Epstein, 2006). Associations between problem and solution, formed from prior experience, are rapidly and effortlessly recalled or reproduced upon problem recognition.

The *insightful* mode produces novel solutions or associations. The concept of insight shares some features with intuition, such as sudden and rapid knowing, being affectively informed, and holistically oriented associations (Hodgkinson et al., 2008). However there are important differences that are unique to the phenomenon of insight. For instance, insight occurs after reaching an impasse in problem solving (Bowden et al., 2005). It may involve a period of incubation (time away from consciously working on the problem) (Mayer, 1995), after which an Aha! moment of insight emerges (Schooler & Melcher, 1995). This Aha! moment of clear and sudden understanding informs the person how to solve a novel or intractable problem. Prior

research has shown that insight may overcome an impasse through restructuring problem elements (Ohlsson, 1984); overcoming various sources of fixation through forgetting (S. M. Smith & Blankenship, 1991); changing the context of problem elements (Seabrook & Dienes, 2003); mental set change (Dodds, Smith, & Ward, 2002); passive spreading activation (Yaniv & Meyer, 1987); finding an analogy to the problem (Glick & Holyoak, 1980); and opportunistic assimilation of environmental cues (Seifert et al., 1995). By overcoming an impasse, an Aha! experience or the “click of knowing” (Iran-Nejad, 2000) creates a novel solution or a new association.

All three of these problem solving modes are available to problem solvers, although a number of factors that are internal to the person, intrinsic to the problem, or specific to the environment may cause one mode to be favored over another. When confronted with a decision, intuition will typically respond first, due to its dynamic and rapid nature, and the fact that it can attend to many things at once (Epstein, 1990; Iran-Nejad & Gregg, 2001). Responding in a rational manner is a cognitive choice. The brain/mind (Iran-Nejad & Gregg, 2001) or cognitive/experiential (Epstein, 1990) systems interact and chose to engage the mind’s single focus of attention on solving a problem through application of rules to information (Epstein, 1990; Iran-Nejad & Gregg, 2001). Even when operating in a rational mode, the dynamic brain-regulated system quietly works to support the rational effort (Epstein, 1990; Iran-Nejad & Gregg, 2001). If these first modes fail to provide a solution due to the novelty of the problem, then an impasse may be reached (Bowden et al., 2005). If there is intrinsic motivation, among other factors, the problem solver may find a way to restructure/reconfigure the problem (Dominowski, 1995), or discover a solution in the environment in such a way that an insight into a novel

solution is revealed (Seifert et al., 1995). It is common for this restructuring to occur during a period of incubation, when the mind is not occupied with the problem (Mayer, 1995).

Considering the centrality of decision making in people's lives and the long history of research on the topic, one would think that there would be a great deal of consensus across research domains about how people make decisions. Yet, all but one of these different research domains have devised or implied their own dual-process models of decision making. While there are some important similarities among them, there are also important differences. This study is designed to take a holistic view of these dual-process models and their related research, including Biofunctional theory, to construct a more accurate model of the phenomenon of human decision making. Thus, the broad research questions directing this inquiry are: (1) What phenomenologically distinct decision-making modes do people employ in their everyday lives? and (2) What are the conditions, abilities, or traits that influence how people employ different decision-making modes?

By demonstrating evidence of three phenomenologically distinct modes of decision making, this research provides an alternative to the traditional dual-process conception of decision making found in the literatures of several domains. It will show that various conditions either promote or inhibit the use of particular decision-making modes, thereby offering insight into how to elicit specific modes. This research will counter the common conflation of intuition and insight through evidence of how they are similar and how they differ. By taking a holistic perspective across multiple domains, this research will expand the understanding of decision making, which may lead to greater understanding of people's day-to-day decisions.

Organisation of the Dissertation

Chapter 2 begins with a review of the evolution of thinking about proper decision making, as reflected in the decision-making literature. A number of dual-process models of human cognition, as well as Biofunctional theory, are applied to decision making. The structures of these models are examined and compared. This reveals a broader range of decision-making capabilities than is typically apparent from an examination of individual theories. A three-mode model of human decision making arises from this examination. The model includes rational decisions, intuitional decisions, and insightful decisions. In this posited model, each mode arises under differing conditions, and is moderated by a number of factors. Chapter 3 details the study's design, including methods for eliciting the three different modes, manipulation of moderating factors, sample selection, and data analysis techniques. Chapter 4 presents an account of the study's findings, including the results of the hypotheses tests. Finally, Chapter 5 provides a synthesis of the study's results, with a discussion of the implications of a phenomenological approach to decision-making research. Specifically, a different conception of decision-making capabilities arises, based not solely on human cognitive mechanisms, but the joint operation of those mechanisms with various internal and external factors.

CHAPTER 2

LITERATURE REVIEW

Decision making, also referred to as problem solving, is a process of recognizing the existence and nature of a problem and finding a solution to it (Andersen, 2000). It is a complex mental process, influenced by a number of factors, which results selecting of a course of action (Mandler, 1980; Ross, Klein, Thunholm, Schmitt, & Baxter, 2004; Simon, 1956). As described in the following review of the literature, both problem recognition and solution path selection may take a number of phenomenologically distinct forms that fall into three modes of decision making.

A prototypical conception of decision making has the decision maker rationally confronting a problem. After cognitively recognizing the problem, the decision maker's task is to weigh the competing courses of action to select the option that best solves the problem and achieves the underlying goals (Anderson, 1983). In many instances, the best solution is the one that either maximizes the payoff, or minimizes loss from among the different outcome choices (Eisenhardt & Zbaracki, 1992; Simon, 1979). Two assumptions are implicit in this model. The first assumption is that the decision maker is selecting from among a set of alternatives. The second is that there are known goals or a purpose from which choices arise, that guide the person to the best choice (Anderson, 1983; Eisenhardt & Zbaracki, 1992). A rationally oriented view of decision making has long been considered by many people to produce superior decisions, due in part to its basis in the philosophy of science (Dewey, 1910/1933; March & Simon, 1958; Nutt, 2008). This classical theory of omniscient rational decision making uses a structured or

analytical approach to problem solving (Allinson, 2000), based on assumptions of perfect rationality, which fully determines choice selection (Simon, 1979).

Over time people came to realize that this strictly rational or analytical approach, often billed as *normative*, failed to describe the decision making approach individuals typically employ (Eisenhardt & Zbaracki, 1992; Simon, 1955, 1956; Stevenson, Busemeyer, & Naylor, 1990). People were often found to substantially violate the assumptions of strictly rational models and yet typically did very well with respect to the decisions and judgments being made (Stevenson et al., 1990). Individuals' goals in problem solving frequently shift or are unclear. Their search for information and alternatives are often haphazard and opportunistic, and people's decisions often reflect standard operating procedures instead of systematic analysis (Eisenhardt & Zbaracki, 1992).

A number of theories have been advanced over the years to address the unrealistic assumptions of a strictly rational decision making approach. Bounded Rationality is a reduced yet practical form of deliberative reasoning (Simon, 1979), that addresses the cognitive limitations of individuals, the finite amount of time available to make decisions, and the quality of the information available (Cyert & March, 1963). Another, Prospect Theory, attempts to address how people evaluate decisions that have potential gains and losses (Kahneman & Tversky, 1979). Simon (1956) recognized that individuals' adaptive behavior during decision making fell far short of the *maximizing* ideal of classical rational deterministic theory. Through their adaptive decision making, people tended to *satisfice* instead of *optimize*. As theory advanced and evidence accumulated that strictly deterministic or probabilistic rational approaches to decision making were not normative, a number of researchers called for a more

realistic view of decision making that moves beyond the emphasis on analysis and rationality (Eisenhardt & Zbaracki, 1992; Simon, 1987; Stevenson et al., 1990).

This present research brings together five different theoretical perspectives in order to create a better understanding of the phenomenon of decision making. Two of these perspectives, Gestalt and social psychology, have well-known dual-process models of decision making. Two other approaches are broad collections of research along the common themes of creativity and insight. An examination of the literature in these areas also reveals previously hidden dual-process models. The fifth perspective comes from Biofunctional theory, with three pairs of dispositional modes of brain functioning. These five groups of research unify to provide a foundation for a three-mode model of human decision making.

Gestalt

Gestalt theory has long been associated with the distinction between decisions where the person does something old versus something new to solve a problem (Dominowski, 1995). Gestalt is often seen as emphasizing novel instances of problem solving, but the theory also recognizes that not all problem solving involves novel solutions (Dominowski & Dallob, 1995). This is a dual-process system, which Maier (1940) referred to as *habitual* and *novel*, and Wallas (1926) called *stereotype* and *illumination*. Habitual or stereotypical solutions arise from recall and application of prior learning (Kohler, 1969), and can be accounted for by memory and the associations formed between a recognized problem and a previously successful solution (Maier, 1940). Most of the problems that people solve in their daily lives are dependent on the use of these stereotypical responses (Maier, 1940). The purpose of problems involving illumination, which need a novel solution, is to do something new and overcome the mental constraints that

are rooted in past experiences and associations (Dominowski, 1995). Kohler (1969) contended that all problem solving involved an awareness of relations. Novel problem solving, which Kohler termed *productive thinking*, involves a change in mental representation or an awareness of new relations among a problem's elements. In order to achieve a novel understanding of a problem's structure, the problem must be viewed as a whole instead of piecemeal, and gaps in understanding must be addressed structurally in order to reveal new structural relations among the problem's elements (Wertheimer, 1959). According to Wallas' (1926) four stages of the association process that leads to novel solutions, a flash of illumination is often preceded by a period of incubation, in which the person either consciously rearranges associations or rests from conscious thought of the problem.

Taking Wallas' work as representative of Gestalt theory, his use of the term stereotype (recall of previous solution associations) is closely equivalent to the notion of the intuitional mode. His notion of illumination (suddenly seeing or knowing how to solve a problem) is closely equivalent to the notion of the insightful mode.

Creativity

The literature of creativity research spans a wide range of human activities, from inventing tools to discovering the inner workings of natural phenomena. These generative activities, often in the service of making a decision or solving a problem, come from moving beyond the recall of discrete stored experiences to produce solutions that are creative and inventive in order to discover something novel and useful (Sternberg, 2001; Ward, Smith, & Finke, 1999). Contrary to a commonly held belief that creativity is limited to specially gifted people, this literature holds that the ability to create is an essential property of normal human

cognition (Ward et al., 1999). Typical creativity literature focuses solely on the nature of creativity or the conditions in which creativity emerges, and rarely delves into the realm of the non-creative (see, e.g Mandler, 1995; Martindale, 1995; Policastro, 1995; Ward et al., 1999). When creative research does address non-creative human activities, as it typically does with problem solving, it reaches back into Gestalt theory for concepts that describe creative and non-creative solutions. Kohler's (1969) Gestalt term *reproductive* is used by both Weisberg (1995) and Dominowski (1995) to describe the recall and application of some previously acquired knowledge to solve a problem. In effect, problems solved this way come from the recall of already-known solution routines and adapting them to the situation at hand (Finke, Ward, & Smith, 1992b). These reproductive habits of thought fail when something truly novel is necessary (Weisberg, 1995, 1999). Weisberg (1995) and Dominowski (1995) borrowed another Gestalt term from creative problem solving, *productive*. In productive problem solving the person uses past experience but only in a general way to create a novel solution. The intent is to use these experiences but avoid becoming trapped by past habits or specific knowledge of situations that are irrelevant to the new situation (Ward et al., 1999; Weisberg, 1999). Much of this productive problem solving is said to be the result of a change in representation or a restructuring that reveal insights (Finke et al., 1992b; Ohlsson, 1984). Such a change in representation is likely to involve a reinterpretation of some problem element or the forming of new relationships between ideas. This is a change from a more familiar initial interpretation to a more novel interpretation, from the more familiar to the new (Dominowski, 1995). While creativity is thought to be maximized by having knowledge about a wide variety of things (Martindale, 1995), there is a tension between knowledge and creativity. Some see an inverted curvilinear relationship between knowledge and creativity, where being too enmeshed in a field

creates too strong a bond between ideas, creating mental ruts and stereotyped responses to problems (Weisberg, 1999). This is somewhat in opposition with the viewpoint that knowledge in a field provides the building blocks with which novel solutions may be created (Weisberg, 1999).

Much has been written about the factors that relate to the emergence of creative behavior, but the creativity literature is far from a cohesive theoretical foundation. As such, each researcher has staked out a somewhat different viewpoint regarding the factors influencing creative behavior. Sternberg (2006) lists intelligence, thinking style, personality attributes, intrinsic motivation, and a supportive environment as factors that influence creative behavior. Martindale (1995) also lists knowledge foundation, but includes the different factors of defocused attention, forming new associations, primary process thinking (analogical, and free associative), and arousal of memory elements as influences on creativity. Finally, Finke et al. (1992b) limit their discussion of memory mechanisms that are involved in creativity to incubation, fixation, and recovery (from fixation). The lack of uniformity within this collection of creativity literature, while giving little theoretical foundation, does provide insight into a broad spectrum of factors thought to influence creative decision making.

Taking Weisberg's (1995) and Dominowski's (1995) work as representative of the broader creativity literature, their use of the term *reproductive* is closely equivalent to the notion of the intuitional mode. Their notion of *productive* is closely equivalent to the notion of the insightful mode.

Social Psychology

Within social psychology there is an emerging consensus that human cognition operates according to the joint operation of two distinct systems (see, e.g. Chaiken, 1980; Groves & Thompson, 1970; Petty, Cacioppo, Strathman, & Priester, 2005; Sloman, 1996; E. R. Smith & DeCoster, 2000; Trope & Alfieri, 1997). These dual-process theories take a number of different forms, yet they are all isomorphic with Wundt's (1896) associative versus intellectual thinking, Kris' (1952) primary-process and secondary-process, and Epstein's (1990) cognitive-experiential self theory (CEST). Epstein's CEST is a well-cited representative of this collection of dual-system theories, and serves to help illustrate this discussion. As in the other dual-process theories mentioned above, Epstein's CEST theory has two parallel and separate systems that interact to control human behavior.

In Epstein's (1990) CEST, the *cognitive* system rationally operates at the conscious level. It is analytic, deliberative, verbally oriented, and operates according to a person's understanding of evidence and rules of logic. Decisions are made slowly, but new rules or new evidence can rapidly change how a decision is made. This relatively affect-free system enables knowledge to be acquired, and decisions to be made by intentional, effortful mental engagement through deliberative analysis. In contrast, the *experiential* system directs most everyday activities. This system, which learns automatically through experience, is believed to be the evolutionally older of the two systems. While it is the more rapidly reacting system, it is slow to respond to changing decision conditions. It operates almost effortlessly in an automatic, holistic and associative manner, and is shaped by emotionally significant experiences (Epstein, 2006). As such, a person's current affect influences how these automatic responses shape associations in the experiential system (Epstein, Lipson, Holstein, & Huh, 1992). The joint operation of the rational

and experiential systems guides all behavior. These two systems interact bi-directionally, both in a sequential and a simultaneous manner (Epstein, 2006). When confronted with a stimulus, the experiential system provides the initial reaction (Epstein, 2006). If that initial reaction is deemed unacceptable by the rational system, the rational system may modify or suppress it. However, if the initial response is acceptable, then it is likely to be expressed (Epstein, 1998). In the interaction of the two systems the rational system is a stimulus for the experiential system, which may elicit an experiential association that can affect the performance of the rational system. This cycle of interaction may elicit more experiential associations, and on and on the interaction goes. Rather than a simple single response in one system instigated by the other system, the two systems typically engage in an ongoing dance in which a step in one system is the stimulus for a step in the other system (Epstein, 1990; Epstein, Pacini, Denes-Raj, & Heier, 1996; Kirkpatrick & Epstein, 1992).

Insightful

A fourth group of dual-process literature contains a loose collection of research on insight. This broad collection of literature addresses several topics related to insight, including:

- The nature of insightful and noninsight problem solving (Jung-Beeman et al., 2004; Metcalfe & Wiebe, 1987; Schooler, Fallshore, & Fiore, 1995; Schooler & Melcher, 1995)
- Insightful judgments about semantic coherence and the effect of positive and negative affect on them (Bolte, Goschke, & Kuhl, 2003; Topolinski & Strack, 2008)
- The neural basis of insightful problem solving (Jung-Beeman et al., 2004; Jung-Beeman, Collier, & Kounios, 2008)
- The associative nature of insights (S. A. Mednick, 1962; Mendelsohn, 1976)

- The nature of the Aha! experience (Bowden & Jung-Beeman, 2003a), and
- The role of fixation and incubation in insight (S. M. Smith, 1995)

Similar to the creativity literature, a number of these investigators have limited their research to only the creative side of this dual-process dichotomy. Yet, if there is creative decision making, there is also noncreative decision making, with several investigators taking that research path.

Noninsight problem solving seems to resemble the rational approach found in other literatures. People's initial reaction to these problems is to carry out the multistep operations that they think are necessary to solve a problem (Metcalf & Wiebe, 1987; Schooler et al., 1995). These problems are described as involving *approach-execution*, with step-by-step execution to achieve a solution (Schooler et al., 1995; Schooler et al., 1993). Functional Magnetic Resonance Imaging (fMRI) studies have shown that there are neuro-anatomical, or brain hemisphere differences between insight and noninsight problem solving, with the left hemisphere's fine semantic encoding playing a greater role in noninsight problem solving (Bowden & Jung-Beeman, 2003a; Jung-Beeman et al., 2004). Non-insight problems involve a lower affective state, and participants are more likely to be able to predict solution success through feelings of gradual increases in warmth ratings (nearness-to-solution)(Bolte et al., 2003; Bowden & Jung-Beeman, 2003a; Metcalf & Wiebe, 1987).

Insightful problem solving strongly resembles Gestalt's *illumination* and creativity literature's *productive problem solving*. Early conceptions of insight tied it to a reinterpretation or a restructuring of factors related to a problem in order to gain understanding (P. I. Ansburg, 2000; Finke, Ward, & Smith, 1992a; Schooler et al., 1995; Wertheimer, 1959). Other conceptions of insight problem solving described it as involving *approach-recognition* where

people suddenly recognize a solution (Schooler et al., 1995). This literature defines insight from two perspectives. The first of these is as an outcome. From this perspective, insight is the sudden unexpected awareness of the solution to a problem (Schooler et al., 1995; S. M. Smith, 1994), seeing inside a problem during a moment of realization (Csikszentmihalyi & Sawyer, 1995), or “the sudden solution to a problem that one has been working on without any progress” (Schooler & Melcher, 1995, p. 98). This act of creativity (Finke et al., 1992a; Jung-Beeman et al., 2004; Schooler & Melcher, 1995) is also seen by this literature from a phenomenological perspective. The affectively informed sudden solution, characterized by an Aha! experience, is believed to be the defining characteristic of insight (Bowden & Jung-Beeman, 2003a; Gick & Lockhart, 1995; Schooler et al., 1993). Positive affect supports this holistically oriented insight mode by broadening people’s perception of semantic coherence. In contrast, negative affect tends to support the more analytically oriented noninsight mode by narrowing people’s perceptual focus (Bolte et al., 2003; Topolinski & Strack, 2008).

Another description of the insight phenomenon ties instances of insight to working on a problem until reaching an impasse, after which a solution suddenly springs to mind (Bowden & Jung-Beeman, 2003a; Jung-Beeman et al., 2004). An *impasse* is a point in time when the solver feels that he is not making progress toward a solution (Bowden & Jung-Beeman, 2007). The causes of an impasse can include being blocked by a mental set; fixation due to prior experience; fixation due to framing effects; or missing, ambiguous, or unrecognized problem information (Davidson, 2003; Dodds, Ward, & Smith, 2003; Finke et al., 1992b; S. M. Smith, 1994; S. M. Smith & Blankenship, 1991). Fixations, originally a Gestalt concept, are mental blocks that interferes with insightful problem solving due to people’s inability to overcome past experience (Davidson, 1995, 2003).

An insight is often thought to emerge after a period of incubation that follows an impasse. An incubation period is a delay or period of time away from consciously working on a problem. It has the connotation of a passage of time, during which something hidden from view operates to cause a perceptual change (Davidson, 1995, 2003; Dorfman, Shames, & Kihlstrom, 1996). Several explanations have been proposed concerning this hidden mental process during incubation. These explanations include overcoming a fixation through forgetting the fixation element (S. M. Smith & Blankenship, 1991), changing the perceived context of a problem's elements (Seabrook & Dienes, 2003), achieving mental set change (Dodds et al., 2002), passive spreading activation to discover new associations (Yaniv & Meyer, 1987), discovering an analogy to the problem (Glick & Holyoak, 1980), overcoming fixations related to the solution process (the Einstellung effect) (Kaplan, 1989; S. M. Smith & Blankenship, 1991), and opportunistic assimilation of environmental cues through incidental exposure to various external stimuli, some of which may be relevant to the problem (Seifert et al., 1995).

Reaching an impasse is said to induce semantic priming or set failure indices. This leads people to subconsciously seek out a solution from remote associations, or to subconsciously recognize potential associations from elements encountered in the environment (Bowden & Jung-Beeman, 2003a; Seifert et al., 1995; Yaniv & Meyer, 1987). Feelings of warmth (nearness to solution), unlike the gradually increasing warmth of noninsight problem solving, remain low until an abrupt increase at the moment of solution (Bowden & Jung-Beeman, 2003a; Metcalfe & Wiebe, 1987; Schooler & Melcher, 1995).

The use of problem-solving strategies that produce novel discoveries has been shown to have its origins in individual differences (Kounios & Beeman, 2009). Schooler and Melcher (1995) found that the abilities needed to restructure one's perception of a problem and to

overcome context induced set (fixation) were highly correlated with creating insights.

Intelligence (IQ) is another significant factor predicting insight, because intelligence and insight are seen as closely intertwined concepts, with insight considered an integral part of intelligence (Davidson, 1995; Seifert et al., 1995). Additionally, diffuse attention increases the likelihood that an individual will perceive remote associations. By having a broad attentional net, a person is more likely to capture unexpected cues from the environment and make associations between remote concepts (Martindale, 1995).

There is only a small amount of evidence in this literature concerning the interaction of the insight and noninsight processes. The nature of the problem and individual differences are the two factors that are typically understood to determine which process a person chooses to solve a problem. Yet Schooler et al. (1995) concluded that most real-world problem-solving required alternating between approach-recognition skills and approach-execution skills. An example of this is moments of inspiration and insights, intermingled with times of fleshing out the inspiration with approach-execution skills. Jung-Beeman et. al. (2004) found that the brain's right hemisphere anterior superior temporal gyrus most strongly influenced the emergence of insight. This brain region was found to be active in initial efforts to solve a problem. They also found that all problem solving relied on the shared cortical network of the right and left hemispheres (Bowden & Jung-Beeman, 2003a; Jung-Beeman et al., 2004). These findings coincide with Epstein's findings that his experiential system is the first to respond to a new problem, but that the cognitive and experiential systems worked together to solve problems (Epstein, 2006).

Biofunctional

Iran-Nejad's brain-mind cycle of reflection (Iran-Nejad & Gregg, 2001) arises from biofunctional theory and gives a biological foundation for human cognition. This theory proposes that cognition and memory are the functional characteristics of the neurons of the *brain*, and that the *mind* is an emergent manifestation of the brain. In this functional model of cognition, the mind does not directly access the outside world. It is only the brain that does, and it is through the brain that the mind interacts with the world. It is also from the capabilities of the brain that intuitive self-awareness of the mind emerges. This self-awareness is the language of the body, as well as the intuitive source of one's perception of self, enabling one to maintain an ongoing awareness of body and mind. The mind interacts with the world through symbols, but the language of the brain's self-awareness is non-symbolic (Iran-Nejad & Gregg, 2001).

A person's intuitive knowledge base (IKB) contains a coordinated combination of knowledge, experience, wisdom, beliefs, affects, emotions, interests, hopes and aspirations (Iran-Nejad, Clore, & Vondruska, 1984; Iran-Nejad & Gregg, 2001). The brain directly creates and maintains this IKB on an ongoing basis and it is upon the IKB that the symbolic mind roams for memory, understanding and problem solving (Iran-Nejad & Gregg, 2001). As a person experiences the world, the brain dynamically reorganizes new knowledge or experiences and integrates them into one's IKB. It is through the symbol-ground perception capability of the brain that a person perceives the environment and experiences the world (Iran-Nejad, 2000; Iran-Nejad & Gregg, 2001).

