MEMORY REFLECTED IN OUR DECISIONS:
WORKING MEMORY AND RISKY CHOICE FRAMING

A Thesis
By
JONATHAN CHARLES CORBIN

Submitted to the Graduate School
Appalachian State University
In partial fulfillment of the requirements for the degree
MASTER OF ARTS

May 2010
Department of Psychology

MEMORY REFLECTED IN OUR DECISIONS:
WORKING MEMORY AND RISKY CHOICE FRAMING

A Thesis
By
JONATHAN CORBIN
May 2010

APPROVED BY:

G. Todd McElroy
Chairperson, Thesis Committee

Hall P. Beck
Member, Thesis Committee

Chris A. Dickinson
Member, Thesis Committee

James C. Denniston
Chair, Department of Psychology

Edelma D. Huntley
Dean, Research and Graduate Studies

FOREWORD

This thesis is written in accordance with the style of the *Publication Manual of the American Psychological Association (6th Edition)* as required by the Department of Psychology at Appalachian State University

I would like to thank my thesis chair, Dr. Todd McElroy for his guidance throughout the thesis process. I would also like to thank my thesis committee; Dr. Chris Dickinson and Dr. Hall Beck for their helpful advice. Finally, I would like to thank James Mills and Cassie Black for their work in the laboratory.

Memory Reflected in Our Decisions:

Working Memory and Risky Choice Framing

Jonathan Corbin

Appalachian State University

Abstract

The current study looks at the role working memory plays in risky-choice framing. Eighty-six participants took the Automatic OSPAN, a measurement of working memory; this was followed by a risky-choice framing task. Results show that participants with high working memory capacities demonstrate well-pronounced framing effects, whereas those with low working memory capacities do not. This pattern suggests that, in a typical risky-choice decision task, individuals with high working memory capacity are especially likely to be influenced by contextual factors, such as the frame, and consequently demonstrate stronger framing effects.

Memory Reflected in Our Decisions:

Working Memory Capacity and Risky Choice Framing

Throughout our lives, we are faced with many small and large decisions. Many of these choices involve some aspect of risk, like choosing whether to invest in certain stocks, deciding on medical treatment options, or even deciding whether to risk human lives. The most studied examples of risk and decision making involve risky choices presented within a positive or negative framework, or framing effects.

Background

Research on framing effects has its origin in economic theory, most notably with Expected Utility Theory (e.g., Von Neumann & Morgenstern, 1947). More recently, psychologists have begun looking at individual differences that may play a role in the facilitation of framing effects. Continuing in the research tradition of individual differences on framing effects, the purpose of this paper is to determine the relationship between working memory capacity (WMC) and framing effects. This paper begins with a review of the decision theories that brought about the discovery of framing effects, beginning with expected utility theory and leading to prospect theory. This is followed by an overview of research on framing effects, and a review of WMC. Finally, connections are made between these two lines of research and hypotheses drawn that make testable predictions for how WMC interacts with risky-choice framing. After providing an empirical test of the hypotheses, the paper concludes with a discussion of the theoretical implications of the findings.

Expected Utility Theory

In order to gain an appreciation for framing effects and their place in the study of judgment and decision making, there must first be an understanding of what spurred interest and theoretical development of these effects. To do this, an overview of expected utility theory is needed. The basis for expected utility theory is the calculation of expected value. In terms of choosing between options that have differing probabilities of occurring, calculating expected value consists of weighting the options by their probabilities. An example is if there is a choice between:

(A.) A 20% chance of getting $1,000

or

(B.) A 25% chance of getting $400

The expected value of each option is: (A) .20($1,000) = $200 or (B) .25($400) = $100, leaving Option A as the best option, according to expected value calculation.

Expected utility theory was proposed as a solution to the basic problem that there are factors beyond raw calculation that affect how a person perceives something's value. The difference in utility between $1 and $1 million is much greater than $8 million and $9 million. In order to correct for this problem in expected value calculation, Von Neumann and Morgenstern (1947) formulated expected utility theory, which creates a numerical basis for calculating the amount of satisfaction (utility) a person can achieve when making a probabilistic choice between multiple options. An example can be found in a situation in which a person owes $5,000 to the bank by tomorrow, or else her home will go into foreclosure. She goes to Las Vegas and is offered a choice between:

(A). A 90% chance to win $3,000

or

(B). A 40% chance to win $5,000.

Calculating expected value prompts the selection of Option A, but with expected utility the options are weighted according to the person's subjective utility (U). Option A could be given a utility of 40, while B is given a utility of 100, due to the fact that Option B offers the full amount needed while Option A has positive utility as a gain, but does not fully satisfy the need. The calculation of these utilities leads one to choose Option B as the superior option (as seen below).

(A) A 90% chance to win U(40) = .9(40) = 36

(B). A 40% chance to win U(100) = .4(100) = 40

Although this approach is still widely used today and thought of as the benchmark for rational decision making in economics and decision making fields, some research has shown discrepancies between expected utility predictions and human behavior (Kahneman & Tversky, 1979). One such finding is the framing effect (Tversky & Kahneman, 1981), in which two choices containing equal expected values will engender different choices depending on how the alternatives are presented.

Prospect Theory

Framing effects are derived from prospect theory predictions (Kahneman & Tversky, 1979) and have become one of the foremost studied examples of rational decision making. Prospect theory was put forth as a descriptive model of decision making that is psychologically superior to expected utility theory. Prospect theory posits that outcomes are viewed in terms of gains and losses relative to a neutral reference point, as opposed to expected utility theory, which looks at outcomes in terms of final states of wealth. The reference point can be affected by the description of a problem or the decision maker's expectations, two aspects of decision making that expected utility theory does not take into account (Kahneman & Tversky, 1979). This effect is due to differences in perceived subjective value and is captured by the S-shaped value function (see Figure 1) which is concave for gains, yielding risk-aversive preferences (e.g., choosing a sure option over a gamble of equal expected value), and convex for losses, yielding risk-seeking preferences (e.g., choosing the risky gamble).