These two systems, the *brain-regulated system* that operates dynamically outside conscious attention or effort, and the *mind-regulated system* that is actively mediated by one's intentions, together regulate all human activity. The brain-regulated system is cognitive energy

conserving and is able to simultaneously attend to all bodily activity, perceive the environment through the senses, and interact through self-reflection with the mind. In contrast, the mind-regulated system is cognitive energy demanding, has a single focus of attention, and is only active during waking hours (Iran-Nejad, 2000). These two systems have ongoing interaction through a cycle of reflection, made possible by the intuitive self-awareness of the brain and the mind (Iran-Nejad, 2000). Similar to Epstein's CEST, the brain and mind engage in a dance of reflective interaction, where the activity of one system may become the stimulus of the other. These two systems are united into a single figure-ground navigation system that Iran-Nejad (2000) calls the brain-mind cycle of reflection.

Within the dynamic-brain and active-mind interaction, biofunctional theory provides three pairs of opposing dispositional modes of brain functioning. The first of these dispositional pairs is *habitual* and *creative* modes (Iran-Nejad & Gregg, 2001). The *habitual* mode is energy conserving, and oriented toward living in the safety of a known world. It is also oriented toward "routine, rest, inaction, and avoidance of challenge" (Iran-Nejad & Gregg, 2001, p. 879). The other dispositional mode in this pair is the *creative* mode. It is oriented toward mobilizing energy for addressing the unknown. It works to enable a person to deal with change, exploration, action, and reacting to a challenge (Iran-Nejad & Gregg, 2001).

The second pair of dispositional modes of brain functioning is *active* and *dynamic* self-regulation (Iran-Nejad & Gregg, 2001). *Dynamic* self-regulation relates to the tacit, involuntary regulation of activity by the brain. This unmediated activity of the brain and body is responsible for the spontaneous coordination of the brain and body. In the *dynamic* mode of brain functioning, the brain is capable of responding to many things at once due to immediate and intuitive self-awareness. The active mode manifests in brain-regulated self-reflection that is

mediated by, or is a reflection of a person's intentions. In practice, this relationship may be better understood through examples of the brain's reaction and the mind's response to that reaction. For instance, the brain's itch and the mind's impulse to scratch, first seeing and then looking, or hearing and then listening. It is the brain's sense-making reaction to stimuli, and the mind's "effort after meaning" (Bartlett, 1932/1995) that empowers this figure-ground navigation system (Iran-Nejad & Winsler, 2000). Biofunctional theory would interpret reaching an impasse during decision making, as creating a state of indeterminacy, for which the dynamic mode's drive toward sense-making provides an impulse to resolve (Auble, Franks, & Soraci, 1979; Iran-Nejad, Watts, Venugopalan, & Xu, 2007).

The third pair of dispositional modes is *constructive* and *unconstructive* brain functioning (Iran-Nejad & Gregg, 2001). The *constructive* mode is a reflection of the brain's natural capacity to solve problems by integrating. In problem-solving situations this dispositional mode manifests in forming associations between a problem's elements and potential solutions, or integrating elements within a person's IKB (Iran-Nejad, 2000). The other half of this dispositional pair, *unconstructive*, runs counter to the brain's natural disposition toward integration. This mode operates through a narrowing of focus, and tends to generate fear, stress, tension and anxiety (Iran-Nejad, 2000). It is thought to arise for a number of reasons, such as performing highly analytical or symbolical tasks, or maintaining a highly active mode of functioning (Iran-Nejad & Gregg, 2001).

The dispositional modes of *dynamic* self-regulation, the *creative* and *constructive* modes together appear to coincide with the notion of the insightful mode. The dispositional modes of *dynamic* self-regulation and the *habitual* mode appear to coincide with the notion of intuition, as

depicted in this research. The dispositional modes of *active* self-regulation and the *unconstructive* mode appear to coincide with the notion of the rational mode.

Three Modes of Decision making: Theoretical Support from Five Research Domains

A longitudinal slice across the broad theoretical foundations of Gestalt, creativity, insight, social psychology, and Biofunctional theory provides strong evidence that there are three phenomenologically distinct modes of decision making. While the three modes are described in detail below, Appendix A presents a summary chart of these contributions from each theoretical base.

Three distinct modes of decision making

Rational decision making is mind-directed, active self-regulation that is effortful and intentional. It has a single point of focus and is directed by one's voluntary intentions (Iran-Nejad & Gregg, 2001). Although it is relatively affect free, negative affect promotes the use of this mode and narrows a person's perceptual focus (Epstein, 1990; Martindale, 1995). In addition, overuse of this mode tends to generate stress, tension and anxiety (Iran-Nejad & Gregg, 2001). This mode is analytic, oriented toward symbol manipulation, deliberate, verbally oriented, and operates by evidence and application of step-by-step rules (Epstein, 1990). The rational mode is slow to make decisions, but the way in which decisions are made is quickly changed, simply by changing the rules or the data. The brain's left hemisphere, which does fine semantic encoding of stimuli, is implicated in this mode of decision making (Bowden & Jung-Beeman, 2003a; Kounios et al., 2008).

Intuitional decision making is brain-directed, dynamic self-regulation, which directs most common daily activities (Epstein, 1990; Iran-Nejad & Gregg, 2001). When faced with a problem, this mode is the first to respond (Bowden & Jung-Beeman, 2003a; Epstein, 1990). It is about doing something that has been done before (Dominowski & Dallob, 1995). Reproduced behavior, stereotypical responses, habits, and adapting known solution routines to a current situation fall into this category of decision making. For intuitional decisions, the decision-maker recalls and applies previously acquired knowledge or associations, yet these previous solutions fail when a novel solution is needed. This mode makes rapid decisions, but changing the way in which decisions are made is very slow (Epstein, 1990). Intuition operates effortlessly in an automatic, holistic and associative manner (Epstein, 1990), and is oriented toward the safety of routine, rest, inaction, and avoiding challenges (Iran-Nejad & Gregg, 2001). It may attend to many things at once, and is never too busy to attend to a new stimulus (Iran-Nejad & Gregg, 2001). A person's intuition is affectively informed. It is shaped by emotionally significant events, and positive affect promotes its use (Bolte et al., 2003). Taken together, an intuitional decision is one that is very rapid and cognitively nearly effortless, where one's "gut" informs them of the solution.

Insightful decision making is another manifestation of brain-directed self-regulation (Iran-Nejad & Gregg, 2001). Insight, in the form of an Aha! experience, may suddenly emerge after initial solution attempts fail. This productive activity is about creating something new or novel. It uses past experience in only a general way, but avoids being trapped by habit or irrelevant associations (Weisberg & Alba, 1981b). This affectively informed act of creativity is typically characterized as the sudden illumination of an Aha! experience (Bowden & Jung-Beeman, 2003a). In achieving illumination, the problem solver is variously said to overcome

mental constraints, overcome fixation, change mental representations, become aware of a new relationship, change the context of some problem element, discover new associations between ideas, reinterpret some element of a problem, or assimilate possible solutions from the environment (Finke et al., 1992a, 1992b; Lubart & Sternberg, 1995; Seabrook & Dienes, 2003; Seifert et al., 1995). It is an essential part of human cognition that is promoted by positive affect. Insight is holistically oriented and energy mobilizing to address the unknown, deal with change, explore, and react to challenges (Iran-Nejad & Gregg, 2001). Reaching an impasse, when initial solutions attempts fail, has been described as inducing semantic priming, setting failure indices, or creating a state of indeterminacy (Iran-Nejad & Gregg, 2001; Seifert et al., 1995; Yaniv & Meyer, 1987). A period of incubation following an impasse, during which conscious work on a problem is set aside, may promote the Aha! experience of insight during subsequent solution attempts (Wallas, 1926). Factors that influence the emergence of insight include breadth of one's knowledge base, defocused attention, intelligence, personality traits that are conducive to forming new associations, and using analogies, as well as intrinsic motivation and a supportive environment (Csikszentmihalyi & Sawyer, 1995; Martindale, 1995; Sternberg, 2006).

Interaction of Rational, Intuition, and Insight during problem solving.

The cognitive mechanisms that underlie the rational and intuitional modes of decision making engage in a dance of cooperation (Epstein, 1990), or a cycle of reflection (Iran-Nejad & Gregg, 2001) to solve the majority of problem that a person encounters in their daily lives. The initial reaction to a problem is by the intuitional system (Epstein, 1990; Iran-Nejad & Gregg, 2001), with most every-day problems quickly and effortlessly solved by this mode through the recall and application of past solution associations (Epstein, 1990). However, the interaction of

the rational and intuitional systems may result in a decision to apply a rational step-by-step approach to solving a problem. During waking times, and especially during decision making efforts, these two systems maintain an ongoing cycle of reflection, where the dynamic intuitional mode and the active rational mode mutually evaluate and support the operation of each other (Epstein, 1990; Iran-Nejad & Gregg, 2001).

When these two modes fail to find an acceptable solution, and assuming there is sufficient intrinsic motivation to further pursue a solution, the person may reach an impasse (Davidson, 2003; Seifert et al., 1995). At this point, conscious effort to solve the problem is stopped, and the dynamic subconscious is given opportunity to overcome the source of the impasse. Sometimes a period of incubation, when conscious attention is directed elsewhere, will help to overcome this impasse. If this happens, the person will experience an Aha! moment of insight about a solution to the problem (Bowers, Farvolden, & Mermigis, 1995; S. M. Smith, 1995).

Hypothesis Development

Solving novel problems

By definition, a novel problem requires a solution that is novel. While a problem may not be novel for one person, it may be for someone else. If a problem is novel for a person, he or she has formed no prior association between the problem and a solution. The task is to find a novel or new association that solves the problem (Mendelsohn, 1976). Until that new association has been formed between the problem and a solution, it remains a novel problem.

When a person attempts to solve a novel problem, the initial reaction is typically an unfruitful attempt to use intuition from past experience to solve it. Through dynamic self-

regulation (Iran-Nejad & Gregg, 2001), the brain perceives the problem's features and searches for a known problem/solution association (Mendelsohn, 1976). Because there is no prior experience with this problem, this initial (intuitional) response will fail. This will trigger the mind and brain (Iran-Nejad & Gregg, 2001), or cognitive and experiential (Epstein, 1990) systems to interact in an attempt to evaluate possible rational options that may have been successful before with a problem of this sort. It is not unusual for this to result in a rationally oriented "step-by-step" or "brute-force" attempt that, depending on factors like problem difficulty, may have a chance of success (Schooler & Melcher, 1995). In this period of initial exposure to a new problem, several iterative attempts to solve a problem are likely to be attempted (i.e. recall of past associations or recall of successful past rational methods) as the dynamic and intuitive brain and the active and rational mind interact through reflection (Iran-Nejad & Gregg, 2001).

With the certain failure of the initial intuitional approach, and if rational attempts fail, the person may reach an impasse, where the person feels that no more progress can be made toward a solution with the existing strategy (Bowden et al., 2005; Dominowski, 1995). Novel insights often emerge after this critical step of reaching an impasse. The person may suddenly discover a novel way to overcome the impasse and gain insight into a novel solution through restructuring the problem (Finke et al., 1992a; Sternberg & Lubart, 1995), gain insight by forgetting the source of the fixation (Finke et al., 1992b; Kohn & Smith, 2009), overcoming a context-based fixation (Seabrook & Dienes, 2003), or calling on a person's knowledge base to supply an unusual new insightful association between the problem's elements (Bowden & Jung-Beeman, 2007; Kounios & Beeman, 2009). Seifert et al's (1995) opportunistic assimilation hypothesis provides a different explanation for the value of an impasse in gaining insights. They propose that an

impasse sets failure indices, or flags the problem as an open question in long-term memory. Any relevant information encountered while the failure indices are unresolved is assimilated into the problem's representation, possibly leading to a new insight.

Problem Difficulty

Problem difficulty plays a significant role in a person's ability to solve novel problems. One way to imagine problem difficulty is the accessibility or activation of the memory elements needed to solve the problem (Graf & Mandler, 1984; Mandler, 1995). Accessibility indicates the ease (or effort) with which mental content, such as a problem solution or a new association, comes to mind (Kahneman, 2003). Having previous experience solving a problem creates high accessibility, while increasing remoteness or novelty of a solution concept signals a decrease in accessibility (Yaniv, Meyer, & Davidson, 1995). There are several factors that are generally considered to determine the difficulty of a problem: a) stereotypical thinking (the use of more crude differentiations or reliance on broader generalizations), framing effects (bias in the salience of a problem's characteristics), or fixation on the wrong path to solve the problem (Kahneman, 2003). b) Inability to generate or imagine a new path or problem space in which to search for a solution (Davidson, 1995, 2003; Kaplan & Simon, 1990; Weisberg & Alba, 1981a), and c) The ease with which a person can restructure a problem so as to reveal previously unseen solution opportunities (Ohlsson, 1984). The cognitive remoteness of the problem space (semantic coherence of the problem's elements) in which the solution resides is then an indicator of the accessibility of the association necessary to create a solution. Due to their relatively accessible (less cognitively remote) solutions, easier problems are more susceptible to being solved on first exposure (P. I. Ansburg & Hill, 2003), either with a stepwise rational approach, or the problem

solver may reach an impasse, quickly experience an Aha! moment and find a solution. More difficult problems (more cognitively remote) will likely require an impasse and an incubation period to increase the accessibility of the solution to produce insightful novel solutions.

The following hypotheses are based on the previous discussion of problem difficulty. When problem difficulty is low, the problem space is smaller. The cognitive distance between the problem and the solution is shorter and the solution less remote. This makes a rational/brute force approach (trying a series of words until a solution is found) more likely to succeed. When problem difficulty is high, the problem space is much larger. There is greater cognitive distance between the problem and its solution, making it far less likely that a rational approach will succeed. The only option to find the solution will be through the larger cognitive leaps of an insightful approach.

Hypothesis 1a: A rational decision-making mode is more likely to be used for novel problems when problem difficulty is low

Hypothesis 1b: An insightful decision-making mode is more likely to be used for novel problems when problem difficulty is high

Affect

Affect or mood plays a number of important roles in decision making. While rationality is considered relatively affect free (Epstein et al., 1996), use of intuition is affectively informed as a hunch or gut feeling (Elsbach & Barr, 1999; Miller & Ireland, 2005; Zajonc, 1980). A person's mood also has a pervasive influence on the evaluative judgments that are made throughout the decision-making process, from the decision to undertake a problem (Zimmerman

& Campillo, 2003), to decisions to persevere in the face of adversity (Isen, Daubman, & Nowicki, 1987; Labouvie-Vief & Medler, 2002), to the choice of a decision-making strategy that is used (Bolte et al., 2003). In general, people in less positive moods are more likely to use a rational, step-by-step approach with considerable attention to detail and increased perceptual focus. They are less likely to undertake a difficult problem, and are more likely to abandon their efforts when faced with adversity (Schwarz & Skurnik, 2003). Less positive mood has been shown to narrow people's perceptual focus. Therefore they notice fewer associations while increasing their ability to focus on a task (Dreisbach & Goschke, 2004; Rowe, Hirsh, & Anderson, 2007). In contrast, a more positive mood facilitates creative problem solving through a broadening of perceptual focus (Isen et al., 1987). It promotes undertaking new problems, and perseverance in the face of adversity (Schwarz & Skurnik, 2003). While positive mood has been shown to increase distractibility (Dreisbach & Goschke, 2004), it promotes flexibility, innovation, and creativity (Isen, 2001). Innovation and creativity typically involve finding solutions that are remote from the problem, possibly from distant domains. Positive mood broadens a person's perception of semantic coherence (Bolte et al., 2003) and enhances access to remote associations (Bowden et al., 2005; Rowe et al., 2007). These changes facilitate a person's ability to innovate and create.

The following hypotheses are based on the previous discussion of the role of affect in decision making. When a person is in a less positive mood, a narrowing of attention, and step-by-step execution of procedures is promoted. These are the hallmarks of a rational decision-making mode. However, when a person is in a more positive mood, a broadening of attention and increased flexibility in thinking are promoted. This facilitates the ability to perceive and

consider solutions that are more remote or unusual. These are the hallmarks of an insightful decision-making mode.

Hypothesis 2a: A rational decision-making mode is more likely to be used for novel problem solving when a person is experiencing lower current affect

Hypothesis 2b: An insightful decision-making mode is more likely to be used for novel problem solving when a person is experiencing higher current affect

Personality preferences for rationality and intuition and emergence of insight

A common perception is that a person's cognitive style has a significant influence on their decision-making strategy, either oriented toward a rational approach, or oriented more toward intuition. In support of this perception, Hunt et al. (1989) found congruence between subjects' cognitive style and their decision strategy. While this congruence is enticingly simple, the actual relationship between personality and decision making is far subtler. As people get older and gain experiences to fuel their intuitions, they tend to move away from higher analytical orientations (Allinson & Hayes, 1996). Other studies have found differences in the influences of each dimension. Those with a strong faith in their intuition have been found to mistake their intuition for rationality, which interferes with their ability to think logically. On the other hand, those with a strong rational orientation are typically more pragmatic, but are also more likely to reject intuition (Epstein et al., 1996). For those more typical people whose personalities do not fall at the extremes, decision making is more a product of the joint operation of these orthogonal rational and intuition systems, with personality-based individual differences accounting for the

degree to which a person relies on rational or intuitive modes of thinking (Allinson & Hayes, 1996; Epstein et al., 1996).

Unlike rationality and intuition, insight does not arise from a separate dimension of personality. Instead, intuition is an antecedent of insight (Hodgkinson et al., 2008), and the problem-solving strategies that produce insights into novel problems originate in the individual differences that lead to one's preference toward intuition (Kounios & Beeman, 2009). Although it is not uncommon for intuition to be conflated with insight (e.g. Allinson & Hayes, 1996; Andersen, 2000; Bowers, Regehr, Balthazard, & Parker, 1990; Raidl & Lubart, 2001; Topolinski & Strack, 2008), insight is a phenomenologically separate mode of decision making. Factors external to the individual, including impasses and incubation periods, play a role in the productive thinking and problem restructuring that is the basis of insight (Dominowski, 1995; Weisberg, 1995).

The following hypotheses are based on the previous discussion of the role of affect in personality preferences. The literature indicates that a person's choice of a problem-solving strategy will tend to correlate with their personality preferences for rationality or intuition.

Hypothesis 3a: A rational decision-making mode is more likely to be used for novel problem solving when a person's personality preferences are oriented more toward rationality

Hypothesis 3b: An insightful decision-making mode is more likely to be used for novel problem solving when a person's personality preferences are oriented more toward intuition

Because the phenomenon of insight in problem solving involves the additional conditions of impasse, incubation and cues, Hypothesis 4, which addresses insight, occurs after discussion of those additional conditions.

Impasse

As discussed earlier, an impasse is an important and necessary point during creative problem solving. At an impasse, a person is likely to feel that no more progress is possible toward a solution with the current strategy (Bowden & Jung-Beeman, 2007), or he is unable to generate a new path or strategy for a solution (Davidson, 2003; Seifert et al., 1995). Reaching an impasse is not simply failing to solve a problem by the end of a short period of time, and it is not reached by simply being interrupted prior to reaching a solution (Davidson, 2003). An impasse triggers subconscious mental activity oriented toward resolving an impasse by setting “failure indices” that flag the problem as an open question in long term memory (Seifert et al., 1995). Other interpretations of impasse include activating memory traces for inaccessible memories (Yaniv & Meyer, 1987), or setting a state of indeterminacy that provides a dynamic self-regulation impulse toward resolution (Auble et al., 1979; Iran-Nejad et al., 2007). While a stereotypical impasse is likely to require an incubation period to resolve, some problems (especially easier ones) may be solved quickly with insight after reaching the impasse. More difficult problems are likely to require an incubation period to solve.

Incubation

Incubation, a concept that originated with Gestalt literature (Wallas, 1926), is a stage of problem solving often experienced after coming to an impasse. A person sets a problem aside for

a period of time, after which an Aha! moment of sudden solution insight may burst into awareness (S. M. Smith & Blankenship, 1991). An incubation period is said to provide a person's subconscious with an opportunity to overcome a fixation or to encounter cues in the environment that may be useful in solving a problem (Finke et al., 1992b; Seifert et al., 1995). This work by the subconscious has sometimes been characterized as allowing unproductive fixations (e.g., getting stuck on the way that a person looks at features of a problem) to weaken or be forgotten, so that useful new associations may surface (S. M. Smith & Blankenship, 1989). Another theory proposes that the main contribution of an incubation period is simply to provide the problem solver with incidental exposures to various external stimuli (cues), some of which may be relevant for resolving the problematic impasse (Seifert et al., 1995). These two theories, overcoming fixation (S. M. Smith & Blankenship, 1989) and opportunistic assimilation (Seifert et al., 1995), are the most highly regarded and widely cited, yet there are other interpretations for the subconscious activity during an incubation period. These include restructuring of a problem's elements to reveal novel associations (Metcalf & Wiebe, 1987; Schooler et al., 1995), overcoming a mental set (being stuck in stereotypical thinking) (Ohlsson, 1984), finding an analogy from the new problem to another problem whose solution is already known (Martindale, 1995; Pretz, Naples, & Sternberg, 2003), spreading activation (making potential solutions accessible in memory) from previously established links in semantic memory to form new remote associations (Yaniv & Meyer, 1987), and overcoming fixation by changing the context of the problem (Seabrook & Dienes, 2003).

Cues during incubation

The presence or absence of solution cues or hints in the environment, during an incubation period, following an impasse, influences the emergence of insight through opportunistic assimilation (Seifert et al., 1995). There are many anecdotal references to solutions arising from cues in the environment, such as water sloshing out of Archimedes' bathtub. Helpful cues can take many forms, from bathtub water, to a collection of objects in a drawer, to words on a screen. Failure indices or indeterminacy created by reaching an impasse may cause any environmentally encountered cues to be related back to the problem and potentially used to solve the original problem if it should be encountered again (Seifert et al., 1995).

There is no formal hypothesis for the research condition in which solution cues are absent during an incubation period. This is treated as an experimental condition due the wide range of the explanations in the literature for overcoming an impasse. These theories, which have previously been discussed, address theoretical mental mechanisms involved in achieving insight. They include overcoming various forms of fixation (Kaplan, 1989; S. M. Smith & Blankenship, 1991), changing the context of a problem's elements (Seabrook & Dienes, 2003), overcoming stereotypical responses or changing one's mental set (Dodds et al., 2002; Epstein et al., 1996), and spreading activation (Yaniv & Meyer, 1987). If a participant solves a novel problem after reaching an impasse, and there was no cue, there is no way to predict the mechanism by which the solution was obtained.

The following hypothesis is based on the previous discussion of the role of cues encountered during an incubation period, after reaching an impasse. It addresses novel problems (no previous mental association between problem and solution) that are solved with insight. Because such a novel problem initially resulted in an impasse, it is likely to be a more difficult

problem, and require a period of incubation to overcome the source of the impasse. Encountering a cue (solution hint) during incubation will provide an opportunity to assimilate the cue and solving the problem with insight. The solution mode will not be intuition because the problem is novel. The mode is also unlikely to be rational because difficult problems are less likely to be susceptible to brute force search approaches.

Hypothesis 4: An insightful decision-making mode is more likely to be used for novel problems where an initial solution attempt has resulted in an impasse and cues are present in the environment during a period of incubation

Non-novel problems

If a previous attempt to solve a novel problem resulted in a successful solution to a problem, an experientially formed association between the problem and the successful solution will have been created (Davidson, 2003; Epstein, 1990). At a subsequent exposure to this now non-novel problem, this association will typically result in rapid reproductive problem-solving through intuition (Davidson, 2003). As dynamic self-regulation (driven by the spontaneous nonexecutive components of the nervous system) (Iran-Nejad, 1990) perceives the problem and recalls the prior association, the person can use intuition to quickly and effortlessly recall the solution (Epstein, 1990; Iran-Nejad, 2000).

The following hypothesis is based on the previous discussion of non-novel problems (previously solved, where an association between problem and solution is already established). The experiential system (Epstein) or dynamic self-regulation (Iran-Nejad) will respond first to a non-novel problem and intuitionally recall the previously discovered solution. This will likely result in the sudden knowing of an intuitional decision.

Hypothesis 5: An intuitional decision-making mode is more likely to be used for non-novel problems

Affect and non-novel problems

As previously discussed, intuition is affectively informed and emerges as a *gut feeling* during decision making (Elsbach & Barr, 1999; Miller & Ireland, 2005; Zajonc, 1980).

According to Slovic et al's (2002) affect heuristic, affect has a direct and important influence in intuition. For non-novel problems, where the experiential system enables rapid and nearly effortless decisions based on past experiences, affect is a form of cognition (Duncan & Barrett, 2007; Epstein, 1990). While those in less positive moods are more likely to rely on rationally-oriented structured decision-making protocols, those experiencing a more positive affective state are more likely to trust in the affectively informed hunches and gut-feelings of their intuition (Elsbach & Barr, 1999).

The following hypothesis is based on the previous discussion of the association between non-novel problems and the effect of positive affect. A person having previously solved a problem does not ensure that they will use intuition to solve a subsequent encounter with the problem. A non-positive current mood could possibly influence someone to ignore his or her intuition and use a rational brute force search strategy. However, someone experiencing positive affect will more likely trust his or her intuition for these non-novel problems.

Hypothesis 6: An intuitional decision-making mode is more likely to be used for non-novel problems solving when an a person is experiencing positive affect

Personality preferences and non-novel problems

As discussed earlier, a person typically uses intuition when solving non-novel problems. It provides people with an energy-conserving way to quickly and accurately solve problems where the path to a solution is already known (Epstein, 1990; Iran-Nejad & Gregg, 2001). A personality preference for an intuitional mode of decision making increases people's trust in their hunches and gut feelings that arise from their experientially-based intuition (Epstein et al., 1996).

The following hypothesis is based on the previous discussion of the association between non-novel problems and the effect of personality preferences for intuition. If someone has a strong preference for rationality, he or she could potentially ignore intuition and use a rational approach. Alternatively, a preference for intuition is likely to facilitate trust in one's experience-based intuition.

Hypothesis 7: An intuitional decision-making mode is more likely to be used for non-novel problems solving when a person's personality preferences are oriented more toward intuition

Hypothesis Development Summary

Hypotheses 1a and 1b address novel problems when problem difficulty is high and low, and predicts that hard problems will be solved with insight and easy problem will be solved with rationality. Hypotheses 2a and 2b address novel problems in light of a person's current affect. These hypotheses predict that positive current affect will enhance insightful problem solving, while less positive affect will correlate to more rational decisions. Hypotheses 3a and 3b again address novel problems, but this time they do so in light of people's personality preferences or orientation toward intuition or rationality. These hypotheses predict that a rational orientation

will lead to more rational decisions, and an intuitional orientation will lead to more insightful decisions.

Hypothesis 5 begins the hypotheses that address non-novel problems. This hypothesis predicts that when a problem is non-novel the problem solver is highly likely to use intuition to solve it. Hypothesis 6, again addressing non-novel problems, predicts that positive affect will promote the use of intuition. Finally, Hypothesis 7 predicts that, for non-novel problems, personal preferences oriented toward intuition will promote the use of intuition.

CHAPTER 3

METHODOLOGY

This chapter describes an experimental design that examines the phenomenologically distinct ways in which people make decisions. This experiment is intended to answer questions about the decision-making modes that people employ, and the different conditions or personal preferences under which these decision-making modes emerge. As described in the detailed procedures in this chapter, this study presented participants with decision-making situations under a range of conditions that are intended to elicit different decision-making modalities. Statistical analysis for this dissertation was generated using SAS (Version 9.2). Approval of the Institutional Review Board of the University of Alabama was obtained prior to data collection.

Samples

Across two samples, a total of 166 male and female undergraduate student participants were recruited for this study. For Sample 1, subjects were 68 students, predominately from the College of Education. 40% were male and 60% were female. The mean age was 20.00, (SD = 1.79), and ranged from 18 to 27 years of age. This sample was 85% Caucasian (n = 58), 12% African American (n = 8), 1.5% Hispanic (n = 1), and 1.5% Asian (n = 1).

In Sample 2, subjects were 98 University of Alabama undergraduate students, recruited from the school of Business. Forty three percent were male and 57% were female. The mean age was 19.64 years, ($SD = 1.14$), and ranged from 18 to 24 years. Sample 2 was 73% Caucasian ($n = 72$), 10% African American ($n = 10$), 2% Hispanic ($n = 2$), 10% Asian ($n = 10$) and 4% Other ($n = 4$).

Demographics

The participants were asked to report their gender, age, race and school major. Campuswide ID number (CWID) was collected only on a sign-in sheet, in order to assign any class credit due for participation in research.

Data Collection Procedures

Overview

All measures for this research were administered through Internet web sites. Intelligence was measured by the Wonderlic Personnel Test – Quicktest (n.d.). For the Wonderlic measure (Appendix D), participants either visited the Wonderlic web site by responding to an emailed invitation or by following a link and entering a personal identification number (PIN). The primary problem-solving study was implemented using the Qualtrics web tools (Qualtrics Labs Inc., Provo, UT).

Both study samples consist of two phases where participants worked to solve Compound Remote Associate (CRA) Test problems (Bowden & Jung-Beeman, 2007). A CRA problem is a three-word puzzle in which the participant is asked to provide a fourth word that makes three compound words from the fourth word and each of the first three words. In Sample 1, each

participant encountered a total of 48 problems. In Sample 2, each participant encountered a total of 50 problems. Through variations of the conditions of novelty and cueing, participants encountered first-phase problems again in the second phase. Between the phases was an incubation period that contained a lexical task during which potential CRA solutions (cues) were randomly encountered in the environment. Table 3 provides a graphical representation of the flow of the study's procedures.

Figure 3.1 Flow of the study's procedures

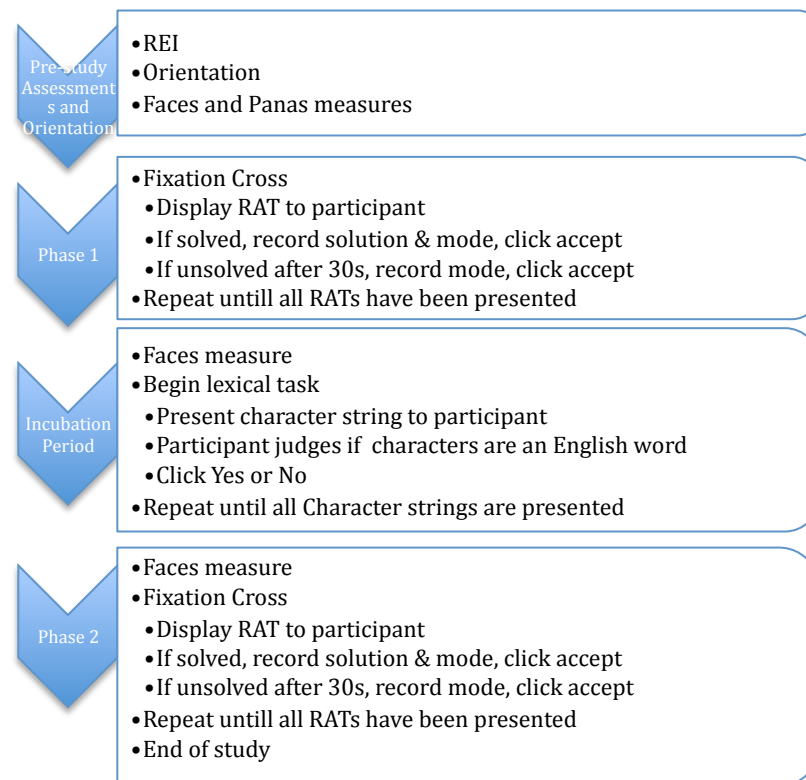


Figure 1. Flow diagram depicting the chronological order of the study tasks.

The recruiting procedures for the two studies were somewhat different. For Sample 1, each participant was given a card at the time of recruitment. This card contained an anonymous and unique identifying number, and a series of instructions (See Appendix G) directing them to complete the Wonderlic Personnel Test – QuickTest (WPT-Q) (Appendix D) and the Rational Experiential Inventory (REI) (Epstein et al., 1996) (Appendix E) measures on their own, prior to arriving for the study. Participants first sent an email requesting an invitation to take the Wonderlic. When the invitation arrived via email, they followed the link and took the test, using the identifier on the card. They then visited the study’s web site to take the REI. The last instruction gave them the time and location of the study. Due to the overly complex nature of these procedures, eleven potential participants completed only parts of the process, or made mistakes that invalidated their responses. Seven completed the REI or Wonderlic but failed to arrive for the main study. Five failed to enter their study ID into the Wonderlic, making it impossible to connect those responses to the study data. Three failed to follow the Wonderlic instructions and were dismissed from the measure before finishing. While the purpose of conducting pre-study activities was to keep the study time under one hour, experience from Sample 1 showed that it was possible to reduce or eliminate these problems by combining all the study activities, and still keep the participant’s time in the study less than one hour.

For Sample 2, recruits were given cards that contained the date, time and location of the study, as well as an email address to confirm their attendance. The REI measure was administered upon arrival to the study. PINS and Study IDs were also handed out upon arrival.

At the beginning of the study, participants attended an orientation session (see Appendix H), where they began by registered to receive class credit for participation. They used their anonymous study ID to log into the study’s web site and begin their participation in the study.

An orientation procedure familiarized participants with the CRA problems they would encounter by giving them two practice CRA problems and two lexical task problems. The computer-based procedures for the study were explained, as well as how they should respond to the questions presented on the computer screen. Participants were told of the phases of the experiment, and that some of the problems they encountered in the first phase might be encountered again in the second phase. They were also informed that they might encounter cues during the lexical task that might help them solve previously unsolved first phase problems. The group orientation instructed them how to distinguishing between solving a problem with insight from a problem solved without insight. (“If you worked through the problem by trying a number of different solution words until you discovered a word that solved the problem, then consider that a *search* solution. If you worked with the problem, but then you had an Aha! experience where the solution suddenly popped into your mind, then consider that an *Aha!* solution).

After orientation, participants were given the URL of the study’s web site. They were directed to try the sample problems, and then to begin the study. The computer asked for their unique study ID, and then asked for their demographic information. The study web site administered the PANAS (Watson, Clark, & Tellegen, 1988) (Appendix C) (once with Sample 1 and twice with Sample 2). At four points during the study, current affect was measured with the Faces scale (Appendix B). The web site scored these measures in the background and recorded the results along with all other answers for each person in the study.

In Phase 1 of the study, participants were iteratively presented with a series of randomized CRA problems. Each problem began with a spinning fixation circle (computer generated spinning circle), positioned at the center of the screen that displayed for 2 seconds. The three words of each CRA problem were then displayed in a vertical column at the center of

the screen. A 30 second countdown timer displayed below the CRA words. Below the timer was a button that, when clicked, stopped the timer and gave participants a field to enter their proposed CRA solution. This screen also gave participants a place to report how they solved the problem (through rational searching or finding an sudden Aha!) After typing their solution word, participants selected either the search or Aha! button. When they clicking the Next button the computer screen advanced them to the next problem. The correctness of the typed solution word was determined retrospectively, and coded as a 1 for correct and a 0 for incorrect. This retrospective examination of solutions also accommodated answers that were correct but mistakenly typed incorrectly. If time expired without a solution, the screen changed and asked the participant to indicate the solving mode they were using when time ran out. When they click the Next button the software advanced to next question. In this phase, problems could be solved *rationally (search)*, with *sudden knowing (Aha!)*, or remain *unsolved* at the end of the 30-second time limit. Once all CRA problems for Phase 1 were presented, a Faces measure of current affect was presented. Then a message appeared that directed participants to sit quietly for one minute until the incubation phase began.

During the incubation period participants participated in a lexical task, which was described as a word-sorting task. The purpose was to help overcome fixations through time away from trying to solve problems, and to provide opportunities for opportunistic assimilation on unsolved problems. This lexical task iteratively presented participants with a series of character-strings that were non-words, English control words, and cue words that were solution words for the CRA problems previously encountered. Each character string was displayed at the center of the screen, and below the character string were two buttons marked “Yes” and “No.” Above the character string was the question “Is this an English word?” Participants indicated with a mouse

click if the displayed character string was an English word, or not. Clicking the Next button advanced to the next character string. This task was scored in order to provide an indication of a subject's active participation. If a participant scored low, it was taken as a possible indication that the participant was simply clicking answers randomly in order to finish quickly. After all character strings were displayed, the computer screen displayed a timer and a message to sit quietly for one minute, waiting on the second CRA phase to begin.

At the beginning of the second phase, a third Faces scale of current affect was presented. The second phase of CRA problems then began. The processes and instructions for this second phase were exactly the same as for the first phase. The CRA problems for the second phase consisted of all the same problems from Phase 1, plus new problems that represented all levels of problem difficulty.

With regard to second phase problems, participants again reported *rational (search)* and *sudden knowing (Aha!)* solutions, or problems remain *unsolved* at the end of the 30-second time limit. Non-novel problems, which participants had successfully solved in the first phase and encountered again, were not treated differently from novel problems regarding solution mode. A participant could solve a non-novel problem *rationally* or with *sudden knowing*. There were two reasons for this operational decision. The first is that remembering a prior solution is likely to be confused with the sudden knowing of solving a novel problem (Dougal & Schooler, 2007). The second reason is the affective similarity of the experiences of the sudden knowing of intuition and the sudden knowing of insight. Few participants were expected to be able to make such a fine distinction between the sudden knowing of novel insight and the sudden knowing of intuition (both were experienced as a gut feelings). Therefore the use of intuition was retrospectively inferred from the circumstances of the second solving of the problem and the

distinguishing characteristics of intuition. If a problem was non-novel, and the time to solution was faster, its solution mode was inferred to be intuition. It was also expected that an Aha! solution mode would likely be the reported solution mode for these reproductively solved problems.

A Faces measure of current affect was administered at the completion of Phase 2. For Sample 2, a PANAS scale was added to the Faces measure at the end of Phase 2. Individuals were thanked and asked to close the web browser and exit.

Measures for Research Variables

Compound Remote Associates (CRA) Test problems

The compound remote associates problems developed by Bowden and Jung-Beeman (2003b) were simple compound-word problems for use in research on the experience of insight during problem solving (Appendix F). The goal of CRA problems is for the problem solver to discover the cognitively remote association that solves the problem. These problems were patterned after Remote Associates Test (RAT) items developed by Mednick (1962) as a means of measuring creative thought where specific knowledge in any field is not necessary. Such RAT problems were not as complex as classical insight problems, but they do exhibit the three properties that distinguish insight problems from non-insight problems. 1) They misdirect the solution retrieval process. 2) Problem solvers were often unable to report any processing that brought them to the solution, 3) Upon solving the problem, problem solvers often experience the affectively oriented Aha! experience (Bowden & Jung-Beeman, 2003a). The CRA problems developed by Bowden and Jung-Beeman have a unique solution word that is associated with all three words in the problem's word triad. The solution word forms a compound word or phrase

with all three of the problem words. For example, the problem AGE/MILE/SAND has a solution word STONE, which will produce the compound words STONEAGE, MILESTONE, and SANDSTONE. In solving one of these novel problems through insight, people often have an Aha! experience, where they suddenly recognize a solution or a path to a solution. The solution-related activation of the association between the problem and the solution suddenly overcomes the threshold of awareness and bursts into awareness. Alternatively, the novel problem may possibly be solved without insight through rational processes, where the problem solver carries out a series of steps or operations in order to achieve a solution (Bowden & Jung-Beeman, 2003a; Schooler et al., 1995). This rational path to a solution is often accompanied by gradually increasing feeling of warmth (nearness to solution) as the problem solver gets closer to solving the problem. Regarding insightful solutions, feelings of warmth typically only increase at the Aha! experience. For Sample 1, 19 CRA problems were used for Phase 1. For Phase 2, these same 19 problems, plus 10 new CRA problems were used. In all, participants experienced 48 problems.

Level of Difficulty

The compound remote associate test problems (CRAs) used in this study were taken from the 144 compound remote associate test problems developed by Bowden and Jung-Beeman (2003b). Difficulty of these problems is initially taken from the normative percentage of participants that solved each problem within an allowed time. The 144 CRA problems were stratified into four groups of difficulty, and a random sample of problems was selected from each group for use in this study. Problems from each difficulty group were coded for difficulty, from easy (1) to hard (4).

After the two samples of data were collected it was discovered during analysis that a number of problem's solution percentages had significantly deviated from expected solution percentages. Problem difficulty ratings were recalculated based on experience with these two samples. Using this revised difficulty rating of the problems that had already been selected, the problems were stratified into three strata. The new difficulty ratings were then used in the analysis of both samples.

Current Affect

Current affect was accessed with a face scale at three points within the study. This seven-point scale (Appendix B) was adapted from the seven point faces scale by LePine and Van Dyne (1998). Their scale was based upon improvements to a set of outdated graphics in a measure by Smith, Kendall and Hulin (1969). For this study, participants were asked to select the face that best expressed their current emotional state.

In addition, affect was measured with the Positive Affect and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988). The full version of PANAS (Appendix C) is comprised of two 10-item mood sub-scales, though only the positive affect items were used in this study. Cronbach's alpha for reliability for current affect, as measured by PANAS PA (Positive subscale) is .89 (Watson et al., 1988). Respondents used a 5-point scale from 1 (very slightly or not at all) to 5 (extremely) to indicate the extent to which the mood-related words in the sub-scales applied to them. This brief scale has been shown to be reliable, and provides an easily administered measure of Positive Affect (PA), reflecting the extent to which a person feels alert, active and enthusiastic. PA is a state of pleasurable engagement, full of energy and

concentration (Watson et al., 1988). The Qualtrics web site was programmed to administer both the Faces measure and the PANAS.

Personality type

Personality preferences for rationality and intuition were measured with Epstein et al.'s Rational Experiential Inventory (REI) (1996). The full REI is a 40-item questionnaire (Appendix E) designed to assess an individual's rational and experiential (intuitive) thinking styles (Pacini & Epstein, 1999). This version of the REI (Pacini & Epstein, 1999) is a refinement of an earlier REI measure that was comprised of the Need for Cognition (NFC) scale (Cacioppo & Petty, 1982) and a Faith in Intuition scale (Epstein et al., 1996). The full REI has an orthogonal two-dimensional structure, with two subscales each, that produces an ability and a favorability measure for each of the two main dimensions. Ten items represent each of these sub-dimensions. In a personal communication, Epstein recommended that only the rational and experiential favorability sub-dimension scales be used to measure participants' personality inclination for rationality and experientiality. Chronbach's alpha for the rational favorability scale is .84, and is .80 for experiential favorability (Epstein et al., 1996). Taking Epstein's recommendation, respondents answered on a 5-point scale that ranged from 1 (definitely not true of myself) to 5 (definitely true of myself). The Rational Favorability subscale gives a measure of one's reliance on, and enjoyment of thinking in an analytical and logical manner. The Experiential Favorability subscale measures the extent to which one relies on and enjoys feelings of intuition during decision making. The measure of a respondent's Rationality and Experientiality (Intuition) were obtained by summing these favorability subscales. Higher scores in one of the scales indicates greater reliance on that type of thinking.

Cues during incubation

Solution cues during incubation were manipulated by inserting solution words into the series of character strings in the lexical task that participants performed between Phase 1 and Phase 2. Half the participants were to be given cues, while the other half would see no cues. Two groups of character strings were prepared, one with cues and one without cues. The Qualtrics web site randomly assigned participants to experience one group of character strings or the other group. Before beginning the lexical task, participants were told that they might see cues to problems before they returned for the second phase, and that they should try to use them. This priming was included because the simple presence of cues is not considered enough to increase the solution rate (an incubation effect) following incubation. Dodds et al. (2002) found that unless participants intended to make use of the cues they encountered, no incubation effect occurred. If a participant had the intent to use environmentally encountered cues after reaching an impasse, the failure indices that marked the impasse may have caused the cues to be related directly back to the impasse, and used to solve it (Seifert et al., 1995). Otherwise, the cues were likely to be ignored (Dodds et al., 2003). As a manipulation check to ensure that participants were paying attention to the character strings in the lexical task, the accuracy of their character string sorting responses was scored. Those who scored poorly were considered for removal from the data.

Cues absent during incubation

Because there is no formal hypothesis for problems with no solution cues in the environment, this condition was treated as exploratory. Incubation effects (S. M. Smith & Blankenship, 1989), which are improvements in problem solving seen during retesting after a

delay, are typically elusive (P. I. Ansburg & Hill, 2003). If, for example, the source of a fixation is still active at the time of the retest, the path to a creative solution may remain blocked (S. M. Smith, 1995). Some have found that the type of problem, length of preparation, and the activity during incubation may contribute to an increase of incubation effects (Sio & Ormerod, 2009). Others have found that theoretical mechanisms, such as activating remote memory traces (Yaniv & Meyer, 1987), or overcoming the cause of a fixation (Ohlsson, 1984; Seabrook & Dienes, 2003; S. M. Smith, 1995) may enable a novel solution. While gaining insightful results may be unpredictable, the results of the no-cues condition may provide valuable and interesting insights into problem solving.

Reaching an impasse

For the purposes of this study, an impasse was reached when a participant experienced the feeling that no more progress could be made with the current strategy. That can occur rather rapidly, and lead to a quick problem restructuring and solution of a problem. It can also occur after struggling unsuccessfully with a problem and then reaching the limit of available time. To facilitate reaching an impasse, instead of simply interrupting the participant prior to reaching a solution, a generous amount of time to work on these problems was allotted. Additionally, in an attempt to instill a sense that typical solution strategies were failing, a “time-remaining” clock was visible while problems were worked on.

Novelty and non-novelty

The status of CRA problems categorized as novel or non-novel in this study was simply a reflection of each individual participant having previously solved or not solved specific

problems. Regardless of the number of times that a participant encountered a problem, if this person had not solved it, the problem remained novel. Once a person solved a problem, an association was made between the problem and its solution, and it was categorized as non-novel.

Intelligence as a covariate

This research treats intelligence as a covariate. Some have claimed that the relationship between intelligence and general problem solving ability is positive, but quite small (Sternberg, 1982; Winke & Frensch, 2003). Prior research has claimed that people that have solved certain types of verbal problems have above average intelligence (Davidson, 2003). Everyday experience supports the observation that some very intelligent people are not creative, and some creative people would fare poorly in standardized IQ tests. Some have linked intelligence to creativity, which is the basis of insightful problem solving. Others have found that increasing intelligence correlates with creativity, but only up to an IQ of about 120, at which point the correlation vanishes (Simonton, 1984, cited in Martindale, 1995). As can be seen from these examples, it appears to be rather difficult to predict the relationship between intelligence and problem solving. A high IQ may predict success in rational problem solving, but fail to predict intuitional or insightful success. The correlation between high IQ and verbal problem solving success may simply be a consequence of a larger vocabulary. Although this research has no formal hypothesis related to intelligence, including intelligence as a covariate presents a rather unique opportunity to test the relationship between traditional measures of intelligence and the modes of problem solving where higher intelligence is thought to provide a positive benefit.

Intelligence was measured in both samples by the Wonderlic Personnel Test – QuickTest (WPT-Q) (Appendix D). This measure is derived from the full Wonderlic Personnel Test, a recognized and highly reliable measure of general intelligence (Dodrill, 1983). The WPT-Q is quick to administer, and has shown long term stability. It is an 8-minute multiple-choice test that consists of 30 items. The test covers problems such as vocabulary words, commonsense reasoning, formal syllogisms, arithmetic reasoning and computation. It also covers analogies, perceptual skill, special relations, number series, scrambled sentences, and knowledge of proverbs. The items are arranged in order of ascending difficulty, and the test is scored by counting the number of correct answers out of the 30 items (Spren & Strauss, 1998). The WPT-Q was administered via the Web, by Wonderlic Inc, and scores provided by the Wonderlic staff.

Statistical analysis of the research questions

Hypotheses 1a, 1b, 2a, 2b, 3a, 3b, and 4 all addressed novel problems and the relationship between the modes used to solve problems as well as the independent variables of personality preferences, problem difficulty, current affect or cues in the environment. The dependent variable for these hypotheses was the problem-solving mode, which could have been either rational or insightful. Intelligence was measured and controlled for.

Hypotheses 5, 6 and 7 all address non-novel problems, and explored the relationship between the mode of solution and the independent variables of novelty status, current affect, and personality preferences. While these non-novel problems had their solution mode reported as either rational or insight, operationalization of this study used the characteristics of experiential-based intuition to infer the use of intuition as the solution mode. This inferring of the solution mode had the unintended consequence of removing all variation in the dependent variable,

making the planned analysis of Hypotheses 5, 6, and 7 impossible. This problem was not discovered until after data from Sample 1 had been collected. To rectify this problem, two replacement hypotheses, 5R and 6R, were created and a second sample was collected.

Using SAS (Version 9.2), multiple regression and logistic regression analyses (among others) were performed for each hypothesis to determine the association and relationship between the independent variable and the individual's use of different decision-making modes. These independent variables also were analyzed for collinearity. In addition, chi-square tests were performed to examine the frequency of distribution for the independent variables. A t-test and a chi-square test examined the time to solution for non-novel problems versus novel problems, both as a group and as individual problems.

Has an impasse occurred?