Framing Effects

Levin, Schneider, and Gaeth (1998) have proposed three different types of framing effects, which subsequently have been shown to represent independent processes (Levin, Gaeth, Schreiber, & Lauriola, 2002). I begin with a brief overview of two of these types of framing: attribute framing and goal framing. I end this discussion with an in-depth look at risky-choice framing.

Attribute framing occurs when the description of an object or event is based on the targets positive or negative characteristics. In a classic example of attribute framing (Levin & Gaeth, 1988), participants are asked to rate ground beef that is either said to be "80% lean" or "20% fat." People who receive the negative description (20% fat) tend to rate the ground beef as lower quality compared to those who receive the positive description (80% lean), despite the fact that the two descriptions are formally equivalent. This type of framing has been found to be very reliable and Levin et al. (2002) have shown that on average, people would spend 8.2 more cents for a pound of ground beef that was labeled as 80% lean compared to ground beef that was labeled 20% fat.

Goal framing occurs when a persuasive message is framed in terms of the negative consequences of not performing an act or the positive consequences of performing an act. In a study by Meyerowitz and Chaiken (1987), female participants were given either information about the negative consequences of not engaging in breast self-examination (BSE) or information about the positive consequences of engaging in BSE. The women who were given the negative information were more likely to engage in BSE. Although goal framing has been found to be the least reliable effect as compared to the other types of framing effects (Levin et al., 1998; Levin et al. 2002), moderating variables such as perceived outcome risk (Ferguson & Gallagher, 2007; Rothman, Kelley, Hertel, & Salovey, 2003) and context (McCormick & McElroy, 2009) can play a role in the facilitation of these effects.

In the most widely tested example of framing, Tversky and Kahneman (1981) presented participants with an Asian disease problem (Appendix A) in which 600 lives were at stake. Participants were then presented with a set of alternatives, one risk-free and the other risky. The alternatives were framed either positively or negatively, in terms of the number of people that would be “saved” or “die.” Their findings revealed that, despite identical expected values, participants preferred the risk-free alternative when the problem was framed positively and the risky alternative when framed negatively. This type of task design is commonly referred to as “risky-choice” (Levin et al., 1998).

This effect is explained by prospect theory in terms of the S-shaped value function (*v*). When a person is given the “saved” condition of the Asian disease problem, they have the option of 200 people being saved or a 1/3 chance of 600 people being saved (2/3 chance no-one is saved). According to prospect theory, participants code this problem as $v(+200)$ vs. $1/3 \times v(+600) + 2/3 \times v(0)$. Due to the fact that the value function is concave for gains, $v(+200) > 1/3 \times v(+600) + 2/3 \times v(0)$, and the participant is likely to choose the sure option. In the "die" condition of the problem, they have the option of 400 people dying ($v(-400)$) or a 2/3 chance of everyone dying and a 1/3 chance of no-one dying ($2/3 \times v(-600) + 1/3 \times v(0)$). Since the value function is convex for losses, $v(-400) < 2/3 \times v(-600) + 1/3 \times v(0)$, the participant is likely to choose the risky option (Kuhberger & Tanner, 2009).

Risky-choice framing problems that follow the Asian disease format show reliable, moderately strong framing effects (Kuhberger, 1998; Levin et al., 1998). However, the typical risky-choice framing effect can be stronger or weaker depending on the variables present within the decision, such as the use of scenarios as in the Asian disease problem or purely numerical problems involving the gain or loss of money (Fagley & Miller, 1997). This effect also has been shown to reverse or even disappear depending on the presentational format of the problem (Kuhberger & Tanner, 2009; Reyna & Brainerd, 1991) and the age group to which the problem is given (Reyna & Ellis, 1994). These findings have created opportunities for new approaches to risky-choice framing research. Some avenues of research have looked at the role different processing styles play in creating stronger or weaker framing effects (Stanovich & West, 2000; McElroy & Seta, 2003), whereas other research has looked at how memory processes affect framing (Reyna & Brainerd, 1995). These perspectives engender new ideas and methods for looking further into the internal processes that underlie the risky-choice framing effect.

Working Memory

Working memory was first proposed by Baddeley and Hitch (1974), describing it as a limited-capacity system that holds and manipulates information. It is commonly viewed as the system responsible for the maintenance of information in memory in the face of interference (Engle, 2002). Because of its importance in cognitive processing, Daneman and Carpenter (1980) created a working memory span-task to measure individual differences in WMC. This task invigorated research interest in the topic as well as further development of working memory measurement.

Research on WMC has discovered strong correlations between WMC and constructs such as fluid intelligence (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Engle, Tuholski, Laughlin, & Conway, 1999), reading comprehension (Daneman & Merikle, 1996), and math ability (LeFevre, DeStefano, Coleman, & Shanahan, 2004). In each of these areas, higher WMC predicts better performance. WMC has also been shown to predict reasoning abilities. Multiple studies have shown that WMC can predict differences in strategy use when encoding information (Cokely, Kelley, & Gilchrist, 2006; McNamara & Scott, 2001) as well as number and strength of alternate hypotheses one can generate when making probability judgments (Dougherty & Hunter, 2003). Those with low WMC tend to rely on rote-rehearsal (Turley-Ames & Whitfield, 2003) whereas those with high WMC appear to employ elaborative encoding, a process that generally leads to superior decision making for those with high WMC (Cokely & Kelley, 2009). The difference in encoding techniques may distinguish high and low WMC with regard to traditional risky-choice framing tasks.