It is likely that some may question how it was possible to know if a participant has reached an impasse. The answer is that no one can be sure. There is no direct way to measure that an impasse was reached, but conditions can be created that are thought to bring it about. The general consensus for reaching an impasse involves working to solve a problem, and being blocked, for instance due to one of several forms of fixation. At some point the problem solver may reach a stage when a feeling occurs that gives the indication that no further progress is possible with the current strategy. (Patalano & Seifert, 1994; S. M. Smith, 1995; S. M. Smith & Blankenship, 1991). Different approaches to evoking impasses have been attempted. One approach that has been taken is to simply interrupt problem solving after a set amount of time, typically 7, 15, or 30 seconds (e.g. Bowden & Jung-Beeman, 2003b; Dodds et al., 2002; S. M. Smith & Blankenship, 1991). Another approach is to simply let participants work on each

problem as long as they desire to do so (e.g. Seifert et al., 1995). Both approaches have shown incubation effects (improved problem solving rates after incubation), an indirect clue that an impasse occurred. Nevertheless, there is no known research to indicate if one approach has an advantage over the other to significantly increase the likelihood of an insightful solution.

For the purposes of this study, working on the problem until the participant desired to stop was impractical. Instead, a more practical method was employed. Thirty seconds is allowed for each problem, and a countdown timer displayed the remaining time. This was done in order to instill a sense of urgency. It was hoped that with these procedures, as time drew short, the feeling of reaching an impasse would be more likely to come to the participant.

Mitigating response bias

In order to minimize the chance for response bias or stereotyped responding, during the orientation session, clear and easily distinguishable examples were given of rational (or search) strategies, and of insight strategies (and the sudden awareness of its Aha! moment). Study procedures ensured that all participants were intuitively familiar with the distinction between these two modes, and all participants were told to make both rational and insightful responses.

CHAPTER 4

RESULTS

These results are presented in two sections. The first section presents the analytical results from Sample 1. Sample 1, with 68 participants, consisted mostly of students enrolled in 100 level classes in the College of Education. The second section presents the analytical results from Sample 2. This second sample, with 98 participants, consisted mostly of students enrolled in 300 level Business and Marketing classes. Both section 1 and section 2 address research questions pertaining to how people make decisions under a number of conditions, such as problem difficulty, varying affect levels, and differing personality preferences. Sample 2 was collected under data collection methods that were revised from Sample 1 in order to reduce methodological complexity and data loss. After Sample 1 had been collected, analysis indicated problems with the research questions pertaining to non-novel decision making. In response, alternative data analysis on Sample 1 was performed, and revised research questions for non-novel decision making were crafted for Sample 2.

The statistical procedures used to analyze this data were primarily linear regression, ANOVAs, and logistic regression. Logistic regression played a large role in this analysis due to the categorical nature of several of the factors collected. The alternative analysis that was performed looked for previously unexpected clustering relationship between factors. To accomplish this, a number of continuous factors were dichotomized and examined with logistic regression. Only the analysis for Sample 2 addresses the revised Hypotheses 5R and 6R. An alpha level of .05 was used for all statistical tests, unless otherwise noted.

Sample 1

Hypothesis 1a: A rational decision-making mode is more likely to be used for novel problems when problem difficulty is low

Hypothesis 1b: An insightful decision-making mode is more likely to be used for novel problems when problem difficulty is high

The decision-making mode reported for these novel problems was coded into two categories of rational (search), and insight (Aha!). Problem difficulty initially had four categories of increasing difficulty, based on Bowden and Jung-Beeman's (2003b) reported percentage of solved CRA problems, as a proxy for difficulty. However, following data collection, it became clear that a number of the CRA problem's percentages solved did not follow the expected solution rates predicted by Bowden and Jung-Beeman. Using the actual percentages of problems solved, from both studies, new problem difficulty rankings were generated and used for analysis.

Both samples had approximately the same number of problems solved per person ($m = 11.1$ vs. $m = 10.8$). When the new solution rates were calculated, several problems moved substantially within the difficulty rankings. Instead of the difficulty rating predicted by the problems author's data, seven problems moved to a higher (harder) ranking, while eight problems moved to an lower (easier) ranking. The original four difficulty categories came from breaking the problems author's percentage of people that solved each problem into four groups, at 25%, 50% and 75%. Instead these four categories, visual examination of the actual solution percentages revealed natural seams of problem difficulty for three categories. The new difficulty categories resulted in six easy problems for 61% to 100% solved, nine moderate difficulty problems for 31% to 60% solved, and twelve difficult problems for 0% to 30% solved.

The 68 participants solved a total of 970 novel problems. Chi-square analysis was used to examine the relationship between the revised problem difficulty rating and the reported mode used to solve problems. This analysis revealed a moderate and significant relationship between problem difficulty and solution mode $\chi^2(2, n = 970) = 16.6, p < .01, \phi = 0.13$. Overall, insight was used almost twice as often (65%) as rationality (35%) to solve novel problems. When novel problems were easy, 73% were solved with the sudden knowing of insight. But as difficulty increased, there was a trend in the data where the percentage of problems solved with insight began to decrease and to shift toward rational solutions. For moderately difficult problems, 63% were solved with insight, and for the most difficult problems, 65% were solved with insight. It should be noted that as difficulty increased, the number of problems solved also decreased.

Logistic regression analysis was used to examine intelligence scores, as measured by Wonderlic, in a possible covariate or mediated relationship with the revised problem difficulty, predicting solution mode. This analysis failed to uncover a statistically significant direct relationship between intelligence and solution mode $b = -0.01(0.06), \chi^2(1, n = 849) = 1.29, p > .10$. The mediated relationship was also non-significant $b = -0.04(0.03), \chi^2(1, n = 849) = 1.64, p > .10$.

Hypothesis 1a predicted that low difficulty problems would be solved with a rational mode. Analysis indicates that this is not supported by the data. Instead of the rational mode predominating for easy problems, it was the insightful mode that was most often used, at a ratio of approximately 3 to 1.

Hypothesis 1b predicted higher difficulty problems would be solved with the insightful mode. While this prediction is supported by the data (55% insight versus 45% rational), a repeated measures logistic regression analysis model, where problem difficulty predicted

solution mode, found a small and significant association, where rational solutions increased as problem difficulty increased $\chi^2(2, n = 970) = 13.3, p < .01, \phi = 0.12$.

Hypothesis 2a: A rational decision-making mode is more likely to be used for novel problem solving when a person is experiencing lower current affect

Hypothesis 2b: An insightful decision-making mode is more likely to be used for novel problem solving when a person is experiencing higher current affect

Current affect was accessed with a seven point Faces measure at four times during the Sample 1 study: At the beginning, after Phase 1, after the lexical task, and at the end. These are named Faces1 through Faces4. PANAS was administered immediately prior to Faces1. Analysis of the relationship between the positive dimension of PANAS and the Faces1 measure indicated a moderate and statistically significant correlation, $r(66) = .34, p < .01$.

All four of these separate affect measures were dummy coded into dichotomous variables, with scores of 1 to 4 coded as low, and 5 to 7 coded as high. As before, the decision-making mode reported for these novel problems was coded as rational (search), and insight (Aha!). Faces 1 and Faces 2 bookend the Phase 1 novel problems, while Faces 3 and Faces 4 bookend novel problems in Phase 2. Therefore, current affect as measured with Faces 1 and Faces 2, was examined for a relationship with the decision-making mode from Phase 1 problems. Affect measured with Faces 3 and Faces 4 was examined for a relationship with Phase 2 problems' solution mode. Chi-square analysis of all four measures indicated a small but statistically significant increase in insight use as affect increased (see Table 4.1).

Table 4.1

Relationship of Affect Measures to Insight Solution Mode

Measures	χ^2	Cramer's V	Low Affect	High Affect
Faces1	6.92	0.12	54.9	67.0
Faces2	15.90	0.18	58.4	78.1
Faces3	16.03	0.18	59.2	76.4
Faces4	9.79	0.14	62.9	77.1

Note: For all values, $p < .01$ and $df = 1$.

As addressed in the discussion of Hypotheses 1a and 1b, the use of insight predominates successful problem solving. This is reflected in the analysis of the relationship between solution mode and current affect measured with Faces1 through Faces4. The greatest proportion of insightful solutions occurred when current affect was highest, and the proportion of insightful solutions fell as current affect became less positive. However, even at the least positive current affect and the lowest percentage of insightful solutions, there were substantially more insightful solutions than rational solutions.

Logistic regression was again used to examine the possible covariance relationship of intelligence with the four Faces measures. Faces1 and Faces2 were examined against the Phase 1 novel problems, and Faces3 and Faces4 were examined against the Phase 2 novel problems. For Faces1 and Faces2 from Phase 1, this analysis found no significant relationship between the intelligence scores and solution mode $b = 0.62(.63)$, $\chi^2(1, n = 441) = 0.98$, $p > .10$, $\phi = 0.05$. For

Faces3 and Faces4 from Phase 2, this analysis again found no significant relationship between the intelligence scores and solution mode $b = 0.66$, $\chi^2(1, n = 408) = 2.57$, $p > .10$, $\phi = 0.08$.

Interestingly, mean current affect measured at four times during the study appears to have responded to the difficulty of the task. To better understand this relationship, a rough measure of task difficulty was developed. Instead of individual problem difficulty ratings, this difficulty rating attempted to gauge the difficulty of the three blocks of tasks (Phase 1 problems, lexical task, and Phase 2 problems). Phase 1 consisted of a series of all novel problems, with problem difficulty from easy to very hard. The lexical task was a simple word/non-word sorting task, and Phase 2 problems contained one third novel problems, along with two thirds non-novel problems that had been seen and possibly solved before. In assigning a difficulty to these task blocks, Phase 1 would be the most difficult. Phase 2 would be less difficult than Phase 1, and the lexical task would be easiest of all.

Using this rough difficulty rating to interpret the observed changes in current affect, participants began with moderately high mean current affect, measured by Faces1. The difficulty of the Phase 1 tasks caused their current affect to fall. As they performed the easy lexical task, their affect recovered. Then the difficulty of the Phase 2 tasks again caused their affect to fall. However, relief from getting to the end of the study caused their affect to recover somewhat. The changes in current affect across the four affect measures gives support to this interpretation. Affect for solved problems began moderately high, $m = 5.0$, $SD = 0.95$, and dropped significantly across Phase 1 problem solving, $m = 3.8$, $SD = 1.2$, $t(969) = 31.1$, $p < .01$, $d = 0.06$. At the end of the lexical task, affect had improved significantly, $m = 4.4$, $SD = 1.25$, $t(969) = -17.1$, $p < .01$, $d = .04$. Across Phase 2 problem solving, affect again dropped significantly, $m = 3.8$, $SD = 1.5$, $t(969) = 11.8$, $p < .01$, $d = 0.02$.

Hypotheses 2a predicted that lower current affect would be associated with more rational solutions, while Hypothesis 2b predicted that higher current affect would be associated with more insightful solutions. There is little direct support for Hypothesis 2a, due to the proportion of solutions at low current affect remaining substantially above 50%, in favor of insight. However, analysis did find that as current affect fell, the proportion of rational solutions increased. Analysis of the data supports Hypothesis 2b and indicates that insight is more likely to be used when affect is higher. As current affect increased, the proportion of insightful solutions increased. In addition, mean current affect appears to have responded to task difficulty by falling as task difficulty increased and rising as task difficulty decreased.

Hypothesis 3a: A rational decision-making mode is more likely to be used for novel problem solving when a person's personality preferences are oriented more toward rationality

Personality preferences were assessed for each participant with Epstein's (1996) Rational-Experiential Inventory (REI). This measure produces orthogonal indices of rational and experiential preferences. In order to explore possible clustering relationships with other factors, both dimensions of this measure were dichotomized using a median split, at 35 for the rational dimension, and 36 for the experiential dimension. Both the dichotomized and non-dichotomized REI dimensions were used in this analysis. The dependent variable for the analysis of these novel problems was the self-reported solution mode of either rational or insight.

This hypothesis addressed only the rational dimension of the REI measure, and chi-square analysis, examining the rational dimension of the REI measure as a predictor of solution mode found no significant relationship between a rational preference and the solution mode, $\chi^2(1, n = 935) = 2.7, p > .10, \phi = 0.05$. Linear regression was also used to examine the relationship

between the percentage of problems solved, by person, that were solved with rationality, and a rational orientation. This analysis found no significant relationship $b = 0.00(0.00)$, $t(56) = -0.75$, $p > .10$, $d = -0.03$. A repeated measures logistic regression model of the proportions between rational preference and solution mode also found no significant relationship $b = -0.00(0.02)$, $\chi^2(1, n = 935) = 0.01$, $p > .10$, $\phi = 0.02$. Examining the frequency distribution of the proportions of high and low rational preference, and reported solution mode revealed that the proportions were opposite to that predicted by this hypothesis. Instead of higher rationality related to more rational solutions, a higher rational orientation was more often associated with insightful solutions (65.76%). In sum, regardless of a person's rational dimension preferences, there was no significant change in the percentage of problems solved with insight.

Additional analysis examined possible relationships between the REI dimensions and other outcomes. A linear regression model was used to examine the rational dimension of the REI measure and the number of correct solutions, per participant. This analysis found that a higher rational tendency was related to solving greater numbers of novel problems $R^2 = .11$, $F(1, 63) = 7.42$, $p < .01$, $d = 0.49$. Logistic regression analysis was used to examine the possible covariance or mediated relationship of intelligence with a rationality preference, to predict solution mode. This analysis found no direct relationship between intelligence and solution mode $b = -0.19(0.16)$, $\chi^2(1, n = 814) = 1.37$, $p > .10$, $\phi = 0.04$. The mediated relationship was also non-significant $b = -0.01(0.00)$, $\chi^2(1, n = 814) = 1.52$, $p > .10$, $\phi = 0.04$.

Hypothesis 3b: An insightful decision-making mode is more likely to be used for novel problem solving when a person's personality preferences are oriented more toward intuition

This hypothesis used the experiential dimension of Epstein's REI. Again the REI dimensions were dichotomized with a median split, at 35 for the rational dimension, and 36 for the experiential dimension. Both the dichotomized and non-dichotomized measure were used in this analysis. As before, the mode of solution for these novel problems was coded as either rational or insight.

Chi-square analysis found no significant relationship between a experiential preference and a solution mode, $\chi^2(1, n = 935) < 0.00, p > .10$. Linear regression was used to examine the relationship between the percent of insightful solutions, by person, and an orientation toward intuition. This analysis found no significant relationship $b = 0.00(0.01), t(56) = -0.09, p > .10, d = 0.00$. A repeated measures logistic regression model examined the relationship between the experiential dimension of the REI measure and solution mode, and found no significant relationship $b = 0.0(0.02), \chi^2(1, n = 935) = 0.02, p > .10$. Examining the frequency distribution of the dichotomized experiential dimension with the solution mode revealed that the use of insight is almost constant, regardless of one's personality preference for experientiality. In both the high and low REI experiential condition, 65% of problems were solved with insight. Logistic regression was used to examine the possible covariance and mediated relationship of intelligence with an intuitional preference, to predict solution mode. This analysis found no direct relationship between intelligence and solution mode $b = -0.06(0.14), \chi^2(1, n = 814) = 0.18, p > .10, \phi = 0.01$. The mediated relationship was also non-significant $b = -0.00(0.00), \chi^2(1, n = 814) = 0.23, p > .10, \phi = 0.02$. Related to the analysis reported under Hypothesis 3a, a higher experiential preference was not found to be associated with a greater number of problems solved $b = 0.01(0.16), F(1, 63) = 3.48, p < .10, d = 0.34$.

While Hypotheses 3a and 3b predicted that there would be a relationship between a person's personality preferences toward rationality and intuition, no significant relationship was found. Higher preference for rationality was found to relate to solving more novel problems, however, no other relationship was found.

Hypothesis 4: An insightful decision-making mode is more likely to be used for novel problems where an initial solution attempt has resulted in an impasse and cues are present in the environment during a period of incubation

This hypothesis examines problems that are encountered a second time, after failing to solve them upon first exposure. It questions whether solution cues in the environment during incubation help produce solutions using an insightful mode.

Of the 195 problems that were solved only after a second exposure to the problem, 61% ($n = 119$) were solved with insight. This is the strong pattern of insight use that has been observed with other hypotheses. Yet, within this statistic concerning insight use, chi-square analysis indicated that there is a significant relationship between a problem's cued condition (whether or not a participant had been presented a solution cue) and the mode used to solve it $\chi^2(1, n = 195) = 6.4, p < .05, \phi = .18$. A repeated measures logistic regression model also found a significant relationship $\chi^2(1, n = 195) = 4.2, p < .05, \phi = .14$, where the probability for the non-cued condition was .67, and the probability for the cued condition was .33. In both the cued and non-cued conditions more problems were solved with insight than were solved with rationality. The proportion of problems solved with insight was higher in the non-cued condition at 73%, and lower in the cued condition at 54%. In absolute terms, the hypothesis is supported because 54% of problems were solved with insight when cues were present. However, this fact belies the

trend in the data, which is away from insightful solutions when cues were present. It is this trend, away from the prediction of the hypothesis, which the statistical analysis has detected.

Additional chi-square analysis found that the presence of cues after unsuccessfully solving problems on the first exposure was significantly related with solving a greater number of these problems at second exposure, $\chi^2(1, n=839) = 7.7, p < .01, \phi = .09$. When not cued, 19% of these problems were solved, but when cued, the percentage of solved problems rose to 27%. However, this conclusion is contradicted by a linear regression analysis that examined counts of solved problems by individual, in relation to their cued condition. This analysis found no significant relationship $b = 1.45(1.54), t(66) = 0.94, p > .10, d = 0.03$. If the presence of cues increases problem solving success, the relationship is weak. A possible covariance relationship between intelligence and cues after an impasse, predicting solution mode was examined with logistic regression and found no direct relationship $b = -0.05(0.05), \chi^2(1, n = 175) = 0.98, p > .10, \phi = .07$.

Hypothesis 4 predicted that encountering solution cues after an impasse would increase insightful solutions. However, there was no statistically significant relationship found between the cued condition and the mode participants reported. For those problems that were not solved after a second exposure, participants strongly reported (80%) that they were trying to use a rational approach when they failed to solve the problem.

Hypothesis 5: An intuitional decision-making mode is more likely to be used for non-novel problems

Hypothesis 6: An intuitional decision-making mode is more likely to be used for non-novel problems solving when an a person is experiencing positive affect

Hypothesis 7: An intuitional decision-making mode is more likely to be used for non-novel problems solving when a person's personality preferences are oriented more toward intuition

Hypotheses 5, 6, and 7 address non-novel problem solving. These are problems that were solved at first exposure, and are non-novel to the participant when encountered again in Phase 2. These hypotheses were derived from an examination of the various literatures, and were intended to examine the relationship between solving non-novel problems and factors such as affect and personality preferences. Later, when this study was operationalized, a decision was made to infer that participants used the intuition mode if the conditions matched the literature's definition of intuitional decisions. This decision was made due to the affective similarity between the sudden knowing on intuition and the sudden knowing of insight's Aha! moment. It was thought that few participants would be able to make such a fine distinction during problem solving. At that time, the principal researcher failed to recognize that this operational decision was at odds with Hypotheses 5, 6, and 7. With these solutions modes now coded as intuition, there was no variation in solution mode.

There were two responses that were undertaken to address this problem. The first was the creation of two new hypotheses that are better suited to the operationalized study, and to collect a second sample. These replacement hypotheses are:

Hypothesis 5R: Solution times are likely to be significantly faster for non-novel problems that are solved a second time

Hypothesis 6R: Non-novel problems will be more likely to be reported as the sudden gut feeling of Aha! when they are solved a second time

The second response was to analyze the Sample 1 data in other ways in order to discover relationships between solution times, solution counts, personality preferences and affect. To facilitate this analysis, new variables, by participant, were created for mean solution times, for non-novel, novel, correct, and not correct problems, as well as the number of problems solved. These variables were then used in statistical models with dichotomized Faces affect measures, and rational (Mdn = 35, SD = 4.8) and experiential (Mdn = 36, SD = 4.6) personality measures.

This linear regression found that a high experiential (intuitional) orientation was significantly related to solving a greater number of non-novel problems $b = 1.38(0.59)$, $t(64) = 2.31$, $p < .05$, $d = 0.07$. In contrast, a higher rational orientation was found to be significantly related to solving a greater number of novel problems $b = 3.25(.99)$, $t(64) = 3.25$, $p < .01$, $d = 0.10$.

Sample 2

This section discusses the separate analyses that were performed on the data from Sample 2. Like the previous discussion, this section addresses the result of analysis performed for each hypothesis.

Hypothesis 1a: A rational decision-making mode is more likely to be used for novel problems when problem difficulty is low

Hypothesis 1b: An insightful decision-making mode is more likely to be used for novel problems when problem difficulty is high

The 98 participants in this sample solved a total of 1221 novel problems. Chi-square analysis indicates that the differences between problem difficulty levels and the solution mode reported by participants was small but significant, $\chi^2(2, n = 1221) = 36.1, p < .01, \phi = 0.17$. Repeated measures logistic regression analysis also found a small and significant differences between problem difficulty levels and solution mode, where increased difficulty was related to a move toward fewer insightful decisions $b = 1.93, \chi^2(2, n = 1221) = 24.3, p < .01, \phi = 0.14$. The probability of an insightful solution was .45 for low problem difficulty, .30 for medium difficulty, and .25 for highest difficulty. As was typical of the data collected in Sample 1, this Sample 2 data also shows an overall pattern where two thirds of the solved problems are solved with insight. Seventy nine percent of easy problems were solved with insight. Sixty four percent of moderate problems and 56% of difficult problems were also solved with insight.

Logistic regression analysis examined the possible covariance and mediation of intelligence with difficulty, in predicting solution mode. However, no direct relationship between intelligence and solution mode was found $b = -0.001(0.05), \chi^2(1, n = 1188) = 0.00, p > .10$. The mediated relationship between intelligence and difficulty, in predicting solution mode was also non-significant $b = -0.03(0.03), \chi^2(1, n = 1188) = 1.81, p > .10, \phi = .01$.

Hypothesis 1a, which predicted that low difficulty problems would be more likely solved with a rational mode was not supported. Only 21% of those easy problems were solved with rationality. Based strictly on the percentage of insightful solution, there was straightforward support for Hypothesis 1b's prediction that higher difficulty problems would more likely be solved with insight. For these most difficult problems, 56% were solved with insight. Yet, a simple rejection of Hypothesis 1a and support for Hypothesis 1b presents an incomplete story. While there was an underlying preference for insightful solutions (from 56% to 79%) at all

problem difficulty levels, the chi-square results previously reported support the observation that as problem difficulty increased, more problems were solved with rationality.

Hypothesis 2a: A rational decision-making mode is more likely to be used for novel problem solving when a person is experiencing lower current affect

Hypothesis 2b: An insightful decision-making mode is more likely to be used for novel problem solving when a person is experiencing higher current affect

As in Sample 1, the Faces scale was used to measure current affect. To check the validity of this measure, it was again correlated against the positive dimension of PANAS. For Sample 2, PANAS was administered immediately before the Faces 1 measure, which preceded Phase 1 problems. The PANAS was also administered immediately following the Faces 4 measure at the end of the study. Correlational analysis indicates a moderate and significant relationship between Faces1 and the first PANAS $r = .42, p < .01$, and between Faces4 and the second PANAS, $r = .56, p < .01$. This provides increased confidence that the Faces measure captured current affect.

All four Faces measures in Sample 2 were dummy coded into dichotomous variables, with scores of 1-4 coded as low, and scores of 5-7 coded as high. Both the dichotomous and non-dichotomous versions of the Faces measures were used in this analysis. Again, the decision-making mode was coded as rational (search), and insight (Aha!).

For Sample 2, these hypotheses examine the novel problems from Phase 1 and Phase 2. Faces 1 and Faces 2 bookend the Phase 1 novel problems, while Faces 3 and Faces 4 bookend the novel problems in Phase 2. No Faces1 analysis was significant. Chi square analysis that used a dichotomous version of the Faces2 measure showed significant differences between current

affect levels, in relation to solution mode $\chi^2(1, n = 699) = 5.6, p = .02, \phi = 0.09$. However, logistic regression using the non-dichotomous Faces2 measure found no significant differences $b = -0.38(0.33), \chi^2(1, n = 699) = 1.40, p > .10, \phi = 0.04$. While chi-square analysis of the dichotomous Faces3 measure was not significant $\chi^2(1, n = 522) = 0.24, p > .10, \phi = 0.02$, the non-dichotomous Faces3 measure was significant for differences in current affect $b = 0.53(0.24), \chi^2(1, n = 522) = 5.03, p < .05, \phi = 0.10$. Chi-square analysis of the dichotomous Faces4 measure showed significant differences between current affect levels $\chi^2(1, n = 522) = 3.94, p < .05, \phi = 0.04$, but logistic regression using the non-dichotomous Faces4 measure was not significant $b = 0.27(0.33), \chi^2(1, n = 522) = 0.66, p > .10, \phi = 0.04$.