Working Memory and Framing

There has been considerable research and theoretical interest in how working memory may influence decision making. Some of the most intriguing findings have come from the investigation of working memory and framing. For example, neuroimaging technology has suggested that the prefrontal cortex plays a crucial role in framing effects; an area of the brain that has also been implicated in studies measuring WMC. De Martino, Kumaran, Seymour, and Dolan (2006) provided participants with a series of financial risky-choice decision tasks. While performing the tasks, participants' cortical activities were monitored using fMRI. Their findings revealed that there was increased activity in participants' prefrontal cortex during the decision tasks. This finding coincides with work by Kane and Engle (2003) that suggests that the prefrontal regions of the brain play an important role in working memory function.

One dual-process model that focuses on memory is fuzzy-trace theory (Reyna & Brainerd, 1989, 1991). The model consists of two independent processes for encoding and storing information: verbatim memory and gist memory. Verbatim memory consists of encoding and storing precise details into long-term memory while gist memory consists of encoding and storing general qualities into long-term memory (Reyna & Brainerd, 1995). If a person were given a list of common dog names with Labrador excluded, then given another list ten minutes later with the same dog names as before with the exception that Labrador is included and asked to verify that the list of names is identical to the first; their answer will depend on the type of memory used. If verbatim recall is used, the person will recognize that Labrador was not on the first list because they will mentally picture seeing each dog name. If gist memory is used the person is likely to believe that Labrador was on the first list because gist memory only encodes the fact that the list was composed of common dog names rather than the exact names on the list.

Fuzzy-trace theory states that framing effects occur because people are focusing on the gist of information rather than verbatim information. Gist information consists of people preferring something over nothing in the gains condition and nothing over something in the loss condition as compared to verbatim information which consists of the exact numerical quantities in the framing problem (Reyna & Brainerd, 1991). Work with framing effects in children has discovered that younger children do not exhibit framing effects, because of the fact that they focus on verbatim information. As children age, framing effects begin to appear (Reyna & Ellis, 1994; Reyna & Farley, 2006). This corresponds to the finding that as children age, their WMC increases (Dempster, 1981). Accordingly, people with high WMC may encoding more elaborative representations that enable reasoning based on gist (e.g., encoding a richer context), whereas people with low WMC may primarily focus on salient and easily available numerical quantities (verbatim). The prediction that can be made from this theoretical approach is that high WMC participants should show framing effects whereas low WMC participants should show little or no framing effects (e.g., Reyna & Brainerd, 1991).

From a theoretical approach, Stanovich and West (2000) have suggested that non-normative reasoning would increase in tasks in which working memory is vital or when it becomes overloaded. In later research, Cokely and Kelley (2009) conducted a study in which participants were presented with a series of 40 gain/loss choice problems. This study was designed to test predictions for expected value choices and differences in how participants encode and process information. To examine their hypotheses, both the gain problems (e.g., “gain $150” or “5% chance of gaining $2000”) and loss problems (e.g., “lose $50” or “5% chance to lose $4000”) were presented in a numerical format. Their findings revealed that people with a higher WMC made more choices which coincided with expected value compared to those with low WMC. They added that higher WMC did not mean that participants actually calculated expected value, but that participants with high WMC may be using elaborative heuristic search processes (i.e., personalization of the decision; what are real world implications of this decision, how does this affect me, etc.) rather than the use of an abstract calculation such as expected value.

Predictions

The current experiment investigates how WMC interacts with the framing of a decision problem using Tversky and Kahneman’s (1981) Asian disease problem in order to test two competing hypotheses that make distinctly different predictions for how working memory may influence decisions. First, one could expect the results to mirror those of Cokely and Kelley (2009), in that people with high WMC are better able to process the probabilities within the task, leading to decreased framing effects as compared to those with low WMC. Alternately, research by Delaney and Sahakyan (2007) indicated that people with high WMC are more context dependent than those with low WMC. High WMC participants in the Delaney and Sahakyan study were less able to recall a word list than low WMC participants after engaging in a task that involved a mental context change (from going through a word list to describing one’s parents’ house). Because risky-choice decision tasks such as the Asian disease problem contain a larger amount of contextual information (a disease threatening the lives of people), a second hypothesis is that those with high WMC may be more affected by the contextual information within the scenario (the frame) than those with low WMC, leading to larger framing effects in those with high WMC. The latter hypothesis is also consistent with theoretical predictions derived from fuzzy-trace theory (Reyna & Brainerd, 1991). In sum, the predictions are that either high WMC participants will be better equipped to calculate the numerical quantities involved in the Asian disease problem leading to smaller framing effects than low WMC participants, or high WMC will show larger framing effects than low WMC participants because of their susceptibility to the contextual information in the Asian disease problem leading them to focus less on numerical information than the low WMC participants who will have less capacity to expend on the context surrounding the numerical information.

Method

Participants

Eighty-six undergraduates in Appalachian State University's research pool participated in exchange for course credit. One participant was excluded from the data set because of low math performance on the Operation Span task, leaving the number of participants at eighty-five (30 male, 54 female, 1 unreported). Approval was given for this project by the Institutional Review Board on February 19, 2009 (Appendix B). All research conducted in relation to this project is in strict accordance with ethical guidelines for research with humans as stated by the Institutional Review Board.

Materials

The Turner and Engle (1989) Operation Span (OSPAN) task requires participants to verify the truth of math operations while trying to remember a set of unrelated letters.

This study uses an automated version of the Turner and Engle OSPAN task, developed by Unsworth, Heitz, Schrock, and Engle (2005). For each trial, the participants were presented with a math problem and asked to determine the truth of the math problem (i.e., 2/1 + 6 = 7). Immediately after the participant judged the truth of the math problem, they were presented with a letter to remember. The operation–letter pairings were presented in sets of two to seven items. Following each complete set, the participant was instructed to recall the letters in the order presented. In order to ensure that participants were not trading off between solving the operations and remembering the letters, an 85% accuracy criterion on the math operations was required for all participants. The participants received several sets of practice trials before beginning the task. For all of the span measures, items were scored for accuracy in specific item recall (i.e., correct letter) as well as the correct position within the serial order of presentation. Therefore the total score for the OSPAN represents total number of correct items as well as the correct serial position.

Procedure

Participants entered the research lab, signed informed consent (Appendix C), and were asked to complete the OSPAN on the computer. When they finished the task, they were given the Asian disease problem and asked to rate their decision on a 7-point scale ranging from 1 (Definitely would recommend A) to 7 (Definitely would recommend B). They were then debriefed and the session ended.

Results

A stepwise regression was performed with the Asian disease rating as the dependent variable. The frame (gain/loss) was entered in the first model, followed by the

OSPAN score (WMC), then finally an interaction term was entered which modeled frame * WMC. The initial model showed that the frame significantly predicted Asian disease ratings, β = .283, $t(82)$ = 2.673, p = .009, 95% CI [.243, 1.655], showing that an overall framing effect was present. The OSPAN scores did not predict Asian disease ratings, β = .025, $t(81)$ = .233, p = .816, 95% CI [-.019, .024]. Finally, the interaction term significantly predicted Asian disease ratings β = .688, $t(80)$ = 2.313, p = .023, 95% CI [.007, .094]. The overall model explained a significant proportion of the variance for Asian disease ratings, R^2 = .106, $F(3, 80)$ = 4.282, p = .007.

In order to better understand the nature of the interaction, the two levels of the frame (gain vs. loss) were teased apart in the regression analysis with respect to WMC. In the gain frame, there was not a non-significant trend toward more risk averse Asian disease ratings as WMC increased, β = -.016, $t(80)$ = -1.214, p = .228, 95% CI [-.04, .01]. The loss frame showed a significant increase toward risk-seeking Asian disease ratings as WMC increased, β = .034, $t(80)$ = 1.983, p = .05, 95% CI [-.0001, .06]. This analysis shows an overall increase in the framing effect for those with high WMC and more consistency in ratings for those with low WMC (see Figure 2).

Discussion

This experiment explored the impact of WMC on the choices individuals make in a risky-choice scenario. The results support the hypothesis that those who have high WMC are more sensitive to the frame within the risky-choice scenario, and therefore show framing effects, while there is no evidence for a traditional framing effect among those with low WMC. Those with high WMC showed slightly larger preference toward risk-aversion in the gain frame than those with low WMC, while showing a much larger preference for risk-seeking in the loss frame than those with low WMC. The significant jump in risk-seeking for losses compared to the small difference in risk-aversion for gains is consistent with Kahneman and Tversky's (1979) Prospect theory, which describes people as being much more sensitive to losses than gains.

In order to reconcile the present findings with those of Cokely and Kelley (2009), methodological differences between the studies must be examined. An obvious difference between designs is the use of unequal expected values in Cokely and Kelley's (2009) choice alternatives. Results from Fulginiti and Reyna (1993) show that when the expected values for alternatives in the Asian disease problem are slightly unequal (in a direction opposite to the typical framing preference) framing effects diminish. It may be the case that when equal expected values are presented, as in the Asian disease problem, this allows high WMC participants to "cancel out" that part of the alternative comparison and consequently, they may be more influenced by the frame. Conversely, when unequal expected values are involved, this may lead high WMC participants to focus more on that part of the alternative comparison and less on the frame. As a result, framing effects may be less robust for high WMC participants.

Another design difference between this study and that of Cokely and Kelley (2009) is the format of the decision task; numeric or verbal. It may be that the format of the task plays a role in how the task is processed. Specifically, it may be that when the decision task is presented in a numerical format, high WMC participants are focused on the numeric information whereas low WMC participants are unable to process this part of the task as efficiently and focus more on the frame. Such processing differences should lead low WMC participants to be more influenced by the frame when the task involves numerically based information. Future research investigating working memory and framing should consider these factors as potential mechanisms for determining the strength and likelihood of the framing effect.

The findings may provide insight for dual-processing approaches that have been widely embraced in the decision making literature (e.g., Epstein, Pacini, Denes-Raj, & Heier, 1996; Evans & Over, 1996; Kahneman & Frederick, 2002; Sloman, 1996; Stanovich, 1999). The dual-process accounts posit that individuals construe information through a heuristic process which takes context and emotion into account (System 1 processing) or an abstract, de-contextualized process of calculation that is typically thought of as higher order processing (System 2 processing; Stanovich, 1999). The traditional dual process view considers System 2 processing the more rational mode of processing (Kahneman & Frederick, 2005; Stanovich, 1999), but the results in this study suggest that encoding processes play an important role for the study of rational thought. Consideration of working memory as a variable resource, which can determine cognitive ability for making rational choices, may help clarify future research in this area (Cokely & Kelley, 2009).

In a similar manner, some dual-process approaches have relied on effort and importance as determining factors for the two processing styles. These findings tend to show that effort, as motivated by task importance (personal or situational), will influence the likelihood of biases and decision making fallacies such as the framing effect (e.g., Biswas, 2009; Igou & Bless, 2007; McElroy & Seta, 2003; Meyers-Levy & Maheswaran, 2004). Future research in this area should consider how effort may influence an individual’s ability to perform decision making tasks in light of WMC. It may be the case that an overall increase in effort by participants may increase overall framing effects among lower WMC participants.