Frequency tables for all four faces measures show the same pattern previously seen, where approximately two thirds of the problems that were solved were reported as being solved with insight. The evidence for the effect of current affect on solution mode is mixed. For those analyses that showed significance, at lower current affect the solution mode was less likely to be insightful, and at higher current affect the solution mode was more likely to be insightful, while still remaining predominately insightful. For example, the Faces2 relationship with solution mode shifted toward greater use of rational solutions (66% insightful) at lower current affect, and greater use of insight (74% insightful) at higher current affect.

Logistic regression was used to examine the possible covariance relationship between intelligence and the four Faces affect measures. Faces1 and Faces2 were examined against the Phase 1 novel problems, and Faces3 and Faces4 were examined against the Phase 2 novel problems. However, intelligence showed no relationship with the solution mode of problems from Phase 1 $b = -0.57(0.35), \chi^2(1, n = 680) = 2.60, p > .10, \phi = .06$. Intelligence also showed

no relationship with solution mode for Phase 2 problems $b = 0.38(0.38)$, $\chi^2(1, n = 508) = 1.04$, $p > .10$, $\phi = .05$.

As in Sample 1, the Faces affect measures appear to have captured participant's affective response to task difficulty. Mean current affect began moderately high $m = 5.1$, $SD = 0.92$. It dropped as a result of the high difficulty of the Phase 1 problems $m = 4.1$, $SD = 1.2$, $t(1221) = 31.88$, $p < .01$, $d = 0.05$. It recovered across the easy word sorting lexical task $m = 4.6$, $SD = 1.2$, $t(1221) = -13.87$, $p < .01$, $d = -0.02$, and then across the moderately difficult Phase 2 problems it dropped again $M = 3.8$, $SD = 1.4$, $t(1221) = 24.28$, $p < .01$, $d = 0.04$. The drop across Phase 1 was not as dramatic as in Sample 1. However, using the same rough task difficulty rating that was developed in Sample 1 to interpret the changing current affect levels, people's current affect appeared to change as a result of the difficulty of the tasks they were asked to perform during the three sections of this research study.

The analysis of all four Faces measures indicated that there was no direct support for the Hypothesis 2a prediction of a likelihood of rational solutions at low current affect. There was ample support for Hypothesis 2b's prediction of a greater likelihood of insightful solutions at higher current affect. The mixed evidence from the chi-square and logistic regression analyses appears to indicate that as current affect fell the proportion of rational solution increased, while the proportion of solutions remained predominately insightful. Intelligence did not appear to significantly covary with current affect. Lastly, current affect appeared to respond to task difficulty.

Hypothesis 3a: A rational decision-making mode is more likely to be used for novel problem solving when a person's personality preferences are oriented more toward rationality

Sample 2 again used Epstein's Rational-Experiential Inventory (REI) to assess personality preferences. The rational (Mdn = 36) and experiential (Mdn = 35) dimensions were again dichotomized using a median split. Both a dichotomized and no-dichotomized REI rational measure were used in this analysis. A self-reported solution mode of either rational or insight was collected for each problem.

Logistic regression examination of the prediction expressed in Hypothesis 3a using the dichotomized REI rational measure indicates no significant differences in the REI rational levels $b = 0.11(0.18)$, $\chi^2(1, n = 1221) = 0.36$, $p > .10$, $\phi = .02$. Logistic regression using the non-dichotomized REI rational measure also indicated no significant differences $b = -0.12(0.09)$, $\chi^2(1, n = 1221) = 1.67$, $p > .10$, $\phi = .02$. Linear regression was used to examine a potential relationship between the percentage of rationally solved problems for each person, and the REI rational measure. This was also found to be non-significant $b = 0.00$, $t(86) = -0.02$, $p > .10$, $d = 0.00$. Intelligence was examined for possible covariance or mediated relationships with a personality preference toward rationality, predicting solution mode. The covariance relationship was non-significant $b = -0.01(0.01)$, $\chi^2(1, n = 1188) = 0.18$, $p > .10$, $\phi = .01$. However the mediated relationship was significant $b = -0.01(0.00)$, $\chi^2(1, n = 1188) = 7.33$, $p < .01$, $\phi = .08$.

Hypothesis 3b: An insightful decision-making mode is more likely to be used for novel problem solving when a person's personality preferences are oriented more toward intuition

For Hypothesis 3b, a personality preference for intuition (expressed as the REI experiential dimension) was dichotomously coded with a median split, Mdn = 36. This dichotomized REI experiential measure and the non-dichotomized REI experiential measure were used to analyze this hypothesis. Logistic regression analysis using the dichotomized REI

experiential dimension found small and significant differences between experiential levels $b = 0.34(0.18)$, $\chi^2(1, n = 1221) = 3.70$, $p < .05$, $\phi = 0.06$. Logistic regression using the non-dichotomized REI experiential measure was not significant $b = -0.12(0.10)$, $\chi^2(1, n = 1221) = 1.41$, $p > .10$, $\phi = 0.03$. This same relationship was examined with a repeated measures logistic regression model, and was again found to be not significant $\chi^2(1, n = 1221) = 1.80$, $p > .10$, $\phi = .04$. Linear regression was used to examine a potential relationship between the percentage of insightfully solved problems for each person, and the experiential dimension of the REI measure. This was also found to be non-significant $b = 0.00$, $t(86) = -0.66$, $p > .10$, $d = -0.02$. Logistic regression was used to examine a possible covariance and mediated relationship of intelligence with a personality preference toward intuition, predicting solution mode. This analysis found no direct differences $b = 0.19(0.11)$, $\chi^2(1, n = 1188) = 3.15$, $p > .10$, $\phi = .05$ and no mediated differences in intelligence levels with preference for intuition in predicting solution mode $b = 0.00(0.00)$, $\chi^2(1, n = 1188) = 3.57$, $p < .10$, $\phi = .05$.

Hypothesis 4: An insightful decision-making mode is more likely to be used for novel problems where an initial solution attempt has resulted in an impasse and cues are present in the environment during a period of incubation

Hypothesis 4 examined problems that were successfully solved after an initial solution attempt failed. Participants were randomly assigned to either the cued or non-cued condition, and were presented with solution cues during the lexical task, depending on which condition they were assigned. This hypothesis asks if the presence of a solution cue might influence a participant to use an insightful mode instead of a rational mode the second time they are given a problem. Logistic regression was used to analyze the cued condition with solution mode of either

rational or insightful solutions. This analysis indicated that the differences between two cued conditions was not significant, $b = -0.01(0.33)$, $\chi^2(1, n = 153) < 0.01$, $p > .10$, $\phi = .00$. Linear regression found that, unlike Sample 1, the presence of cues during incubation did not appear to contribute to solving more problem $b = -0.88(1.48)$, $t(94) = -0.59$, $p > .10$, $d = -0.01$.

Additionally, a possible covariance or mediated relationship between intelligence and cues after an impasse was examined with logistic regression. Examination of the direct association was found no differences between intelligence levels and solution mode $b = 0.02(0.08)$, $\chi^2(1, n = 150) = 0.26$, $p > .10$, $\phi = .04$. Examination of the mediated association was also non-significant $b = -0.11(0.10)$, $\chi^2(1, n = 150) = 1.11$, $p > .10$, $\phi = .09$. There is no support for Hypothesis 4. Cues did not contribute to solving more problems, and intelligence had no direct or mediated association with cues.

Hypothesis 5R: Solution times are likely to be significantly faster for non-novel problems that are solved a second time

Differences between the second solution time and the first solution time (deltas) were calculated for each problem solved by each participant. For this new hypothesis, it was critical to first establish the unit of analysis that would enable the hypothesis to be answered with a sufficient level of certainty. The first of the four levels was the individual question level, per participant. Deltas were calculated as the difference in solution time of the second solution, compared to the first solution time for each individual question. A large number of the individual question deltas indicated a much shorter solution time for a second solution. However, many deltas indicated second solution times that were fractions of a second faster or slower, with a few second solutions substantially longer. At this level of granularity, there was no way to answer the

question posed in Hypothesis 5R. However, with the use of a t-test it was possible to say that first and second solution times for the same problem were not statistically equivalent, $m = 5.16$, $SD = 6.8$, $t(659) = 19.57$, $p < .01$. Other levels of analysis were then considered.

The second level of analysis combined all the questions solved by an individual participant. A t-test of each person's differences in solution times (deltas) is included as Appendix I. 62% of the participants had statistically significant reductions in second solution times. However, 9% of the participants solved too few of the problems a second time to calculate statistical significance, and 28% of the participants had reductions in solution times that were not significant. An ANOVA was used to examine the differences in means between the statistically significant and the not significant groups of deltas. This revealed that the differences in proportions between the groups was significantly different from random chance $R^2 = 0.13$, $F(1, 91) = 13.89$, $p < .01$, $D = 0.56$. With 62% of participants showing improvement that was statistically significant (Delta Seconds: $m = 5.9$, $SD = 3.4$), there was an indication of support for Hypothesis 5R, but this level of granularity still left some doubt. Therefore other levels of analysis were considered.

The third level of analysis combined deltas across participants for each question (see Appendix J). At this level a clearer pattern began to emerge. 80% (16) of the problems indicated statistically significant improvement in second solution times. However, four problems' t-test values were not significant at the .05 level, with only one of these not significant at the .10 level. An ANOVA that examined the differences in means between the significant and non-significant groups failed to find significant differences $R^2 = 0.00$, $F(1, 18) = 0.00$, $p > .10$, $D = 0.0$. This is likely due to the non-significant group's small number of solved problems. Though the evidence is mixed, there was some support of Hypothesis 5R, which predicted that second solutions would

be faster than first solutions. However, given the nonsignificance of the ANOVA, and the lack of significance for four problems, some doubt still remained. One more level of analysis was considered.

The last level of analysis combined all the deltas, and gave the least ambiguous and best answer to this hypothesis. There were 659 problems that were solved, first as a novel problem, and then again as a non-novel problem. A t-test analysis indicated that the differences between the solution times (delta seconds) of novel solutions and non-novel solutions was moderately strong and statistically significant ($m = 5.16$, $SD = 6.8$), $t(658) = 19.57$, $p < .01$. Linear regression analysis that compared novel solution times to non-novel solution times was large and significant $R^2 = 0.17$, $F(1, 1879) = 393.32$, $p < .01$, $d = 0.96$. Referencing Table 4.2, additional analysis visually examined the means of the rational and insightful solutions, comparing the novel and non-novel conditions. In general the non-novel solutions means took half the time or less to solve the same problems, compared to the novel condition. Standard deviations were also substantially smaller for the non-novel condition. The statistical significance, and indications that problems were solved faster and with less variation is strong evidence in support of Hypothesis 5R.

Additional analysis investigated the relationship between intelligence and the deltas between first and second solution times. A small positive delta would mean that the second solution was only a little faster, while a larger positive delta would indicate that the second solutions were much faster than first solutions. Any negative delta would indicate that second solutions took longer. For this analysis, the mean delta for each participant was calculated, and a Pearson correlation was run to explore the relationship between participant's intelligence and their mean delta solution times. A statistically significant negative correlation was found

between intelligence and solution time deltas $r = -0.21$, $p < .05$. A regression model of the relationship also found that intelligence significantly predicted second solution time deltas $b = -0.23(0.12)$, $t(88) = -2.01$, $p < .05$, $d = -0.05$. This implies that increasing intelligence correlates with smaller deltas, or that lower intelligence correlates with larger differences between first and second solutions.

Table 4.2

Mean Solution Times

Solution Mode	n	mean	s.d.
Novel Rational	215	14.22	8.22
Novel Insight	484	7.15	4.86
Novel Combined	699	9.34	6.91
Non-Novel Rational	85	7.21	7.03
Non-Novel Intuition	574	3.35	2.47
Non-Novel Combined	659	3.86	3.65

Hypothesis 6R: Non-novel problems will be more likely to be reported as the sudden gut feeling of Aha! when they are solved a second time

In order to determine if non-novel problems are more likely to be solved with the intuition of an Aha! gut feeling, this analysis examined the raw percentages of the solution mode of non-novel problems from Sample 2. It then looked at a comparison to solution percentages of other categories. It must to be noted that this analysis was complicated by the dual meaning of the term Aha!. Participants were instructed to identify an Aha! solution by the phenomenon of

sudden knowing. However, in this analysis, “sudden knowing” applies to the use of *insight* for novel problems, and to the use of *intuition* for non-novel problems.

Nearly 6% of the time, participants failed to solve a non-novel problem that they had solved a few minutes before. However, when participants did solve non-novel problems, 87% of the time it was reported as having been solved with the intuition of an Aha! solution. 13% of the time they reported solving it with a rational solution. Chi square analysis of the reported solution mode for these non-novel problems found a large and significant difference between the two solution modes $\chi^2(1, n = 659) = 362.85, p < .01$.

Comparing the trends in solving novel problems to solving non-novel problems, the use of intuition’s sudden knowing increased dramatically from 68% for novel solutions, to 87% for non-novel solutions. Interestingly, some people still reported using a rational approach, even though they had solved the same problem a few minutes before. Additional analysis investigated the possible covariate relationship with intelligence, predicting the reported solution mode for non-novel solved problems. Logistic regression was used to examine this possible relationship, and no significant differences were found $b = 0.01(0.03), \chi^2(1, n = 640) = 0.08, p > .10, \phi = .01$.

Hypothesis 5R predicted that non-novel solutions would be more likely reported as sudden knowing, and there was significant evidence to support that prediction. There was also evidence that this pattern in non-novel problem solving was different from the pattern observed in solving novel problems.

Table 4.3

Percentages Reported as Solution Mode

Problem Type	Sudden Knowing	Rational	Cumulative
All	42%	58%	38.4%
Novel Solved	68%	32%	29.1%
Non-Novel Solved	87%	13%	94.3%

Other Analysis

Acknowledging the value of the alternative analysis that was performed on Sample 1, the same analysis to look for clustering and unexpected relationships was performed on Sample 2. The relationship between a greater intuitional orientation and solving a greater number of non-novel problems was not found. The weak relationship between a greater rational orientation and not solving problems was also not found. Unlike Sample 1, linear regression analysis that examined the relationship between an intuitional orientation and solving a greater number of novel problems found a significant relationship $b = 0.34(0.15)$, $t(94) = 2.23$, $p < .05$, $d = 0.05$.

Intelligence

There was no formal hypothesis concerning IQ, even though it was included in this research as a control, and on the chance that it might be useful in predicting different problem solving strategies. It was not surprising that higher IQ, measured by Wonderlic, was found to correlate with an overall shorter time to take the survey, $r = -.35$, $p < .01$, and with solving greater numbers of novel, $r = .27$, $p < .01$ and non-novel problems, $r = .27$, $p < .01$. In Sample 2, a small yet significant negative correlation was found between IQ and the time to solution, $r = -0.08$, $p < .01$. In regard to Hypothesis 5R, intelligence was found to be related to smaller

differences between novel solution times and non-novel solution times for the same problems. No relationship was found between IQ and the use of any mode of problem solving.

Lexical task

The lexical task was scored ($m = 55.1$, $SD = 4.8$, Range 37-60, $CI = 54.17 - 56.10$) in order to give an indication of participants who were not taking the task seriously, and simply clicking random answers in order to finish quicker. The lexical task score did not correlate with the number of problems solved or the time it took to complete the study. A t-test found that the mean number of lexical problems solved was statistically different from random chance $t(97) = 51.74$, $p < .01$, $d = 1.07$. Since there was no evidence that participants had not taken the survey seriously no participants' data was removed.

CHAPTER 5

DISCUSSION

The purpose of this research was to increase the understanding of decision making, by searching for evidence of three phenomenologically distinct modes of decision making, and to explore the factors that are related to, or that influence the use of particular modes. Specifically, this research searched for evidence of a rational mode, an intuitional mode, and an insightful decision-making mode. The factors of problem novelty, solution cues, problem difficulty, personality preferences, intelligence, and current affect were examined in relationship to self-reported solution mode, time to solution, solution correctness, and number of problems solved. Analysis has indicated that there is evidence of three phenomenologically distinct decision-making modes, and that some hypotheses were supported, while other hypotheses were not supported. In addition, this research revealed a previously unknown bias in people's modes of decision making, and unexpected trends that emerge as decision-making conditions change. This discussion is organized into somewhat discrete categories where the findings are interpreted and the theoretical significance of these results is discussed.

Insight Bias

Before beginning the discussion and interpretation of the various hypotheses put forth in this research, it is important to discuss an unexpected finding. While a search of the literature has so far failed to find this pattern in previous studies, this research found a strong and possibly overwhelming bias in the mode used to solve novel problems. In both studies, when a novel

problem was solved, two thirds of the time it was solved with insight. This is contrary to the overall trend for all problems (solved and unsolved), where the rational mode was dominant. From an analysis point of view, this strong bias toward intuition is like an ocean current, and the factors intentionally designed into this research are like a wind or a breeze blowing across its surface. While some of the intentional factors had moderate to strong significant relationships to the solution mode, the underlying bias toward insight was much stronger. This means that any predicted changes or patterns in the solution mode for novel problems brought about by relationships to other factors, if they existed, were shifted strongly toward insight. Efforts were made to prevent any bias, such as this, from being introduced as a result of methodological errors. During the orientation process before each study, procedures were used to ensure that there was no bias for an Aha! solution over a Search solution due to demand characteristics. Verbal and written instructions described both types of solutions, and it was emphasized that both were valid ways to solve problems.

As mentioned, no known research has addressed a bias toward insight. However, in a personal communication with Mark Beeman, one of the CRA problem's authors, he indicated that in his research with these problems, people have reported insightful solutions approximately 60% of the time. In other possibly related research, Allinson (2000) found that people frequently bypass rational problem solving for problems that are difficult or novel. Because the problems presented to participants were certainly difficult and novel, this explanation may apply here. However, the insight bias was not found in the mode of problems that were not solved. Instead, for unsolved problems there was a bias toward rationality.

As another possible alternative explanation for the insight bias, Kounios and Beeman (2009) addressed the question of why problems are sometimes solved insightfully, and

sometimes analytically. Through the use of functional MRI (fMRI) they examined the patterns of brain activity preceding problems solved both insightfully and rationally. Their research suggests that the pattern of brain activity already present when a new problem is displayed may impart a bias, and may increase the chances that the current problem will be solved in the same way as the previous problem. When this possible explanation is examined in light of the design of this current research, a potential explanation arises. This research presented participants with 30 novel problems in rapid succession, 20 in Phase 1, and 10 more mixed into 20 non-novel problems in Phase 2. After solving the first few problems, participants may have been mentally preparing to solve "...upcoming problems with insight by directing attention inward--priming for lexical-semantic processing and the detection and retrieval of weakly activated potential solutions..." (Kounios & Beeman, 2009, p. 212).

The insightful bias may possibly have come from people's predisposition toward solving problems in ways that make them feel good, while using as little cognitive energy as possible (Chaiken, 1980). A rational solution would require a somewhat laborious effort to try words, over and over until a solution is found. Such a solution through rational means is likely to be less affectively pleasing, because it would not be cognitively informed, or have affective valence (Kahneman, 2003). In contrast, an insightful solution's gut feeling may be more affectively pleasing, while also being more cognitively energy conserving (Epstein, 2006; Iran-Nejad & Gregg, 2001).

Considering the cognitive energy demands of solving these problems may provide another potential explanation for the insight bias. Because of the affective similarities between intuitional and insightful problem solving, the same human tendencies that drive people to

attempt intuitional solutions first (Bowden & Jung-Beeman, 2003a; Epstein, 1990) may also have driven people to attempt insightful solutions over rational solution.

A final possible explanation for the insight bias may come from examining the methods of the study and seeing the series of problems and the time pressures of the 30-second countdown clock as a high-pressure environment. A number of research articles claim that time pressures like those used in this study have the effect of increasing rapid decisive decision making, and tending to discourage elaborate analysis (Allinson, 2000; Allinson & Hayes, 1996; Mintzberg, Raisinghani, & Theoret, 1976).

Most of these potential explanations only address the bias for insight in solved problems. However, when all solved and unsolved problems are examined, a bias in favor of the rational mode was found. If time pressures or any of these other possible explanations were the cause of the insight bias, then insight would have also emerged as the dominant mode of the combined solved and unsolved problems. It may be that the problems presented to participants, under the high-pressure conditions in this research, were more likely to be successful solved with insight. Other problems and different study methods may create conditions where a rational approach is more likely to succeed. In that case, a rational bias in solved problems may be found.

If the insight-bias for solved novel problems found in this research holds up to scrutiny, it may give further credence to an abundance of past research that has found that business executives are prone to rely on their intuitions most often, especially in high velocity environments (e.g. Allinson, 2000; Andersen, 2000; Bourgeois & Eisenhardt, 1988; Dreyfus & Dreyfus, 1986; Mintzberg & Westley, 2001). While much of the past decision-making research has either been field studies or was qualitative, this current quantitative research may provide a path to additional rigor in the study of decision making. There are notable similarities between

the conditions of this research and high-pressure business environments where deadlines and time pressures are common, and many decision are either novel or repetitious. When one considers the traits that are shared between insight and intuition, it is easy to imagine a business executive who has a broad and extensive knowledge base, feeling comfortable making non-novel decisions reproductively with intuition, and novel decisions productively with insight. This executive may naturally have a decision-making bias for insight, but may not even be actually aware that a particular problem is novel or non-novel. He may simply trust in what he thinks is his intuition to enable him to make decisions accurately and rapidly. Further research is needed to establish whether the insightful bias is more than an artifact of the methods used here. There is also a need to investigate the causal mechanisms behind the bias toward insight in novel problem solving that this study uncovered.

Problem difficulty

Problems for use in this research were randomly selected to represent a range of problem difficulty, from easy to hard. This difficulty rating was based on the norms provided by the problem's authors (Bowden & Jung-Beeman, 2003b), and used the percentage of people that typically solved each problem as an indication of difficulty. During the analysis of the data from both samples, it became apparent that several of the problems' difficulty ratings were not performing as expected. Initial analysis with the original difficulty ratings found little or no relationship between difficulty and the dependent variables. Many of the problems' original solution rates were close to the expected rates; however, several problems' rates were significantly different. This is likely due to the participants' lack of familiarity with the compound words that are generated in solving these problems. Similar to the way that Mednick's

(1964) original RATs no longer have currency due to the lack of modern usage of his terms, problems that performed unexpectedly are likely due to changes in the currency of some words with the population from which the sample was drawn. Using the actual solution rates from the combined samples, new difficulty ratings were calculated and assigned to one of three difficulty levels. When the analysis was revisited with the new difficulty ratings, a number of significant or surprising relationships were revealed, including a strong relationship with the solution mode. Taken together, Hypotheses 1a and 1b reflected an interpretation of the literature regarding accessibility of solutions and cognitive remoteness. This interpretation predicted that hard problems would more likely be solved with insight because people would bypass rationality (Allinson, 2000) and because of the cognitive remoteness of the solution (Yaniv et al., 1995). Since the literature was somewhat ambiguous about how easy problems would be solved, Hypothesis 1b, regarding easy problems, was an extrapolation from the literature regarding harder problems.

The pattern that emerged from the analysis of the data tells a story very different from that predicted by Hypotheses 1a and 1b. Participants solved over three quarters of the easy novel problems with insight. Then, in a trend that was opposite to that predicted in these hypotheses, as difficulty increased, the percentage of insightful solutions declined. Yet, even at the highest difficulty level there were significantly more insightful solutions than rational ones.

This unexpected trend toward increased rational problem solving when difficulty increases is certainly contrary to the implication that one may draw from previous research. For example, Allinson (2000) claimed that rational problem solving will be bypassed when problems are difficult or novel. Kaplan and Simon (1990) clearly related a problem's difficulty of being restructured to the sudden comprehension of the Aha! experience (insight). Kounios et al. (2006)

also saw the sudden illumination of insight as necessary for solving difficult problems. Lastly, Metcalfe and Wiebe (1987) appear to relate problem difficulty to the emergence of sudden illumination, at least for problems requiring insight. Again, a natural bias toward insightful solutions for novel problems, as found here, may provide some explanation for those previous findings. However, overlaying that bias is the trend toward more rational solutions as difficulty increased. This trend may be indicating that people prefer the experience of insightful problem solving, but when insightful approaches appear to be failing in high velocity environments (time pressure) people will turn to rational approaches for help (Schooler & Melcher, 1995).

There was one unsurprising finding in the analysis of difficulty. When problems were easy, people solved more of them, and when problems were hard, people solved fewer of them. In addition, a surprising result also emerged. A natural inclination would be to think that easier problems would be solved faster, while harder problems would tend to take longer to solve. This was not the case. An examination of the relationship between difficulty and solution times for novel problems found that there was little difference between mean solution times for easy problems and hard problems. A post-hoc re-examination of the normative data from Bowden and Jung-Beemans's (2003b) CRA problems confirms these results, that there was little relationship between problem difficulty and solution time. For these novel problems it appears that achieving the sudden knowing of an insightful solution takes about the same time for hard problems as for easy problems.

Affect

Mood or affect is frequently mentioned as a factor that influences how decisions are made. Hypotheses 2a and 2b are an interpretation of the substantial amount of theory and

research that predicts that at higher affect levels people will tend to be more insightful in their decision making, and at lower affect levels people will tend to be more rational in their decision making. This analysis looked at the relationship between the current affect that was measured immediately preceding and following blocks of problems, and the self-reported mode used to solve novel problems. As predicted, a higher affect level was significantly associated with a greater likelihood of insightful decisions, and when affect fell, the trend in the data showed an increased likelihood of a rational decision. However, the bias in insightful problem solving again complicates interpretation. Even though the likelihood of rational decision increased with lower affect, insightful decisions were still more likely.

The shift toward rational decisions at lower affect levels is not surprising, but it was overwhelmed by the intuitional bias for novel problems. Like difficulty, the data appears to be implying that people tend to prefer to use insight for novel decisions when they are under pressure. When their affect is high they may be more distractible. They may be more likely to broaden their perceptual focus, or to find the more remote association that is typical of insightful decision making. Then when their affect is low, they may be less distractible, and better able to focus. They may be less likely to grasp the semantic coherence of remote associations and to fall back on a rational approach. Thus, they would show an increased tendency to use a rational approach.

An unplanned relationship concerning affect and difficulty also appeared in the affect data. Individuals' reported affective response to the difficulty of the task was not surprising in hindsight. During the analysis of the changing current affect levels across the four measurements in this study, the rise and fall of mean affect sparked the question of what might be causing these changes. A rough task difficulty rating was developed for the task blocks between the affect

measures. This rating was used to interpret the observed changes in mean current affect that was measured by the Faces scales. A comparison of affect to difficulty indicated that mean affect appeared to respond to task difficulty. When the effort required to solve a group of problems was higher, affect fell. When the effort required to solve a group of problems or sort character strings was lower, affect rose. Simple fatigue was considered in an attempt to find an alternative explanation for the rise and fall of affect. However, if fatigue were the source of the changes in affect, the pattern seen would have been one of steadily falling affect levels. Although that is not what the data showed, fatigue cannot be ruled out as a covariate.

This unplanned affect/difficulty finding appears to include a causal direction, where affect changed in response to the difficulty of the activity. This very rough analysis needs additional research to explicitly explore the relationship between task difficulty and resulting affect.

Personality preferences

There is a common impression that individual personality preferences have an influence on the way people solve problems and make decisions. Hypotheses 3a and 3b were crafted to explore this influence between a personality preference and decision-making mode. A number of personality measures were considered for this research, and the REI measure by Epstein et al. (1996) was chosen, largely due to the independent nature of its rational and intuitional dimensions. Analysis of both Sample 1 and Sample 2 found no relationship between a personality preference toward rationality or intuition, and solution mode. As in the earlier discussion, the bias for insightful decision making was evident, with a near-constant 66% of novel decisions made with insight, regardless of personality preferences.

In hindsight, the time pressures on decision making, the count-down clock on screen, and the long stream of often-difficult CRA problems in this study are likely to have contributed to finding no relationship with personality preferences. It may be fruitful to conceive of personality preferences in high-pressure environments as expendable decision-making luxuries, which are ignored when the pressure is on, or which may be expressed when the circumstances permit. If true, factors such as the speed that a decision must be made, past experience with the type of problem, and the breadth or depth of one's knowledge base may preempt the expression of one's individual preference for intuition or rationality. Future research into the relationship between personality preferences and solution mode may consider varying the time allowed to solve problems or other problem circumstance to obtain a better understanding of the role of personality in decision making.

Solution Cues

After mentally engaging a problem and having failed to find a solution, theory predicts that people become subconsciously sensitized to potential solutions that they might encounter in their environment. Hypothesis 4 is an interpretation of this theory, and predicts that if a solution cue is encountered, it may emerge as an insightful solution (suddenly knowing) if the problem is encountered again (P. I. Ansburg & Hill, 2003; Seifert et al., 1995).

Only in Sample 1 was there a small and significant relationship between the presence of cues and the solution mode. The relationship, however, was opposite of the hypothesized prediction. The non-cued condition was most strongly associated with insight and the cued condition was associated with an increased percentage of rational solutions. Yet, the percentage of insightful solutions was still predominant, which complicates an interpretation of this finding.

If this association between cues and increased rational solutions is more than simply an artifact of this one sample, a possible explanation may be to consider this relationship as being the result of increased activation of the solution word (P. I. Ansburg & Hill, 2003). If true, the solution words would be more activated and more accessible due to participants having seen them during the lexical task (Bargh & Pietromonaco, 1982). It would then be more likely that a cued solution word would come to mind when a rational search for a solution is used.

Secondary analysis looked at a related question. Did the presence of solution cues help people solve more problems that they had failed to solve the first time? Again, only in Sample 1 was there a significant relationship, where solution cues encountered after an initial failure helped increase the number of solved problems. While some of the literature on opportunistic assimilation predicts that cued solutions will be solved creatively with insight (P. I. Ansburg & Hill, 2003; Chaiken, 1980), some of this research simply addresses how the increased activation from cues may help solvers reinterpret a problem (Bowden & Jung-Beeman, 2003a), or how cues may help when a search strategy is used (Dorfman et al., 1996). This secondary finding should be seen as supporting the theory of opportunistic assimilation (Seifert et al., 1995).

In summary, cues were related to the use of a rational solution mode (opposite to the theory), and to increased problem solving after an initial failure to solve problems. It is difficult however to claim strong support because the relationships were found in only one sample. Perhaps the weak evidence for cues is related to the problem of knowing if a person really reached an impasse. Further research may help identify impasses, or uncover the unknown factors that prevented the relationships from being found in the second sample, and answer the question of why the relationship with cues was only found with a rational solution mode.

Alternative Analysis

When the original Hypotheses 5, 6, and 7 were replaced, a decision was made to explore alternative analysis paths in an attempt to discover any significant relationships that had not been previously considered. The short list below outlines the only statistically significant findings that were discovered.

1. Only in Sample 1, a personality preference more oriented toward intuition was related to solving a greater number of non-novel problems
2. In contrast, in both samples a personality preference oriented toward rationality was related to solving a greater number of novel problems.
3. Only in Sample 1, a strong rational orientation was related to failing to solve greater numbers of problems.
4. In both samples, higher IQ was correlated with shorter overall survey times, with solving greater numbers of novel and non-novel problems, and with smaller differences between first and second solution times for the same problems.

The first three of these findings appear to present mixed messages. If a person trusts intuition, it would be normal to think that he or she would be better at solving the non-novel problems that are best solved with intuition. Alternatively, a person with a strong preference for rational thinking would seem to be a poor candidate for solving greater numbers of novel problems. Yet, this same preference for rational thinking was also found to correlate with failing to solve a greater number of problems.

A fruitful way to make sense of the first two seemingly contradictory findings may be to imagine anyone who is strong in either or both of the two independent personality dimensions, rationality and intuition, as simply more able and likely to solve problems. The third significant relationship may possibly be understood when seen from the perspective that these problems are often best solved with insight, where a strong preference for rational thinking would naturally lead to a larger number of unsolved problems. Still, finding 3 and finding 2 are logically at odds. Since findings 1 and 3 were only found in one sample, a healthy level of skepticism is warranted until further research can explore the relationships further. Finally, the least surprising outcome is the finding that people with higher IQ solved more problems and solved them faster. Finding 4 simply confirms several expectations of more intelligent people. They are more likely to solve more problems, and complete tasks faster than those who are less intelligent. They also show less improvement in problem solving speed, from first to second solution. One can easily imagine someone who is less intelligent struggling for a longer time on a novel problem, and then responding quickly the next time the problems is encountered. However, the more intelligent person would solve a novel problem faster, and the solution time of the second exposure to the problem would show less improvement.

Non-novel Problems

This section concerns the findings for the replacement hypotheses, which address non-novel problems. These are problems that were previously solved when they were novel, and then after an incubation period, people were given another opportunity to solve the same problems. The replacement hypotheses, 5R and 6R, explored the evidence for a separate and distinct intuitional mode of decision making. Specifically, intuitional solution times for decisions

on non-novel problems were expected to be faster than solution times when the problems were novel. Secondly, intuitional decision should be experienced much like insightful decisions due to two shared characteristics. Intuition and insight are both affectively informed, and they are both experienced as a feeling of sudden knowing. An Aha! feeling of sudden knowing was interpreted as insight for novel problems, and as intuition for non-novel problems. These non-novel problems only occurred in the second phase after having solved the same problem in Phase 1.

Faster non-novel intuitional solutions

As stated in Hypothesis 5R, there was no explicit or implied level of analysis. The literature only stated that intuition was fast (e.g. Epstein, 1990). However, a number of unexpected items in the data appeared to go against the expectation of speed. Therefore, the proper unit of analysis had to be resolved in order to answer Hypothesis 5R. Four units of analysis were considered, where the analysis at each level gave increasing confidence that intuitional solutions were faster than novel solutions. At each level the data was analyzed from a different perspective, or at a greater level of aggregation. At each level, the analysis gave stronger indications that the time differences between second solutions and first solutions were statistically different from random chance. In the end, a less ambiguous answer about second solution times for non-novel problems came from combining the solution time differences for all second solution times, for all problems and all participants. This analysis indicated that solution times for second solutions were significantly faster than first solution times. This also provided the first of two important pieces of evidence that intuitional decisions are distinct from rational and insightful decisions. Second solutions were faster than first solutions.

As mentioned, there were a number of individual cases that appeared to go against the trend of faster second solution times. One has to ask why would a person who solved a problem at the first exposure, fail to solve the same problem the second time it was seen, or why would a person who had already solved a problem take much longer to solve it a second time? To answer these questions one may consider the procedures of the study. Participants in this study were asked to solve a significant number of often-difficult problems in rapid succession, with a timer on screen to provide pressure to solve problems as fast as possible. In addition, the study's procedures did not confirm if a solution that a participant entered was correct. Some people may have simply guessed at a solution at first exposure and the mental association between problem and solution would not have been formed. It is also easy to imagine that mental fatigue or simple distraction may have played a role in creating longer second solution times or missed second solutions.

Intuition perceived as sudden knowing

After establishing the novelty status of these problems, this analysis examined problems that were non-novel, and were reported as solved with an Aha! feeling of sudden knowing. Results indicated that solved non-novel problems were solved at a very high success rate, and were overwhelmingly solved with an affectively informed sudden knowing that is interpreted as intuition. As the second piece of evidence that intuitional decisions are distinct from rational and insightful decisions, this result was not surprising.

Implications for intuitional decisions

When people solve problems that they have solved before, they draw upon the associations that they established when they solved them the first time. The result of these associations is that the percentage of problems that are successfully solved jumps dramatically to over 90%. Solution times are likely to be significantly faster, and are very likely to be experienced as a gut feeling of sudden knowing. Conversely, when participants chose to solve one of these non-novel problems with rationality, solution times were longer, and solution rates fell.

Perhaps the most surprising finding for non-novel problems is that 5.7% of the problems that had been solved before were not solved when they were presented a second time. One speculation is that these participants failed to form an association between the problem and its solution because they had only guessed (albeit successfully) at a solution when first exposed to the problem. Because the procedures of the study provided no confirmation of a correct solution, they would not have known they had been successful.

Another surprising outcome is that 13% of the non-novel problems that were solved again were solved with a rational approach, instead of the expected intuitional approach. Analysis found no support for a possible relationship between a strong rational orientation and the use of a rational solution mode for non-novel problems. This finding goes along with the earlier finding for novel problems that personality preferences were not related to solution mode. One speculation for these rational solutions is that as participants began work to solve these problems, they began with a rational approach. The increased activation of the solution word from the earlier phase brought the solution to mind as they were working through possible solutions.

Summary

This research explored many aspects of decision making. Some of the results confirmed expectations and the supporting theory, while other results defied expectations or went against the supporting theory. Sometimes there were unexpected trends or relationships discovered while looking for other relationships. In other cases, a better understanding of what was found came through hindsight instead of the plans based on theory or logic.

The primary goal of this research was to find evidence of three phenomenologically distinct modes of problem solving, and this goal was met. Through overlaying theory from several domains, this research was expected to find frequency-of-use, speed-of-solution, and success rate differences in all three problem solving modes. Similarities between modes were also expected, related to how some modes were experienced.

Evidence for a distinct rational mode was found. Rational problem solving was the slowest and the least frequently used mode for successfully solving novel problems. One third of successful problem solving attempts reported finding a solution through rational means. However, it was the most frequently used mode when solution attempts failed. People appeared to increase their use of rational problem solving as current affect fell and as problem difficulty increased. The probability of solving a novel problem in this study with rationality was the lowest of the three modes, at 9%.

The distinctiveness of insight also emerged from the data. Insightful problem solving, on average, took half the time of rational solutions to solve novel problems. It was by far the most frequently used mode for successfully solving novel problems. Two thirds of successful solutions came as a result of insightful problem solving. Its influence was so strong that it may have overwhelmed other factors in influencing the solution mode that was used. When problem

difficulty was low, people's use of insight was most frequent. Even though people increased their use of rationality as difficulty increased, at the highest level of difficulty insightful solutions still predominated. As current affect increased, people were more likely to have used insight. Insightful solutions took approximately half the time of rational solutions, and the probability of solving a novel problem with insight was twice that of rationality, at 20%.

Distinct evidence for the third mode, intuition, also emerged. Intuitional problem solving for non-novel problems was the fastest of all problem-solving modes. On average, intuition took half the time of insight to solve problems, or one quarter of the time of rational problems. The experience of intuitional problem solving shared the affectively informed gut feeling of sudden knowing with insightful solutions. In this study, when a problem was non-novel and intuition was used, the probability of it being successfully solved increased dramatically to 82%.

The literature contains many examples of the conflation of insight and intuition. Some of this confusion likely comes from the affectively informed shared trait of sudden knowing. It is possible that in many conditions insight may appear indistinguishable from intuition due to their functional and affective similarities. These similarities are also the likely reason that so much prior research has tended to conflate them.

While many of the findings about the three modes were expected, there were some unanticipated outcomes. The literature had given this research the expectations that rational solutions would be slow, fast to respond to changes, and success dependant on the quality of the process. Intuitional solutions would be fast, slow to respond to changes, and success dependant on the depth one's knowledge and experiences. Insightful solutions would be sudden, and success dependant on many factors, including one's breadth of experience. However the dramatic differences found between the speed and success rates of the three modes was

unexpected. As a result of this research, under circumstances that could be called high pressure or high velocity, it is now possible to quantify the relative speed and accuracy differences between rational, insightful and intuitional decision making. The implication is that if you need speedy and accurate decisions, work to make them reproductive. If you need creative solutions to novel problems, they will be faster and more accurate if you look for insights than if you devise a rational approach to a solution. The dual mode models of decision making that are found in the earlier literature seemed to be missing explanatory power for some aspects of human decision-making. Together, these three distinct modes of decision making make up a better model of human decision making.

This research also found strong unexpected biases in the solution mode results. When novel problems were solved, two thirds were solved with insight. When participants failed to solve novel problems, there was a bias in favor of rationality. No known prior research has reported such strong biases, but the best speculation about their causes is related to the nature of human decision making under pressure.

The literature concerning problem difficulty lead to the expectation that rationality would be bypassed, and insight used when problems were hard. Instead, this research found a decrease in insightful solutions in favor of more rational solutions as difficulty increased. This was an unexpected finding that may be related to the high-pressure or high-velocity methods used. At the time that this study's methods were planned, the 30-second time limit, and the series of repeated problems were not considered high pressure. Thirty seconds, the longest time given to other participants in prior research using these CRAs, was thought to be generous in order to evoke reaching an impasse. However, after observing participants and talking to them afterward, it is now clear that they were working hard and were under pressure. This was even more evident

in conversations with participants for which English was a secondary language. It is also possible that prior research failed to detect a move toward rational solutions at higher difficulty due to a strong bias for insight. Further research is needed to explore this unexpected finding with study methods that reduce the pressure on participants.

There is strong and consistent literature regarding the effect of a person's affect on how they make decisions. Unlike some other factors, affect had the influence on solution mode that the extensive prior literature had predicted. More positive affect was related to greater use of insight, and less positive affect was related to greater use of rationality. While this outcome was not surprising, another finding was unexpected. Post hoc analysis using a rough gauge of difficulty for the task blocks in this study found that people's affect rose and fell in response to task difficulty. It is easy to imagine a participant's current affect falling as they worked through difficult problem after difficult problem, and their current affect rising when the task became easier. There are certainly many job related implications to both findings. Certainly managers should keep task difficulty and its interaction with affect in mind when designing job duties.

The theory concerning incubation, impasses, opportunistic assimilation, and cues in the environment is not at all cohesive. The methods employed in this research were pieced together from several lines of research. However, there was an expectation of a larger effect from planting cues in the environment during the incubation period. Cues did help increase the number of problems solved after an initial failure, and they had a small, one-sample influence on solution mode. Unexpectedly, the relationship to solution mode was opposite to what was expected. These results were not very strong and certainly were not conclusive. There was acknowledged uncertainty regarding the ability of this study's methods to evoke an impasse. It is possible that these unexpected results are related to a failure of the methods to elicit impasses. Other options

need to be investigated for modifying the methods of this research so that cues and incubation effects might emerge more clearly from the data.

A sizable amount of prior research has addressed the effect of personality preferences on how people make decisions. Based on this research, there was an expectation that people's independent personality preferences for rationality and intuition would be related to how they made decisions. However, this was not the case. Unexpectedly, this factor had the least amount of influence on solution modes of any factor in this research. The differences in solution mode ratios across the personality preference dimensions never changed. On the other hand, strong personality preferences were related to solving more problems. One possible explanation for these odd findings is to think of strong rational and intuitional preferences as being related to a person's self efficacy or willingness to trust in the dimension in which they are strong. An individual with strong belief in his or her problem-solving ability is more likely to solve problems than someone with a low self-worth. Under the high-pressure procedures of this research, those same preferences would be an expendable luxury that is ignored in the push to get problems solved in time. Future research using less intense methods is needed to explore the influence of personality. Hopefully, when the pressure is lower the effect of personality can be seen.

There were no expectations about the influence of intelligence on decision making. The literature was inconclusive, so it was decided to include a measure of intelligence in order to control for it. There was no relationship found between intelligence and any of the dependent factors, with the exception of solution speed and number of problems. Those with higher intelligence were able to complete the survey in shorter time. They solved more problems, and their first and second solution times for the same problem were closer together. One

interpretation of this finding is that the highly intelligent were already fast when they solved the problem the first time, and they did not show as much solution time improvement in their second opportunity to solve the problem as less intelligent people. For those who are less intelligent, it shows that experience is a powerful way to overcome the differences in performance between themselves and the more intelligent. While these findings are interesting, they are not surprising.

Limitations and confounds

This study was confined to undergraduate students. Sample 1 came predominately from students enrolled in a 100 level course in the College of Education. Sample 2 came predominately from students enrolled in 300 level courses in the School of Business. The two studies were administered in reserved university computer labs, across multiple sessions on multiple days. For Sample 1, the Wonderlic IQ measure and REI personality measures were self-administered through the participant's own computer, prior to arriving for the main study. However, for Sample 2, these measures were combined into one session with the main study. Wonderlic administered the Wonderlic IQ test online. The survey was created online, and administered online through the Qualtrics survey tool. During all eight data collection sessions approximately 40 incidents occurred where the web browser client failed to remain in contact with the Qualtrics web server. The browser would time-out while waiting for a signal from the server. Restarting the browser would pick up the survey where it had stalled. Although extensive effort was expended trying to stop this problem, it continued across all the eight sessions. The effect of these stalls on the data that was collected is unknown, but thought to be negligible.

This study used self-reports to capture the solution mode from the ephemeral moment that people solved problems. Efforts were taken to mitigate any problems with self-reports by

collecting the mode of solution proximal to the event. Even though there is likely a natural tendency to view insight more favorably than rationality, efforts were also taken to reduce demand characteristics for reporting more insight use. There was also a concern that participants would be unable to consistently distinguish between the sudden knowing of insight for novel problems, and the sudden knowing of intuition for non-novel problems, due to their affective similarity. Therefore an operational decision was made that all sudden knowing was to be reported as Aha!. During analysis, insight was distinguished from intuition by the novelty status of each problem, and by the speed of solution times.

A stated goal of this research was to understand the distinct decision-making modes that people employ in their everyday lives. Admittedly, this research was a laboratory study, and there are limited comparisons to everyday life. However, people do make rational decisions, reproductive intuitional decisions, and creative insightful decisions throughout their normal daily activities. Instead of a separation of the modes as in this research, it is plausible that many real-life decisions are more complex and contain a blend of all three modes; a little rational, mostly intuitional, and the occasional insightful when one encounters something new. Despite these limitations, this research was able to find persuasive evidence that there are three phenomenologically distinct modes of decision making. It also discovered relationships between these modes and factors that influence decision making. These results give guidance for future research.

Future research

In research with such a broad scope, there are many opportunities for future research. A primary aim of any future research will be to understand the unexpected outcomes that this

research found. This includes the biases for insight and for rationality, the unexpected shift toward rationality as difficulty increased, and the insignificance of personality preferences and solution cues. To accomplish this, other research methods will be considered that will reduce the pressure, or help elicit impasses, in the hope that when those methodological factors will begin show their relationships to solution mode. Another opportunity for future research will be to better understand the decision-making strategies that people use as an emergent property of the social environment in which the decision maker resides.

REFERENCES

- Allinson, C. W. (2000). Intuition and entrepreneurial behaviour. *European Journal of Work and Organizational Psychology*, 9(1), 31-43.
- Allinson, C. W., & Hayes, J. (1996). Cognitive Style Index: A Measure of Intuition-Analysis for Organizational Studies. *Journal of Management Studies*, 33(1), 119-135.
- Allison, G. T. (1969). Conceptual Models and the Cuban Missile Crisis. *The American Political Science Review*, 63(3), 689-718.
- Andersen, J. A. (2000). Intuition in managers: Are intuitive managers more effective? *Journal of Managerial Psychology*, 15(1), 46-63.
- Anderson, P. A. (1983). Decision Making by Objection and the Cuban Missile Crisis. *Administrative Science Quarterly*, 28(2), 201-222.
- Ansburg, P. I. (2000). Individual Differences in Problem Solving via Insight. *Current Psychology*, 19(2), 143.
- Ansburg, P. I., & Hill, K. (2003). Creative and analytic thinkers differ in their use of attentional resources. *Personality and Individual Differences*, 34(7), 1141-1152.
- Auble, P. M., Franks, J. J., & Soraci, S. A. (1979). Effort toward comprehension: Elaboration or Aha. *Memory and Cognition*, 7(6), 426-434.
- Bargh, J. A., & Pietromonaco, P. (1982). Automatic Information Processing and Social Perception: The Influence of Trait Information Presented Outside of Conscious Awareness on Impression Formation. *Journal of Personality and Social Psychology*, 43(3), 437-449.
- Bartlett, S. F. C. (1932/1995). *Remembering: a Study in Experimental and Social Psychology*. Cambridge University Press.
- Bolte, A., Goschke, T., & Kuhl, J. (2003). Emotion and Intuition: Effects of Positive and Negative Mood on Implicit Judgments of Semantic Coherence. *Psychological Science*, 14(5).
- Bourgeois, L. J., & Eisenhardt, K. M. (1988). Strategic Decision Processes in High Velocity Environments: Four Cases in the Microcomputer Industry. *Management Science*, 37(7).
- Bowden, E. M., & Jung-Beeman, M. (2003a). Aha! Insight experience correlates with solution activation in the right hemisphere. *Psychonomic Bulletin & Review*, 10(3), 730-737.