In related work, Stanovich and West (1998, 1999, 2000) have explored whether rational choice may be tied to intelligence. Recently, Stanovich and West (2008) found that there was a small interaction between SAT and risky-choice framing effects, where those with higher scores displayed slightly larger framing effects (opposite to their predictions). Because WMC has been shown to have a moderate correlation with scores on IQ tests (Luciano et. al., 2001), the association between framing effects and higher cognitive ability is consistent with our findings. Further, Stanovich (2008) suggests an individual difference variable, the Master Rationality Motive (MRM), as a means for understanding rational choice. This approach suggests that individuals vary in how much they seek rational integration of information. This motive is seen as the impetus for searching across preferences, ending in rational integration. In other words, at varying levels, there is an innate desire for individuals to look back upon the reasons for their behaviors and integrate them in such a fashion that they feel such behaviors are justified according to their beliefs. As Stanovich points out, the MRM is to be differentiated from cognitive ability or intelligence. However, this processing difference certainly seems to share similarities with WMC, leaving speculation for whether the differences in MRM processing could reflect differences associated with high and low working memory. In light of this investigation's findings, it may be beneficial for future studies to approach the ability to integrate multiple levels of preference with one's memory storage and maintenance capacity.

A number of individual difference factors have been shown to attenuate the framing effect and are likely to rely on working memory. For example, need-for-cognition, which reflects the extent that people engage in effortful thought and how much they enjoy it, has been shown to influence the strength of the framing effect (e.g., Chatterjee, Heath, Milberg & France, 2000; Simon, Fagley & Halleran, 2004; Smith & Levin, 1996; Zhang & Buda, 1999). Numeracy, a skill variable that tests individuals' abilities to do statistical and probabilistic reasoning tasks seems a likely candidate for WMC due to the fact that it can require complex processing of numerical information. Similar to need-for-cognition, numeracy has also been shown to be a predictor of not only how prone individuals are to biases and decision making fallacies, but an indicator that there are multiple processes that may lead to biases as well as rational decision making (Peters & Levin, 2008; Peters et al., 2006). Peters and Levin (2008) suggested that WMC may interact with numeracy in creating different methods of approaching the risky-choice framing effect.

This investigation looked at the differences that exist in risky-choice decision making between those with higher verses lower cognitive ability, as measured through WMC. The results of this study have shown that higher cognitive abilities do not always reflect rational decision making. Rather than acting in accordance with normative reasoning, the results indicate that higher ability individuals may rely on more thorough encoding and decision making processes (Baron, 1985; Cokely & Kelley, 2009). Specifically, this study suggests that individuals higher in WMC rely on gist based memory representations due to differential encoding, leading them toward a more biased decision in the case of traditional risky-choice framing problems. This provides an alternative approach to traditional dual process theories of rationality that focuses on quantitative differences in memory rather than qualitative differences in reasoning in order to predict performance.

References

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (pp. 47-89). New York: Academic Press.

Baron, J. (1985). *Rationality and intelligence*. New York, NY US: Cambridge University Press.

Biswas, D. (2009). The effects of option framing on consumer choices: Making decisions in rational versus experiential processing modes. *Journal of Consumer Behavior, 8*, 284-299.

Chatterjee, S., Heath, T.B., Milberg, S.J., & France, K. R. (2000). The differential processing of price in gains and losses: The effects of frame and need for cognition. *Journal of Behavioral Decision Making*, *13*, 61-75.

Cokely, E. T., & Kelley, C. M. (2009). Cognitive abilities and superior decision making under risk: A protocol analysis and process model evaluation. *Judgment and Decision Making, 4,* 20-33.

Cokely, E., Kelley, C., & Gilchrist, A. (2006). Sources of individual differences in working memory: Contributions of strategy to capacity. *Psychonomic Bulletin & Review*, *13*, 991-997.

Conway, A., Cowan, N., Bunting, M., Therriault, D., & Minkoff, S. (2002). A latent variable analysis of working memory capacity, short-term memory capacity, processing speed, and general fluid intelligence. *Intelligence*, *30*, 163-184.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, *19*, 450-466.

Daneman, M., & Merikle, P. M. (1996). Working memory and language comprehension: A meta-analysis. *Psychonomic Bulletin & Review, 3,* 422–433.

Delaney, P., & Sahakyan, L. (2007). Unexpected costs of high working memory capacity following directed forgetting and contextual change manipulations. *Memory and Cognition*, *35,* 1074-1082.

De Martino, B., Kumaran, D., Seymour**,** B., & Dolan, R. J. (2006). Frames, biases, and rational decision-making in the human brain, *Science, 313*, 684–687.

Dempster, F.N. (1981). Memory span: sources of individual and developmental differences. *Psychological Bulletin*, *89,* 63–100.

Dougherty, M., & Hunter, J. (2003). Hypothesis generation, probability judgment, and individual differences in working memory capacity. *Acta Psychologica*, *113*, 263-282.

Engle, R. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science*, *11*, 19-23.

Engle, R., Tuholski, S., Laughlin, J., & Conway, A. (1999). Working memory, short-term memory, and general fluid intelligence: A latent-variable approach. *Journal of Experimental Psychology: General*, *128*, 309-331.

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,* 390-405.

Evans, J. St. B. T., & Over, D. E. (1996). *Rationality and reasoning*. Hove, UK: Psychology Press.

Fagley, N., & Miller, P. (1997). Framing effects and arenas of choice: Your money or your life?. *Organizational Behavior and Human Decision Processes*, *71*, 355-373.

Ferguson, E., & Gallagher, L. (2007). Message framing with respect to decisions about vaccination: The roles of frame valence, frame method and perceived risk. *British Journal of Psychology*, *98*, 667-680.

Fulginiti, J. V., & V. F. Reyna. (1993, November). *Qualitative versus quantitative processing in decision making: A fuzzy-trace theory analysis.* Paper presented at the annual meeting of the Society for Judgment and Decision Making, Washington, DC.

Igou, E. R., & Bless, H. (2007). On undesirable consequences of thinking: Framing effects as a function of substantive processing. *Journal of Behavioral Decision Making*, *20*, 125-142.

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In T. Gilovich, D. Griffin, and D. Kahneman [eds]. *Heuristics & Biases: The Psychology of Intuitive Judgment* (pp. 49-81). New York: Cambridge University Press.

Kahneman, D., & Frederick, S. (2005). A model of heuristic judgment. *The Cambridge handbook of thinking and reasoning* (pp. 267-293). New York, NY US: Cambridge University Press.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*, 263-291.

Kane, M. J., & Engle, R. W. (2003). The role of the prefrontal cortex in working-memory capacity, executive attention, and general fluid intelligence: An individual differences perspective. *Psychonomic Bulletin & Review, 9*, 637-671.

Kuhberger, A. (1998). The influence of framing on risky decisions: A meta-analysis. *Organizational Behavior and Human Decision Processes, 75*, 23-55.

Kuhberger, A., & Tanner, C. (2009). Risky choice framing: Task versions and a comparison of prospect theory and fuzzy trace theory. *Journal of Behavioral Decision Making.* Advance online publication. doi: 10.1002/bdm.656

LeFevre, J.-A., DeStefano, D., Coleman, B., & Shanahan, T. (2004). Mathematical cognition and working memory. In J. I. Campbell (Ed.), *Handbook of Mathematical Cognition* (pp. 361-376). New York: Psychology Press.

Levin, I. P., & Gaeth, G. J. (1988). Framing of attribute information before and after consuming the product. *Journal of Consumer Research, 15,* 374–378.

Levin, I. P., Schneider, S.L., & Gaeth, G.J. (1998). All frames are not created equal: A typology and critical analysis of framing effects. *Organizational Behavior & Human Decision Processes, 76*, 149-188.

Levin, I., Gaeth, G., Schreiber, J., & Lauriola, M. (2002). A new look at framing effects: Distribution of effect sizes, individual differences, and independence of types of effects. *Organizational Behavior and Human Decision Processes, 88,* 411-429.

Luciano, M., Wright, M. J., Smith, G. A., Geffen, G. M., Geffen, L. B., & Martin, N. G. (2001). Genetic covariance among measures of information processing speed, working memory and IQ. *Behavior Genetics, 31,* 581-592.

McCormick, M., & McElroy, T. (2009). Healthy choices in context: How contextual cues can influence the persuasiveness of framed health messages. *Judgment and Decision Making, 4,* 248-255.

McElroy, T., & Seta, J. J. (2003). Framing effects: An analytic-holistic perspective. *Journal of Experimental Social Psychology*, *39*, 610-617.

McNamara, D., & Scott, J. (2001). Working memory capacity and strategy use. *Memory & Cognition*, *29*, 10-17.

Meyerowitz, B. E., & Chaiken, S. (1987). The effect of message framing on breast self-examination attitudes, intentions, and behavior. *Journal of Personality and Social Psychology, 52*, 500–510.

Meyers-Levy, J., & Maheswaran, D. (2004). Exploring message framing outcomes when systematic, heuristic or both types of processing occur. *Journal of Consumer Psychology, 14*, 159-167.

Peters, E., & Levin, I. P. (2008). Dissecting the risky-choice framing effect: Numeracy as an individual-difference factor in weighting risky and riskless options. *Judgment and Decision Making, 3,* 435–448.

Peters, E., Västfjäll, D., Slovic, P., Mertz, C., Mazzocco, K., & Dickert, S. (2006). Numeracy and decision making. *Psychological Science*, *17*, 407-413.

Reyna, V. F. & C. J. Brainerd. (1989, November). *Fuzzy-trace theory of framing effects in choice*. Presented at the 30th Annual Meeting of the Psychonomic Society, Atlanta, GA.

Reyna, V.F., & Brainerd, C.J. (1991). Furzy-trace theory and framing effects in choice: Gist extraction, truncation, and conversion. *Journal of Behavioral Decision Making, 4,* 249-262.

Reyna, V. F., & Brainerd, C. J. (1995). Fuzzy-trace theory: An interim synthesis. *Learning and Individual Differences, 7,* 1–75.

Reyna, V. F., & Ellis, S. C. (1994). Fuzzy-trace theory and framing effects in children's risky decision making. *Psychological Science, 5,* 275-279.

Reyna, V. F., & Farley, F. (2006). Risk and rationality in adolescent decision making: Implications for theory, practice, and public policy. *Psychological Science in the Public Interest, 7,* 1-44.

Rothman, A. J., Kelly, K. M., Hertel, A. W., & Salovey, P. (2003). Message frames and illness representations. In L. D. Cameron & H. Leventhal (Eds.), *The self-regulation of health and illness behavior* (pp. 278–296). New York: Routledge.

Simon, A. F., Fagley, N.S., & Halleran, J.G. (2004). Decision framing: Moderating effects of individual differences and cognitive processing. *Journal of Behavioral Decision Making, 17,* 77-93.

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin, 119*, 3 – 22.