- Bowden, E. M., & Jung-Beeman, M. (2003b). Normative data for 144 compound remote associate problems. *Behavior Research Methods, Instruments, & Computers*, 35(4), 634-639.
- Bowden, E. M., & Jung-Beeman, M. (2007). Methods for investigating the neural components of insight. *Methods*, 42(1), 87-99.
- Bowden, E. M., Jung-Beeman, M., Fleck, J., & Kounios, J. (2005). New approaches to demystifying insight. *TRENDS in Cognitive Sciences*, 9(7), 1-7.
- Bowers, K. S., Farvolden, P., & Mermigis, L. (1995). Intuitive antecedents of insight. In S. Smith, T. Ward & R. Finke (Eds.), *The creative cognition approach* (pp. 27-51). Cambridge, MA: MIT Press.
- Bowers, K. S., Regehr, G., Balthazard, C., & Parker, K. (1990). Intuition in the Context of Discovery. *Cognitive Psychology*, 22(1), p72-110.
- Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, 42, 116-131.
- Chaiken, S. (1980). Heuristic versus systematic information processing and the use of source versus message cues in persuasion. *Journal of Personality and Social Psychology*, 39, 752-766.
- Csikszentmihalyi, M., & Sawyer, K. (1995). Creative insight: The social dimension of a solitary moment. In R. J. Sternberg & J. E. Davidson (Eds.), *The Nature of Insight* (pp. 329-363). New York: Cambridge University Press.
- Cyert, R. M., & March, J. G. (1963). A Behavioral Theory of the Firm. *Englewood Cliffs, NJ*.
- Davidson, J. E. (1995). The Suddenness of Insight. In R. J. Sternberg & J. E. Davidson (Eds.), *The Nature of Insight* (pp. 125-155). Cambridge MA: The MIT Press.
- Davidson, J. E. (2003). Insights about Insightful Problem Solving. In J. E. Davidson & R. J. Sternberg (Eds.), *The Psychology of Problem Solving*.
- Denes-Raj, V., & Epstein, S. (1994). Conflict between intuitive and rational processing: when people behave against their better judgment. *Journal of Personality and Social Psychology*, 66(5), 819-829.
- Dewey, J. (1910/1933). *How We Think: A Restatement of the Relation of Reflective Thinking to the Educative Process*. Boston, MA: DC Heath & Co.
- Dodds, R. A., Smith, S. M., & Ward, T. (2002). The Use of Environmental Clues During Incubation. *Creativity Research Journal*, 14(3/4), 287-304.

- Dodds, R. A., Ward, T. B., & Smith, S. M. (2003). Review of experimental literature on incubation in problem solving and creativity. In M. A. Runco (Ed.), *Creativity research handbook* (Vol. 3). Cresskill, NJ: Hampton Press.
- Dodrill, C. B. (1983). Long-Term Reliability of the Wonderlic Personnel Test. *Journal of Consulting and Clinical Psychology, 51*(2), 316-317.
- Dominowski, R. L. (1995). Productive Problem Solving. In S. M. Smith, T. B. Ward & R. A. Finke (Eds.), *The Creative Cognition Approach*: MIT Press.
- Dominowski, R. L., & Dallob, P. (1995). Insight and Problem Solving. In R. J. Sternberg & J. E. Davidson (Eds.), *The Nature of Insight*: USA, MIT Press.
- Dorfman, J., Shames, V. A., & Kihlstrom, J. F. (1996). Intuition, incubation, and insight: Implicit cognition in problem solving. *Implicit cognition, 257-296*.
- Dougal, S., & Schooler, J. W. (2007). Discovery misattribution: When solving is confused with remembering. *Journal of Experimental Psychology: General, 136*(4), 577-592.
- Dreisbach, G., & Goschke, T. (2004). How positive affect modulates cognitive control: reduced perseveration at the cost of increased distractibility. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*(2), 343-353.
- Dreyfus, H. L., & Dreyfus, S. E. (1986). *Mind over machine: the power of human intuition and expertise in the era of the computer*. New York, NY, USA The Free Press.
- Duncan, S., & Barrett, L. (2007). Affect is a form of cognition: A neurobiological analysis. *Cognition & Emotion, 21*(6), 1184-1211.
- Eisenhardt, K. M., & Zbaracki, M. J. (1992). Strategic Decision Making. *Strategic Management Journal, 13*, 17-37.
- Elsbach, K. D., & Barr, P. S. (1999). The Effects of Mood on Individuals' Use of Structured Decision Protocols. *Organization Science, 10*(2), 181-198.
- Epstein, S. (1990). Cognitive-experiential Self-theory. In L. Pervin (Ed.), *Handbook of personality theory and research: Theory and research* (pp. 165-192). NY: Guilford Publications, Inc.
- Epstein, S. (1998). Personal control from the perspective of cognitive-experiential self-theory. In G. Kofta, G. Weary & G. Sedek (Eds.), *Personal control in action: Cognitive and motivational mechanisms* (Vol. 5, pp. 5-26). New York: Plenum.
- Epstein, S. (2006). Demystifying Intuition: What it is, What it Does, And How it Does it. Unpublished Manuscript.

- Epstein, S., Lipson, A., Holstein, C., & Huh, E. (1992). Irrational reactions to negative outcomes: evidence for two conceptual systems. *Journal of Personality and Social Psychology*, 62(2), 328-339.
- Epstein, S., Pacini, R., Denes-Raj, V., & Heier, H. (1996). Individual Differences in Intuitive-Experiential and Analytical-Rational Thinking Styles. *Journal of Personality and Social Psychology*, 71(2), 390-405.
- Finke, R. A., Ward, T. B., & Smith, S. M. (1992a). Creative Strategies for Problem Solving. In *Creative Cognition* (pp. 167-187). Cambridge, MA: The MIT Press.
- Finke, R. A., Ward, T. B., & Smith, S. M. (1992b). Insight, Fixation, and Incubation. In *Creative Cognition: Theory, Research, and Applications* (pp. 143-166). Cambridge, MA: The MIT Press.
- Fredrickson, J. W. (1985). Effects of decision motive and organizational performance level on strategic decision processes. *Academy of Management Journal*, 28(4), 821-843.
- Gick, M. L., & Lockhart, R. S. (1995). Cognitive and Affective Components of Insight. In R. J. Sternberg & J. E. Davidson (Eds.), *The Nature of Insight* (pp. 197-228). Cambridge, MA: The MIT Press.
- Glick, M. L., & Holyoak, K. J. (1980). Analogical Problem Solving. *Cognitive Psychology*, 12, 306-355.
- Graf, P., & Mandler, G. (1984). Activation Makes Words More Accessible, but Not Necessarily More Retrievable. *Journal of Verbal Learning and Verbal Behavior*, 23, 553-568.
- Groves, P. M., & Thompson, R. F. (1970). Habituation: A Dual-Process Theory. *Psychological Review*, 77(5), 419-450.
- Haidt, J., & Joseph, C. (2004). Intuitive ethics: how innately prepared intuitions generate culturally variable virtues. *Daedalus*, 133(4), 55-66.
- Hodgkinson, G. P., Langan-Fox, J., & Sadler-Smith, E. (2008). Intuition: A fundamental bridging construct in the behavioural sciences. *British Journal of Psychology*, 99(1), 1-27.
- Hunt, R. G., Krzystofiak, F. J., Meindl, J. R., & Yousry, A. M. (1989). Cognitive Style and Decision Making. *Organizational Behavior and Human Decision Processes*, 44, 436-453.
- Iran-Nejad, A. (1990). Active and Dynamic Self-Regulation of Learning Processes. *Review of Educational Research*, 60(4), 537-602.

- Iran-Nejad, A. (2000). Knowledge, self-regulation, and the brain-mind cycle of reflection. *The Journal of Mind and Behavior*, 21(1/2), 67-88.
- Iran-Nejad, A., Clore, G. L., & Vondruska, R. J. (1984). Affect: A Functional Perspective. *The Journal of Mind and Behavior*, 5(3), 279-310.
- Iran-Nejad, A., & Gregg, M. (2001). The Brain-Mind Cycle of Reflection. *Teachers College Record*, 103(5), 868-895.
- Iran-Nejad, A., Watts, J. B., Venugopalan, G., & Xu, Y. (2007). The Wholetheme Window of Dynamic Motivation in Writing to Learn Critical Thinking: A Multiple-Source Perspective. In S. Hidi & P. Boscolo (Eds.), *Studies in writing and motivation* (pp. 31-49). Amsterdam: Elsevier.
- Iran-Nejad, A., & Winsler, A. (2000). Bartlett's schema theory and modern accounts of learning and remembering. *The Journal of Mind and Behavior*, 21(1/2), 5-35.
- Isen, A. M. (2001). An Influence of Positive Affect on Decision Making in Complex Situations: Theoretical Issues With Practical Implications. *Journal of Consumer Psychology*, 11(2), 75-85.
- Isen, A. M., Daubman, K. A., & Nowicki, G. P. (1987). Positive affect facilitates creative problem solving. *Journal of Personality and Social Psychology*, 52(6), 1122-1131.
- Jung-Beeman, M., Bowden, E. M., Haberman, J., Frymiare, J. L., Arambel-Liu, S., Greenblatt, R., et al. (2004). Neural Activity When People Solve Verbal Problems with Insight. *PLoS Biology*, 2(4), 501-510.
- Jung-Beeman, M., Collier, A., & Kounios, J. (2008). How insight happens: Learning from the brain. *NeuroLeadershipJournal*, 1, 20-25.
- Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist*, 58(9), 697-720.
- Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision Under Risk. *Econometrica*, 47(2), 263-292.
- Kaplan, C. A. (1989). Hatching a theory of incubation: Does putting a problem aside really help? If so, why? Unpublished Unpublished doctoral dissertation. Carnegie-Mellon University.
- Kaplan, C. A., & Simon, H. A. (1990). In search of insight. *Cognitive Psychology*, 22, 374-419.
- Kirkpatrick, L. A., & Epstein, S. (1992). Cognitive-Experimental Self-Theory and Subjective Probability: Further Evidence for Two Conceptual Systems. *Journal of Personality and Social Psychology*, 63(4), 534-544.

- Kohler, W. (1969). *The task of Gestalt psychology*. Princeton, NJ: Princeton University Press.
- Kohn, N., & Smith, S. M. (2009). Partly versus Completely Out of Your Mind: Effects of Incubation and Distraction on Resolving Fixation. *The Journal of Creative Behavior*, 43(2), 102-118.
- Kounios, J., & Beeman, M. (2009). The Aha! Moment. *Current Directions in Psychological Science*, 18(4), 210-216.
- Kounios, J., Fleck, J. I., Green, D. L., Payne, L., Stevenson, J. L., Bowden, E. M., et al. (2008). The origins of insight in resting-state brain activity. *Neuropsychologia*, 46, 281-291.
- Kounios, J., Frymiare, J. L., Bowden, E. M., Fleck, J. I., Subramaniam, K., Parrish, T. B., et al. (2006). The Prepared Mind - Neural Activity Prior to Problem Presentation Predicts Subsequent Solution by Sudden Insight *Psychological Science*, 17(10), 1-10.
- Kris, E. (1952). *Psychoanalytic explorations in art*. New York: International Universities Press.
- Labouvie-Vief, G., & Medler, M. (2002). Affect Optimization and Affect Complexity: Modes and Styles of Regulation in Adulthood. *Psychology and Aging*, 17(4), 571-588.
- LePine, J. A., & Van Dyne, L. (1998). Predicting Voice Behavior in Work Groups. *Journal of Applied Psychology*, 83(6), 853-868.
- Lubart, T. I., & Sternberg, R. J. (1995). An Investment Approach to Creativity: Theory and Data. In *The Creative Cognition Approach* (pp. 271-302). Cambridge, Massachusetts: The MIT Press.
- Maier, N. R. F. (1940). The behavior mechanisms concerned with problem solving. *Psychological Review*, 47(1), 1-16.
- Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review*, 87(3), 252-271.
- Mandler, G. (1995). Origins and Consequences of Novelty. In S. M. Smith, T. B. Ward & R. A. Finke (Eds.), *The Creative Cognition Approach*. London England: MIT Press.
- March, J. G., & Simon, H. A. (1958). *Organizations*. New York: John Wiley and Sons.
- Martindale, C. (1995). Creativity and Connectionism. In S. Smith, T. Ward & R. Finke (Eds.), *The Creative Cognition Approach* (pp. 249-268). London, England: The MIT Press.
- Mayer, R. E. (1995). The Search for Insight: Grappling with Gestalt Psychology's Unanswered Questions. In R. J. Sternberg & J. E. Davidson (Eds.), *The Nature of Insight* (pp. 3-32). New York: Cambridge University Press.

- Mednick, M. T., Mednick, S. A., & Mednick, E. V. (1964). Incubation of creative performance and specific associative priming. *Journal of Abnormal and Social Psychology*, 69(1), 84-88.
- Mednick, S. A. (1962). The associative basis of the creative process. *Psychological Review*, 69(3), 220-232.
- Mendelsohn, G. A. (1976). Associative and attentional processes in creative performance. *Journal of Personality*, 44(2), 341-369.
- Metcalfe, J., & Wiebe, D. (1987). Intuition in insight and noninsight problem solving. *Memory & Cognition*, 15(3), 238-246.
- Miller, C. C., & Ireland, R. D. (2005). Intuition in strategic decision making: Friend or foe in the fast-paced 21st century? *Academy of Management Executive*, 19(1), 19-30.
- Mintzberg, H., Raisinghani, D., & Theoret, A. (1976). The Structure of "Unstructured" Decision Processes. *Administrative Science Quarterly*, 21(2), 246-275.
- Mintzberg, H., & Westley, F. (2001). Decision Making: It's Not What You Think. *MIT Sloan Management Review*, 42(3), 6.
- Nutt, P. C. (2008). Investigating the Success of Decision Making Processes. *Journal of Management Studies*, 45(2), 425-455.
- Ohlsson, S. (1984). Restructuring revisited. I. Summary and critique of the Gestalt theory of problem solving. *Scandinavian Journal of Psychology*, 25(1), 65-78.
- Pacini, R., & Epstein, S. (1999). The Relation of Rational and Experiential Information Processing Styles to Personality, Basic Beliefs, and the Ratio-Bias Phenomenon. *Journal of Personality and Social Psychology*, 76(6), 972-987.
- Patalano, A. L., & Seifert, C. M. (1994). Memory for impasses during problem solving. *Memory and Cognition*, 22, 234-242.
- Petty, R. E., Cacioppo, J. T., Strathman, A. J., & Priester, J. R. (2005). To think or not to think: Exploring two routes to persuasion. In T. Brock & M. Green (Eds.), *Persuasion: Psychological insights and perspectives* (2nd ed., pp. 81-116). Thousand Oaks, CA: Sage.
- Policastro, E. (1995). Creative Intuition: An Integrative Review. *Creativity Research Journal*, 8(2), 99-113.
- Pretz, J. E., Naples, A. J., & Sternberg, R. J. (2003). Recognizing, Defining, and Representing Problems. In J. E. Davidson & R. J. Sternberg (Eds.), *The Psychology of Problem Solving* (pp. 3-30). New York: Cambridge University Press.

- Raidl, M. H., & Lubart, T. I. (2001). An Empirical Study of Intuition and Creativity. *Imagination, Cognition and Personality*, 20(3), 217-230.
- Ross, K. G., Klein, G. A., Thunholm, P., Schmitt, J. F., & Baxter, H. C. (2004). The Recognition-Primed Decision Model. *Military Review*, 84(4), 6-10.
- Rowe, G., Hirsh, J. B., & Anderson, A. K. (2007). Positive affect increases the breadth of attentional selection. *PNAS*, 104(1), 383-388.
- Schooler, J. W., Fallshore, M., & Fiore, S. M. (1995). Epilogue: Putting Insight Into Perspective. In R. J. Sternberg & J. E. Davidson (Eds.), *The Nature of Insight*: The MIT Press.
- Schooler, J. W., & Melcher, J. (1995). The Ineffability of Insight. In S. M. Smith, T. B. Ward & R. A. Finke (Eds.), *The Creative Cognition Approach* (pp. 97-134). Cambridge, MA: MIT Press.
- Schooler, J. W., Ohlsson, S., & Brooks, K. (1993). Thoughts Beyond Words: When Language Overshadows Insight. *Journal of Experimental Psychology: General*, 122(2), 166-183.
- Schwarz, N., & Skurnik, I. (2003). Feeling and Thinking: Implications for Problem Solving. In J. E. Davidson & L. Steinberg (Eds.), *The Psychology of Problem Solving* (pp. 263-291). New York: Cambridge University Press.
- Seabrook, R., & Dienes, Z. (2003). *Incubation in Problem Solving as a Context Effect*. Paper presented at the 25th Annual Meeting of the Cognitive Science Society, Boston.
- Seifert, C. M., Meyer, D. E., Davidson, N., Patalano, A. L., & Yaniv, I. (1995). Demystification of cognitive insight: Opportunistic assimilation and the prepared-mind perspective. In R. J. Sternberg & J. E. Davidson (Eds.), *The Nature of Insight*. Cambridge, MA: The MIT Press.
- Simon, H. A. (1955). A Behavioral Model of Rational Choice. *The Quarterly Journal of Economics*, 69(1), 99-118.
- Simon, H. A. (1956). Rational Choice and the Structure of the Environment. *Psychological Review*, 63(2), 129-138.
- Simon, H. A. (1965). *The Shape of Automation: for Men and Management*. New York: Harper and Row.
- Simon, H. A. (1979). Rational Decision Making in Business Organizations. *The American Economic Review*, 69(4), 493-513.
- Simon, H. A. (1987). Making management decisions: The role of intuition and emotion. *Academy of Management Executive*, 1(1), 57-64.

- Sio, U. N., & Ormerod, T. C. (2009). Does incubation enhance problem solving? A meta-analytic review. *Psychological Bulletin*, 135(1), 94-120.
- Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, 119(1), 3-22.
- Slovic, P., Finucane, M., Peters, E., & MacGregor, D. G. (2002). The affect heuristic. In T. Gilovich, D. Griffin & D. Kahneman (Eds.), *Heuristics and Biases* (pp. 397-420). New York: Cambridge University Press.
- Smith, E. R., & DeCoster, J. (2000). Dual-process models in social and cognitive psychology: Conceptual integration and links to underlying memory systems. *Personality and Social Psychology Review*, 4(2), 108.
- Smith, R. C., Kendall, L. M., & Hulin, C. L. (1969). *The Measurement of Satisfaction in Work and Retirement*. Chicago, IL: Rand McNally & Company.
- Smith, S. M. (1994). Getting Into and Out of Mental Ruts: A theory of Fixation, Incubation, and Insight. In R. J. Sternberg & J. E. Davidson (Eds.), *The Nature of Insight* (pp. 121-149). Cambridge, MA: MIT Press.
- Smith, S. M. (1995). Fixation, incubation, and insight in memory and creative thinking. In S. M. Smith, T. B. Ward & R. A. Finke (Eds.), *The Creative Cognition Approach* (pp. 135-155). Cambridge, MA: The MIT Press.
- Smith, S. M., & Blankenship, S. E. (1989). Incubation effects. *Bulletin of the Psychonomic Society*, 27(4), 311-314.
- Smith, S. M., & Blankenship, S. E. (1991). Incubation and the persistence of fixation in problem solving. *The American Journal of Psychology*, 104, 61-87.
- Spreen, O., & Strauss, E. (1998). *A compendium of neuropsychological tests*: Oxford University Press.
- Sternberg, R. J. (1982). Reasoning, problem solving, and intelligence. In R. J. Sternberg (Ed.), *Handbook of human intelligence* (pp. 225-307). Cambridge, MA: Cambridge University Press.
- Sternberg, R. J. (2001). What is the Common Thread of Creativity? Its Dialectical Relation to Intelligence and Wisdom. *American Psychologist*, 56(4), 360-362.
- Sternberg, R. J. (2006). The Nature of Creativity. *Creativity Research Journal*, 18(1), 87-98.
- Sternberg, R. J., & Lubart, T. I. (1995). *Defying the crowd: Cultivating creativity in a culture of conformity*. New York: Free Press.

- Stevenson, M. K., Busemeyer, J. R., & Naylor, J. C. (1990). Judgment and Decision-making Theory. In M. D. Dunnette & L. M. Hough (Eds.), *Handbook of industrial and organizational psychology* (2nd ed., Vol. 1, pp. 283-374). Palo Alto, CA: Consulting Psychologists Press, Inc.
- Topolinski, S., & Strack, F. (2008). Scanning the “Fringe” of consciousness: What is felt and what is not felt in intuitions about semantic coherence. *Consciousness and Cognition*.
- Trope, Y., & Alfieri, T. (1997). Effortfulness and Flexibility of Dispositional Judgment Processes. *Journal of Personality and Social Psychology*, 73(4), 662-674.
- Wallas, G. (1926). *The Art of Thought*. London: C. A. Watts & Co Limited.
- Ward, T. B., Smith, S. M., & Finke, R. A. (1999). Creative Cognition. In R. J. Sternberg (Ed.), *Handbook of Creativity*. Cambridge, U.K.: Cambridge University Press.
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales. *Journal of Personality and Social Psychology*, 54(6), 1063-1070.
- Weisberg, R. W. (1995). Case Studies of Creative Thinking: Reproduction versus Restructuring in the Real World. In S. M. Smith, T. B. Ward & R. A. Finke (Eds.), *The creative cognition approach*. London England: MIT Press.
- Weisberg, R. W. (1999). Creativity and Knowledge: A Challenge to Theories. In R. J. Sternberg (Ed.), *Handbook of Creativity*. New York, NY: Cambridge University Press.
- Weisberg, R. W., & Alba, J. W. (1981a). An Examination of the Alleged Role of "Fixation" in the Solution of Several "Insight" Problems. *Journal of Experimental Psychology: General*, 110(2), 169-192.
- Weisberg, R. W., & Alba, J. W. (1981b). Gestalt Theory, Insight, and Past Experience: Reply to Dominowski. *Journal of Experimental Psychology: General*, 110(2), 193-198.
- Wenke, D., & Frensch, P. A. (2003). Is Success or Failure at Solving Complex Problems Related to Intellectual Ability? In J. E. Davidson & R. J. Sternberg (Eds.), *The Psychology of Problem Solving* (pp. 87-126). Cambridge, MA: Cambridge University Press.
- Wertheimer, M. (1959). *Productive thinking*. New York: Harper Brother.
- Wiley, J. (1998). Expertise as mental set: The effects of domain knowledge in creative problem solving. *Memory and Cognition*, 26, 716-730.

- Winke, D., & Frensch, P. A. (2003). Is Success or Failure at Solving Complex Problems Related to Intellectual Ability? In J. E. Davidson & R. J. Sternberg (Eds.), *The Psychology of Problem Solving* (pp. 87-126). Cambridge, MA: Cambridge University Press.
- Wonderlic, Inc (n.d.) The Wonderlic Cognitive Pretest (Computerized Assessment Program). Vernon Hills, IL: Author
- Wundt, W. (1896). *Lectures on human and animal psychology*. New York: McMillan.
- Yaniv, I., & Meyer, D. E. (1987). Activation and metacognition of inaccessible stored information: Potential bases for incubation effects in problem solving. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 13(2), 187-205.
- Yaniv, I., Meyer, D. E., & Davidson, N. S. (1995). Dynamic Memory Processes in Retrieving Answers to Questions: Recall Failures, Judgments of Knowing, and Acquisition of Information. *Journal of Experimental Psychology*, 21(6), 1509-1521.
- Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist*, 35(2), 151-175.
- Zimmerman, B. J., & Campillo, M. (2003). Motivating self-regulated problem solvers. In J. E. Davidson & R. J. Sternberg (Eds.), *The Psychology of Problem Solving* (pp. 233-262). New York: Cambridge University Press.