Smith, S. M., & Levin, I.P. (1996). Need for cognition and choice in framing effects. *Journal of Behavioral Decision Making, 9*, 283-290.

Stanovich, K. (1999). *Who is rational?: Studies of individual differences in reasoning*. Mahwah, NJ US: Lawrence Erlbaum Associates Publishers.

Stanovich, K. E. (2008). Higher-order preferences and the master rationality motive. *Thinking & Reasoning, 14*, 111-127.

Stanovich, K. E., & West, R. F. (1998). Individual differences in rational thought. *Journal of Experimental Psychology: General, 127*, 161–188.

Stanovich, K. E., & West, R. F. (1999). Discrepancies between normative and descriptive models of decision making and the understanding/acceptance principle. *Cognitive Psychology, 38,* 349–385.

Stanovich, K.E., & West, R.F. (2000). Individual differences in reasoning: Implications for the rationality debate? *Behavioral and Brain Sciences, 23,* 645-726.

Stanovich, K. E., & West, R. F. (2008). On the relative independence of thinking biases and cognitive ability. *Journal of Personality and Social Psychology, 94,* 672-695.

Turley-Ames, K., & Whitfield, M. M. (2003). Strategy training and working memory task performance. *Journal of Memory & Language, 49,* 446-468.

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory & Language, 28,* 127-154.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science, 211,* 453–458.

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods, 37,* 498–505.

Von Neumann, J., & Morgenstern, O. (1947). *Theory of games and economic behavior*. Princeton, New Jersey: Princeton University Press.

Zhang, Y., & Buda, R. (1999). Moderating effects of need for cognition on responses to positively versus negatively framed advertising messages. *Journal of Advertising, 28*, 1-15.

Figure Captions

Figure 1. S-shaped value function developed by Kahneman and Tversky (1979).

Figure 2. Predicted Asian disease rating as a function of high/low WMC and the frame. Higher OSPAN score represents higher WMC.

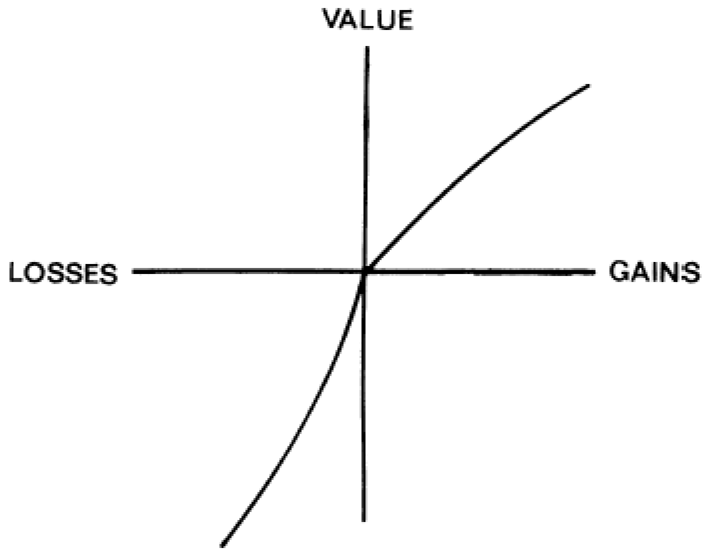

Figure 1. S-shaped value function developed by Kahneman and Tversky (1979).

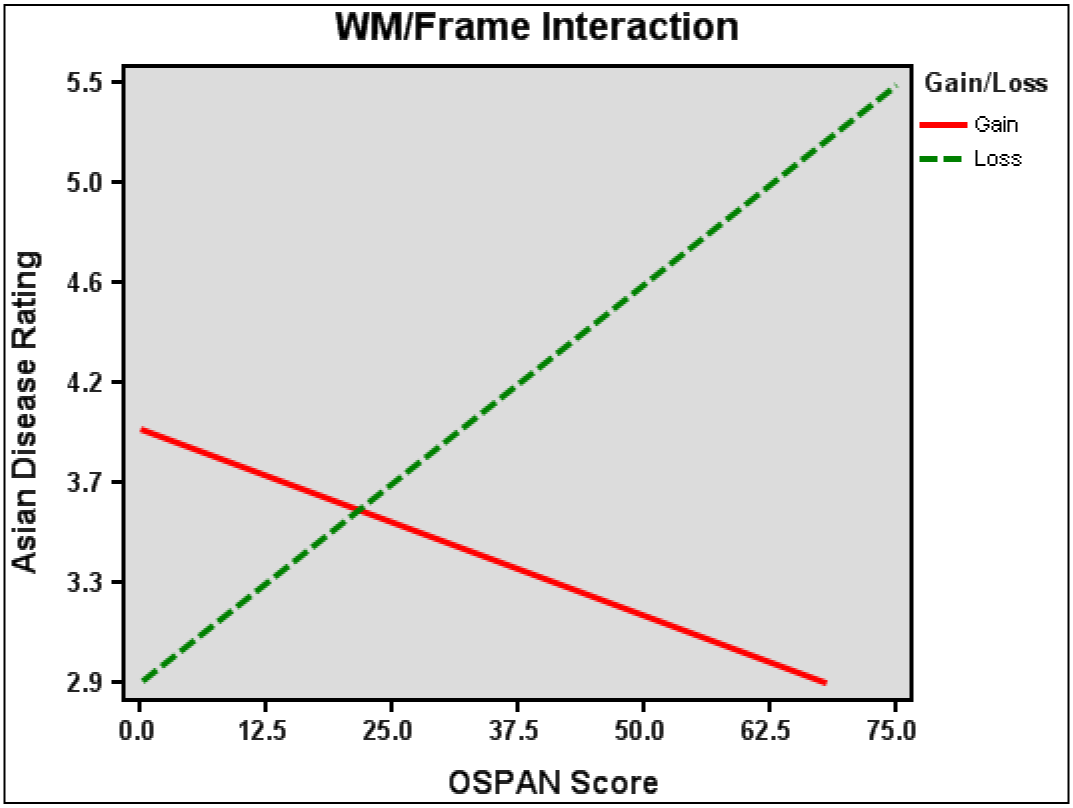

Figure 2. Predicted Asian disease rating as a function of high/low WMC and the frame. Higher OSPAN score represents higher WMC.