APPENDICES

Appendix A. Contribution of Theoretical Bases to Understanding of the Three Modes

<p>Rational</p> <p>Social Psych</p> <ul style="list-style-type: none"> Analytic, deliberative, verbally oriented, operates by evidence and rules Slow decisions but fast changes to how it operates Relatively affect free Intentional Effortful <p>Insightful</p> <ul style="list-style-type: none"> Carry out necessary multi-step operation Step-by-step execution Left Hemisphere involvement, does fine semantic encoding Lower affective state Able to predict if you are near to a solution A- promotes this mode Narrows perception <p>Biofunctional</p> <ul style="list-style-type: none"> Mind regulated, Active self-regulation, Voluntary, directed by one's intentions Single focus of attention Tends to generate stress, tension and anxiety 	<p>Intuition</p> <p>Gestalt</p> <ul style="list-style-type: none"> Doing something old Stereotypical Habit Recall and application of prior knowledge Reproductive <p>Creativity</p> <ul style="list-style-type: none"> Reproductive Recall and application of previously acquired knowledge Adapting known solution routines to the situation at hand Unable to address the need for novel solutions <p>Social Psych</p> <ul style="list-style-type: none"> Directs most daily activities Rapid decisions but slow to make functional changes Effortless operation Automatic, holistic, associative Shaped by emotionally significant events First to react to a stimulus <p>Biofunctional</p> <ul style="list-style-type: none"> Habitual Energy conserving Oriented to feeling safe Routine, rest, inaction, avoiding challenges Dynamic self-regulation Brain regulated Many things at once Drive toward sense-making 	<p>Insight</p> <p>Gestalt</p> <ul style="list-style-type: none"> Doing something new Illumination or Novel Overcoming mental constraints Productive Change in mental representation Awareness of new relationships Seeing a problem holistically An impasse, possible followed by a period of incubation, followed by a flash of illumination <p>Creativity</p> <ul style="list-style-type: none"> Generative activity Discovering something novel and useful An essential part of human cognition Productive Uses past experiences in a general way but avoids being trapped by habit or irrelevant associations A change in representation, or restructuring to reveal insights Reinterpreting some problem element Forming new associations between ideas Factors influencing: intelligence, thinking style, personality attributes, intrinsic motivation, supporting environment Factors: broad knowledge base, defocused attention, readiness to form new associations, ability to use analogy and free association Fixation, incubation and recovery from fixation <p>Insightful</p> <ul style="list-style-type: none"> Sudden recognition of a solution Seeing inside a problem during a moment of sudden realization A creative act Sudden solution after reaching an impasse Affectively informed Aha! experience A+ promotes Holistically oriented through broadening perception Impasse= overcoming fixation or missing, ambiguous, missing information, during incubation Changing the context Spreading activation Analogical reasoning Opportunistic assimilation Impasse induces semantic priming or sets failure indices Individual factors: intelligence. Diffuse attention <p>Biofunctional</p> <ul style="list-style-type: none"> Creative Energy mobilizing Oriented to address the unknown Enables dealing with change,
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		<p>exploration, action, reacting to challenge</p> <ul style="list-style-type: none"> • Brain regulated • Many things at once • Resolving indeterminacy • Solving problems through integrating ideas
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Appendix B. Faces

DIRECTIONS: Click on the face below that best expresses your **current emotional state**.



1



2



3



4



5



6



7

Appendix C. PANAS

The PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent [INSERT APPROPRIATE TIME INSTRUCTIONS HERE]. Use the following scale to record your answers.

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely
	<input type="checkbox"/> interested		<input type="checkbox"/> irritable	
	<input type="checkbox"/> distressed		<input type="checkbox"/> alert	
	<input type="checkbox"/> excited		<input type="checkbox"/> ashamed	
	<input type="checkbox"/> upset		<input type="checkbox"/> inspired	
	<input type="checkbox"/> strong		<input type="checkbox"/> nervous	
	<input type="checkbox"/> guilty		<input type="checkbox"/> determined	
	<input type="checkbox"/> scared		<input type="checkbox"/> attentive	
	<input type="checkbox"/> hostile		<input type="checkbox"/> jittery	
	<input type="checkbox"/> enthusiastic		<input type="checkbox"/> active	
	<input type="checkbox"/> proud		<input type="checkbox"/> afraid	

We have used PANAS with the following time instructions:

Moment	(you feel this way right now, that is, at the present moment)
Today	(you have felt this way today)
Past few days	(you have felt this way during the past few days)
Week	(you have felt this way during the past week)
Past few weeks	(you have felt this way during the past few weeks)
Year	(you have felt this way during the past year)
General	(you generally feel this way, that is, how you feel on the average)

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The Wonderlic Personnel Test

Wonderlic, Inc.

WPT™ Sample Questions

1. Assume the first 2 statements are true.
Is the final one:

1. true 2. false 3. not certain

The boy plays baseball. All baseball players wear hats. The boy wears a hat.

2. Paper sells for 21 cents per pad. What will 4 pads cost?

3. How many of the five pairs of items listed below are exact duplicates?

Nieman, K.M.	Neiman, K.M.
Thomas, G.K.	Thomas, C.K.
Hoff, J.P.	Hoff, J.P.
Pino, L.R.	Pina, L.R.
Warner, T.S.	Wanner, T.S.

4. PRESENT RESERVE - Do these words...

1. have similar meanings
2. have contradictory meanings
3. mean neither the same or opposite?

5. A train travels 20 feet in 1/5 second. At this same speed, how many feet will it travel in three seconds?

6. When rope is selling at \$.10 a foot, how many feet can you buy for sixty cents?

7. The ninth month of the year is

1. October 2. January 3. June
4. September 5. May

8. Which number in the following group of numbers represents the smallest amount?

7 .8 31 .33 2

9. In printing an article of 48,000 words, a printer decides to use two sizes of type. Using the larger type, a printed page contains 1,800 words. Using smaller type, a page contains 2,400 words. The article is allotted 21 full pages in a magazine. How many pages must be in smaller type?

10. Three individuals form a partnership and agree to divide the profits equally. X invests \$9,000, Y invests \$7,000, Z invests \$4,000. If the profits are \$4,800, how much less does X receive than if the profits were divided in proportion to the amount invested?

11. Assume the first two statements are true. Is the final one: 1. true 2. false 3. not certain
Tom greeted Beth. Beth greeted Dawn.
Tom did not greet Dawn.

12. A boy is 17 years old and his sister is twice as old. When the boy is 23 years old, what will be the age of his sister?

These are sample test questions and are intended for demonstration purposes only. The Wonderlic Personnel Test is published by Wonderlic, Inc.

Answers

- | | |
|-----------------|------------------|
| 1. true | 2. 84 cents |
| 3. 1 | 4. 3 |
| 5. 300 feet | 6. 6 feet |
| 7. September | 8. .33 |
| 9. 17 | 10. \$560 |
| 11. not certain | 12. 40 years old |

Appendix E. Rational-Experiential Inventory (REI)

Please fill in your name, gender, and age on the answer sheet. Next, rate the following statements about your feelings, beliefs, and behaviors using the scale below. Work rapidly; first impressions are as good as any.

1 = Definitely False, 2 = Mostly False, 3 = Undecided or Equally True and False, 4 = Mostly True, 5 = Definitely True

1. I'm not that good at figuring out complicated problems.
2. If I were to rely on my gut feelings, I would often make mistakes.
3. I prefer complex to simple problems.
4. I generally don't depend on my feelings to help me make decisions.
5. I have no problem in thinking things through clearly.
6. When it comes to trusting people, I can usually rely on my gut feelings.
7. Thinking is not my idea of an enjoyable activity.
8. I like to rely on my intuitive impressions.
9. I am not a very analytical thinker.
10. I believe in trusting my hunches.
11. I enjoy solving problems that require hard thinking.
12. I think it is foolish to make important decisions based on feelings.
13. I suspect my hunches are inaccurate as often as they are accurate.
14. I usually have clear, explainable reasons for my decisions.
15. Knowing the answer without having to understand the reasoning behind it is good enough for me.
16. I would not want to depend on anyone who described himself or herself as intuitive.
17. Using logic usually works well for me in figuring out problems in my life.
18. I enjoy intellectual challenges.
19. I can usually feel when a person is right or wrong, even if I can't explain how I know.
20. I often go by my instincts when deciding on a course of action.
21. My snap judgments are probably not as good as most people's.
22. Reasoning things out carefully is not one of my strong points.
23. I don't like situations in which I have to rely on intuition.
24. I try to avoid situations that require thinking in depth about something.
25. I trust my initial feelings about people.
26. I have a logical mind.
27. I don't think it is a good idea to rely on one's intuition for important decisions.
28. I don't like to have to do a lot of thinking.
29. I don't have a very good sense of intuition.
30. I am not very good in solving problems that require careful logical analysis.
31. I think there are times when one should rely on one's intuition.
32. I enjoy thinking in abstract terms.
33. Using my gut feelings usually works well for me in figuring out problems in my life.
34. I don't reason well under pressure.
35. I tend to use my heart as a guide for my actions.
36. Thinking hard and for a long time about something gives me little satisfaction.

- 37. I hardly ever go wrong when I listen to my deepest gut feelings to find an answer.
- 38. I am much better at figuring things out logically than most people.
- 39. Intuition can be a very useful way to solve problems.
- 40. Learning new ways to think would be very appealing to me.

Scoring of 40-item REI: Sum of ratings (1-5) of items in a scale. Item numbers followed by an “r” are reverse scored as follows: 1 = 5, 2 = 4, 3 = 3, 4 = 2, 5 = 1.

Rationality: Rational Ability + Rational Favorability

Rational Ability: 1r, 5, 9r, 14, 17, 22r, 26, 30r, 34r, 38

Rational Favorability: 3, 7r, 11, 15r, 18, 24r, 28r, 32, 36r, 40

Experientiality: Experiential Ability + Experiential Favorability

Experiential Ability: 2r, 6, 10, 13r, 19, 21r, 25, 29r, 33, 37

Experiential Favorability: 4r, 8, 12r, 16r, 20, 23r, 27r, 31, 35, 39

Appendix F. Sample Compound Remote Associate Test Problems and Norms

Remote Associate Items	Solutions	Maximum Time Allowed for Producing a Solution									
		2 sec <i>n</i> = 89 % of Participants Solving Item	7 sec <i>n</i> = 85				15 sec <i>n</i> = 76			30 sec <i>n</i> = 39	
			% of Participants Solving Item	Mean Solution Time (sec)	<i>SD</i>		% of Participants Solving Item	Mean Solution Time (sec)	<i>SD</i>	% of Participants Solving Item	Mean Solution Time (sec)
cottage/swiss/cake	cheese	52	84	3.28	1.25	96	3.96	2.37	64*	10.85	7.04
cream/skate/water	ice	34	76	3.42	1.16	92	4.04	1.87	90	4.12	3.58
loser/throat/spot	sore	22	61	4.19	1.49	86	5.38	3.02	82	6.31	4.06
show/life/row	boat	31	72	4.42	1.44	82	5.67	2.34	79	10.30	7.22
night/wrist/stop	watch	38	65	4.33	1.31	82	6.00	3.00	97	6.27	5.83
duck/fold/dollar	bill	31	69	4.33	1.25	80	6.05	2.82	92	6.58	4.28
rocking/wheel/high	chair	37	73	3.98	1.43	80	4.98	2.55	87	5.84	5.36
dew/comb/bee	honey	30	66	4.24	1.50	80	5.63	3.15	100	4.12	2.14
fountain/baking/pop	soda	34	71	4.25	1.23	78	6.01	2.69	92	5.50	3.30
preserve/ranger/tropical	forest	18	59	4.00	1.34	76	5.76	2.98	85	9.73	6.08
aid/rubber/wagon	band	22	56	4.21	1.50	75	5.41	2.15	69	6.51	4.62
flake/mobile/cone	snow	9	47	4.20	1.61	71	6.72	3.10	79	8.68	7.02
cracker/fly/fighter	fire	17	45	4.95	1.54	68	5.91	2.54	85	6.12	3.87
safety/cushion/point	pin	24	51	3.91	1.58	66	5.83	2.78	74	5.00	2.84
cane/daddy/plum	sugar	19	60	4.43	1.53	66	6.14	3.11	97	5.45	4.92
dream/break/light	day	24	56	4.36	1.49	64	5.35	2.56	56	7.91	6.72
fish/mine/rush	gold	17	46	4.27	1.09	63	6.48	3.32	74	9.07	6.83
political/surprise/line	party	7	26	5.06	1.29	61	7.84	3.43	90	8.79	5.20
measure/worm/video	tape	10	45	4.74	1.59	58	6.12	2.90	87	8.36	5.24
high/district/house	school/court	18	42	4.36	1.34	55	5.59	2.45	74	8.90	7.75
sense/courtesy/place	common	8	33	4.67	1.29	54	6.28	2.89	67	9.24	8.11
worm/shelf/end	book	17	49	4.31	1.38	53	5.88	2.90	85	6.76	6.25
piece/mind/dating	game	6	19	5.61	1.22	53	7.83	2.41	46	15.34	7.78
flower/friend/scout	girl	9	22	5.26	1.47	51	8.06	2.94	67	11.43	7.70
river/note/account	bank	2	29	5.64	0.99	50	7.98	2.81	79	10.53	5.88
print/berry/bird	blue	10	38	4.91	1.47	49	7.18	3.77	77	13.24	7.94
pie/luck/belly	pot	15	38	4.35	0.93	49	5.31	2.03	44	8.68	4.36
date/alley/fold	blind	13	40	4.51	1.22	47	6.99	3.33	85	7.06	5.42
opera/hand/dish	soap	16	33	5.26	1.41	47	6.54	3.11	62	7.92	6.45
cadet/capsule/ship	space	18	34	4.13	1.49	47	5.53	2.78	74	5.46	3.96
fur/rack/tail	coat	2	16	5.42	1.35	46	7.89	3.49	79	8.00	6.76
stick/maker/point	match	1	4	5.42	1.23	46	6.65	3.46	21	12.19	8.15
hound/pressure/shot	blood	4	32	4.51	1.43	42	6.48	3.94	72	6.98	5.32

Appendix G. Script for Recruiting Card

Study ID: <1234C>

You are invited to participate in a study about how people make decisions. If you want to participate, you must agree to follow these instructions.

1. Send an email today to: KensDMStudy@gmail.com. Ask to be included in this study. When you receive the email invitations, find a quiet place and time to take the tests on line. Change the last name on the Wonderlick test sign-in screen to the Study ID number on this card, then complete the test. It will only take 10 minutes.
2. For the second test, follow the link in the email invitation and log in using the same study ID number from this card. Answer the questions about how you make decisions.
3. Complete steps 1 & 2 before arriving at the lab in <###> Graves Hall at <date> <time>. You will be done in about an hour. Bring this card with you!

Appendix H: Script for Orientation

Thank you for participating.

Have you completed the 2 assessments sent by email invitation? If not, please see <helper> at the end of this orientation in order to get this done.

This study has 2 problem-solving phases, with a word sorting exercise in between. In both problem-solving phases you will be asked to solve word problems by finding a word that makes sense with all three of the words in the problem. For example, the solution word “cheese” makes the terms “cottage cheese”, “swiss cheese”, and “cheese cake” from the problem cottage/swiss/cake. You will be given a chance to practice on a couple of problems in a few minutes.

Phase 1

For each problem, you will be given up to 30 seconds to solve it. A timer on the screen will let you know how much time you have remaining on each problem.

If you solve a problem before the 30 seconds runs out, you should quickly click the “I have a solution” button. This will stop the timer and give you a chance to type in your answer to the problem.

When you solve a problem, you will type in the solution word, which in the example is “cheese”. Then we want to know how you solved it.

If you searched your memory and tried a number of words with the problem, and one of them worked, then you should select the “Search” button.

But, if you were working to solve a problem, but you suddenly had an Aha! moment where you just knew the answer in your gut, then you should select the “Aha!” button. As we work on problems, we almost always try different strategies along the way. We try one thing, and then another, and no one strategy is necessarily any better than any other. What this study is interested in is what you were doing at the moment you found the answer. Even though you may have tried other approaches along the way, we want to know what was happening at the moment you found the solution. Did you search for the solution word till you found it, or did it come to you in a gut feeling flash?

If time runs out, we still want to know how you were trying to solve a problem. Were you searching through words, or were you mentally wandering, hoping to have an Aha! moment? Click the appropriate answer.

Lexical task

After a minute of rest following Phase 1, problem solving will continue with a word sorting exercise. Your job is to read each word that displays and decide if that word is a proper word in the English language. All you need to do is click the “Yes” or “No” button and then click the “next >>” button.

You may find that some of the words you encounter in this word sorting exercise may be solution words for problems you had trouble solving in the first phase. You should pay attention to them in case you get a second chance to solve a missed problem.

Phase 2

After another minute of rest, this study will again present you with word problems that you have 30 seconds to solve. If you solve it, then quickly click the “I have an answer” button, and type the solution word into the answer field. Like before, if you searched for a solution word until you found it, click the “Search” button. But if you had a sudden

Aha! gut feeling, or just knew the answer, click the “Aha!” button. We’re still interested in the way the answer was found at the exact moment you found it.

Trial problems

#10: Rocking/wheel/high - chair

#64: knife/light/pal - pen

When you begin the study, in a few minutes, you will again use the Study ID to login to begin the study. Answer the demographic questions that are asked, and then begin the study.

Appendix I. Subject Level Analysis for Faster Second Solutions

Subject ID	N	t Value	Pr > t	Mean	95% LCLM	95% UCLM
70	11	4.25	0.00	2.38	1.13	3.63
71	5	0.15	0.89	0.87	-15.54	17.28
72	5	3.21	0.03	6.82	0.93	12.71
73	7	3.16	0.02	8.46	1.90	15.02
74	8	0.20	0.85	0.44	-4.74	5.61
75	1			6.48		
76	9	4.34	0.00	4.78	2.24	7.32
77	9	0.27	0.79	0.98	-7.36	9.32
78	2	4.25	0.15	13.75	-27.31	54.82
79	6	2.36	0.06	3.10	-0.28	6.49
80	8	4.10	0.00	3.85	1.63	6.06
81	9	1.52	0.17	2.50	-1.29	6.30
82	3	1.00	0.42	0.77	-2.54	4.07
83	6	2.89	0.03	8.00	0.88	15.11
84	6	3.91	0.01	5.06	1.73	8.39
85	6	2.62	0.05	7.62	0.15	15.09
86	8	4.72	0.00	9.27	4.62	13.92
87	9	2.56	0.03	3.01	0.30	5.73
88	9	3.71	0.01	9.24	3.51	14.98
89	4	2.52	0.09	4.68	-1.23	10.60
90	6	3.54	0.02	11.81	3.23	20.39
91	8	2.77	0.03	5.38	0.79	9.97
92	5	1.97	0.12	3.57	-1.46	8.61
93	6	2.24	0.08	5.14	-0.77	11.06
94	7	5.08	0.00	3.43	1.78	5.09
95	11	3.73	0.00	13.46	5.42	21.50
96	7	3.63	0.01	4.14	1.35	6.93
97	3	1.69	0.23	7.98	-12.37	28.34
98	6	-0.63	0.55	-3.05	-15.42	9.31
99	6	2.92	0.03	5.77	0.68	10.86
100	11	2.29	0.04	3.85	0.11	7.60
101	4	1.74	0.18	5.86	-4.87	16.59
102	7	1.14	0.30	1.59	-1.82	5.00
103	13	6.13	0.00	4.91	3.17	6.66
104	11	3.02	0.01	3.86	1.01	6.71
105	8	1.74	0.13	1.46	-0.53	3.45
106	9	3.36	0.01	6.19	1.94	10.45
107	4	3.90	0.03	5.81	1.07	10.55
108	7	4.27	0.01	3.41	1.45	5.37
109	5	-0.69	0.53	-1.77	-8.90	5.35
110	3	-1.65	0.24	-6.96	-25.14	11.22
111	4	1.35	0.27	8.69	-11.83	29.22
112	6	3.24	0.02	7.20	1.49	12.90
113	9	3.41	0.01	3.43	1.11	5.74

114	9	3.77	0.01	3.83	1.49	6.18
115	8	2.13	0.07	3.41	-0.38	7.19
116	5	3.00	0.04	3.87	0.29	7.46
117	6	1.61	0.17	4.63	-2.75	12.00
118	0					
119	9	2.72	0.03	5.05	0.78	9.32
120	9	4.52	0.00	10.15	4.98	15.33
121	6	3.38	0.02	1.45	0.35	2.55
122	5	2.36	0.08	9.13	-1.59	19.86
123	5	2.92	0.04	5.53	0.27	10.78
124	6	3.48	0.02	5.64	1.47	9.81
125	7	2.87	0.03	12.33	1.83	22.83
126	0					
127	9	2.46	0.04	6.41	0.41	12.42
128	7	4.29	0.01	3.25	1.40	5.10
129	8	0.20	0.85	0.32	-3.49	4.12
130	5	3.97	0.02	11.06	3.32	18.79
131	10	4.20	0.00	7.37	3.40	11.34
132	9	2.15	0.06	4.04	-0.29	8.37
133	11	4.47	0.00	4.41	2.21	6.61
134	6	4.70	0.01	4.54	2.06	7.03
135	11	3.49	0.01	5.70	2.06	9.33
136	8	2.71	0.03	7.63	0.98	14.29
137	5	3.66	0.02	7.08	1.71	12.46
138	8	2.48	0.04	7.79	0.37	15.21
139	1			2.84		
140	12	3.34	0.01	4.14	1.41	6.87
141	2	1.81	0.32	5.69	-34.17	45.54
142	1			7.53		
143	6	1.00	0.36	1.47	-2.31	5.24
144	10	3.02	0.01	6.61	1.65	11.56
145	8	1.46	0.19	2.91	-1.81	7.64
146	8	2.47	0.04	6.81	0.30	13.32
147	7	1.48	0.19	2.97	-1.93	7.87
148	10	1.69	0.13	4.13	-1.40	9.67
149	0					
150	0					
151	1			20.71		
152	0					
153	9	2.68	0.03	6.34	0.88	11.79
154	13	3.55	0.00	6.97	2.69	11.25
155	8	0.75	0.48	1.54	-3.32	6.40
156	9	1.02	0.34	3.04	-3.84	9.92
157	8	1.95	0.09	1.92	-0.41	4.25
158	8	1.38	0.21	0.95	-0.68	2.57
159	10	2.09	0.07	3.19	-0.26	6.63
160	6	3.50	0.02	4.09	1.08	7.10

161	3	2.06	0.18	12.16	-13.27	37.59
162	2	1.21	0.44	13.75	-131.21	158.72
163	8	1.87	0.10	5.20	-1.36	11.76
164	9	3.50	0.01	11.66	3.97	19.34
165	10	2.07	0.07	4.58	-0.43	9.58
166	12	2.43	0.03	7.43	0.69	14.17
167	9	3.36	0.01	10.52	3.29	17.75

Appendix J. Question Level Analysis for Faster Second Solutions

probnum	N	delta_t	delta_Probt	delta_Mean	delta_LCLM	delta_UCLM
4	85	6.17	0.00	1.84	1.25	2.44
12	35	5.61	0.00	6.46	4.12	8.80
21	67	8.49	0.00	7.15	5.47	8.84
23	75	5.08	0.00	2.90	1.76	4.04
35	36	5.15	0.00	7.25	4.39	10.11
36	53	6.67	0.00	5.47	3.82	7.11
48	19	5.20	0.00	6.43	3.83	9.03
53	45	7.40	0.00	5.97	4.35	7.60
55	35	1.72	0.09	2.55	-0.46	5.56
57	29	4.82	0.00	6.71	3.86	9.56
74	42	5.05	0.00	4.86	2.91	6.80
86	51	7.14	0.00	6.96	5.00	8.91
133	18	2.00	0.06	5.55	-0.31	11.41
136	7	2.57	0.04	5.36	0.26	10.45
149	3	6.82	0.02	7.91	2.92	12.91
151	19	4.87	0.00	8.34	4.74	11.94
152	5	2.44	0.07	6.95	-0.95	14.84
160	4	1.06	0.37	7.63	-15.21	30.48
168	4	4.51	0.02	3.00	0.88	5.11
171	27	3.38	0.00	5.23	2.05	8.42

Appendix K. IRB Certification

Office for Research
Institutional Review Board for the
Protection of Human Subjects

THE UNIVERSITY OF
ALABAMA
R E S E A R C H

November 19, 2010

Ken Gunnells
Dept. of Educational Psychology
College of Education
Box 870231

Re: IRB#: 10-OR-367 "Rational, Intuition and Insight: Three
Phenomenologically Distinct Modes of Decision-Making"

Dear Mr. Gunnells:

The University of Alabama Institutional Review Board has granted approval for
your proposed research.

Your application has been given expedited approval according to 45 CFR part
46. Approval has been given under expedited review category 7 as outlined
below:

(7) Research on individual or group characteristics or behavior (including, but
not limited to, research on perception, cognition, motivation, identity, language,
communication, cultural beliefs or practices, and social behavior) or research
employing survey, interview, oral history, focus group, program evaluation,
human factors evaluation, or quality assurance methodologies

Your application will expire on November 16, 2011. If your research will
continue beyond this date, complete the relevant portions of Continuing Review
and Closure Form. If you wish to modify the application, complete the
Modification of an Approved Protocol. Changes in this study cannot be initiated
without IRB approval, except when necessary to eliminate apparent immediate
hazards to participants. When the study closes, complete the appropriate portions
of the Continuing Review and Closure Form.

Please use reproductions of the IRB approved stamped consent forms to obtain
consent from your participants.

Should you need to submit any further correspondence regarding this proposal,
please include the above application number.

Good luck with your research.

Sincerely,



Stuart Usdan, PhD.
Chair, Non- Medical Institutional Review Board
The University of Alabama

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