Appendix A

Stimulus Materials: Asian Disease problem (Tversky & Kahneman, 1981).

Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:

If program A is adopted, 200 people will be saved.

If Program B is adopted, there is a one-third probability that 600 people will be saved and a two-thirds probability that no people will be saved.

Please rate your opinion of these options on the following scale:

1………2………3………4………5………6………7

Definitely would	Definitely would
Recommend <u>A</u>	Recommend <u>B</u>

Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:

If program A is adopted, 400 people will die.

If Program B is adopted, there is a one-third probability that nobody will die and a two-thirds probability that 600 people will die.

Please rate your opinion of these options on the following scale:

1………2………3………4………5………6………7

Definitely would	Definitely would
Recommend <u>A</u>	Recommend <u>B</u>

Appendix B

IRB Approval Form.

From: ______________________________________

Jay W. Cranston, M.D., Chair, Institutional Review Board

Date: 2/19/2009

RE: Notice of IRB Exemption

Study #: 09-0164
Study Title: The Relationship Between WMC and Decision Making
Exemption Category: (2) Anonymous Educational Tests; Surveys, Interviews or Observations

This submission has been reviewed by the above IRB Office and was determined to be exempt from further review according to the regulatory category cited above under 45 CFR 46.101(b). Should you change any aspect of the proposal, you must contact the IRB before implementing the changes to make sure the exempt status will continue. Otherwise, you will not need to apply for annual approval renewal. Please notify the IRB Office when you have completed the study.

Appendix C
Consent Form for Participants.

APPALACHIAN STATE UNIVERSITY

Informed Consent for Participants in Research
Projects Involving Human Subjects

Title of Project: Decision Making
Investigator(s): Jonathan Corbin, Cassie Black, Kelli Haas, James Mills, Dr. Todd McElroy

I. Purpose of this Research/Project

The study in which you are being asked to participate is exploring the relationship between working memory capacity and decision making. This type of study is important to researchers and educators because it may allow them to understand rationality which in turn can promote more rational decisions.

II. Procedures

In today's session you will be asked to take part in a computerized task. You will also complete a questionnaire in which you will make a decision. Your involvement will only be necessary on this one occasion and will take place in the Psychology Research Lab.

III. Risks

There are no anticipated physical or psychological risks associated with participating in this study.

IV. Benefits

We cannot guarantee any direct benefits for taking part in this study. One benefit to you is the opportunity to learn about how empirical research is conducted in the field of psychology. However, while you may not directly benefit from participating in this study, your participation will help to increase knowledge that could help others in the future.

V. Extent of Anonymity and Confidentiality

Please be assured that confidentiality is a priority with this study. The only record we will have of your participation will be your name on this informed consent statement. During data collection, all data will only be connected using a participant number. This number will be the same for all aspects of data you provide, but will not be included on the informed consent statement. Therefore, it will be impossible for anyone to identify any participant by the responses that he or she gives.

VI. Compensation

In the event that you are receiving course credit for you participation, we will fill out a course credit form that you may return to your instructor for credit.

VII. Freedom to Withdraw

The previous information is provided so that you can determine whether you wish to participate in this study. You may choose not to answer specific questions or respond to experimental situations without penalty. Your participation is voluntary, and you should be aware that even if you agree to participate, you are free to withdraw from the experiment at any time, without penalty. Choosing not to participate in this study will not affect your relationship with Appalachian State University, its instructors, or the students involved in conducting this study in any way.

VIII. Approval of Research

Appalachian State University and the Psychology Department support the practice of protection for human subjects participating in research. Accordingly, this research project has been approved, as required, by the Institutional Review Board of Appalachian State University.

________________________ __________________________

IRB Approval Date Approval Expiration Date

IX. Subject's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities:

- I agree to participate seriously, and honestly, and to the best of my ability.
- I will refrain from discussing my participation with friends or acquaintances who may also participate in this research project until the study has been completed in May of 2009.

X. Participant's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

____Date___________

Subject signature

Should I have any questions about this research or its conduct, I may contact:

Cassie Black	Jonathan Corbin	Kelli Haas
Investigator	Investigator	Investigator
(828) 719-5502	(828) 230-0671	(704) 301-7075
lb47644@appstate.edu	corbinj@appstate.edu	kh51845@appstate.edu

If, at any time during this study, you feel your rights have been violated, you may contact the Institutional Review Board by mail, email, or phone.

Robert L. Johnson	**828-262-2692**	**johnsonrl@appstate.edu**
Administrator, IRB	Telephone	e-mail

Graduate Studies and Research
Appalachian State University
Boone, NC 26608

Biographical Sketch

Jonathan Charles Corbin was born in Jacksonville, NC on November 22, 1985. He graduated with a Bachelor of Arts degree in Psychology from the University of North Carolina at Asheville in May, 2004. In the fall of 2004, he entered the Experimental Psychology Masters program at Appalachian State University. The Masters of Arts degree was awarded in May 2010. In August 2010, Mr. Corbin will commence work toward his PhD. in Human Development at Cornell University.