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Memory reflected in our decisions: Higher working memory capacity predicts greater bias in risky choice

Jonathan Corbin,* Todd McElroy and Cassie Black
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. Participants with high working memory capacities demonstrated well pronounced framing effects, while those with low working memory capacities did not. This pattern suggests that, in a typical risky-choice decision task, elaborative encoding of task information by those with high working memory capacity may lead them to a more biased decision compared to those with low working memory.

Keywords: Asian disease problem, framing, risky choice, working memory capacity, context, fuzzy-trace theory.

1 Introduction

Throughout our lives, we are faced with many small and large decisions that exist within a variety of contexts. 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 risky-choice framing effects.

Risky-choice framing effects are derived from Prospect Theory predictions (Kahneman & Tversky, 1979) and have become one of the most studied examples of rational decision making. According to Prospect Theory the presentation of an outcome as either a loss or gain affects the amount of risk a person is willing to accept. This effect is attributed to differences in perceived subjective value and is captured by the value function, which is concave for gains, yielding risk-aversive preferences, and convex for losses, yielding risk-seeking preferences.

In the most widely tested example, Tversky and Kahneman (1981) presented participants with an Asian disease problem wherein 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 people that would be "saved" or "die". Their findings revealed that, despite identical expected values, most 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, Schneider, & Gaeth, 1998).

1.1 Working memory and framing

There has been considerable research and theoretical interest in how working memory capacity (WMC) may influence decision making. Multiple studies have shown that WMC can predict differences in strategy use when encoding information (Cokely, Kelley, & Gilchrist, 2006; McNamara & Scott, 2001; Turley-Ames & Whitfield, 2003) as well as number and strength of alternate hypotheses one can generate when making probability judgments (Dougherty & Hunter, 2003). Those with high WMC appear to employ elaborative encoding techniques while those with low WMC tend to rely on rote-rehearsal (Turley-Ames & Whitfield, 2003). The difference in encoding technique generally leads to superior decision making for those with high WMC (Cokely & Kelley, 2009). The difference may distinguish high and low WMC with regard to traditional risky-choice framing tasks.

One dual-process model that focuses on memory is fuzzy-trace theory (Reyna & Brainerd, 1989; Reyna & Brainerd, 1991; Reyna & Brainerd, 1995). 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 ex-

*Thanks to James Mills for help in collecting the data, and to the reviewers for helpful comments. Address for Corbin or McElroy: Department of Psychology, Appalachian State University, Boone, NC 28608. Email: jccorbin1985@gmail.com.

act numerical quantities in the framing problem (Reyna & Brainerd, 1991). Recent research by Kuhberger and Tanner (2009) has shown multiple replications of framing predictions made by fuzzy-trace theory. Work with framing effects in children has discovered that younger children do not exhibit framing effects, due to 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), while 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 while low WMC participants should show little or no framing effects (e.g., Reyna & Brainerd, 1991).

Stanovich and West (2000) have suggested that non-normative reasoning would increase in tasks where working memory is vital or when it becomes overloaded. In later research, Cokely and Kelley (2009) conducted a well-designed 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 elaborative heuristic search. 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. People with a higher WMC made more choices that coincided with expected value compared to those with low WMC. However, higher WMC was not associated with expected value calculations. Instead, participants with higher WMC engaged in more thorough and elaborative heuristic based decision making.

While this methodology was appropriate for testing their hypotheses, it differs substantially from the typical risky-choice design (Levin, Schneider, & Gaeth, 1998) represented by the Asian disease problem (Table 1). One crucial difference between designs is the equality of expected value between alternatives. In the Asian disease problem, the alternatives have equal expected values whereas in the Cokely and Kelley (2009) problems, the alternatives had unequal expected values. Another difference lies in their presentational format. Cokely and Kelley noted that a large amount of deliberation and contextualization of problems led to expected-value choices. However, the numerical format used differs substantially from the context of the Asian disease problem. In fact, prior research has shown that presentation of a decision task in the context of money shows a weaker framing effect compared to the context of human lives (Fagley & Miller, 1997). Therefore, given the differences between the Cokely and Kelley, method and a typical risky-choice design, alternative predictions can be made for how working memory may interact with a decision task such as the Asian disease problem.

1.2 Predictions

The current experiment investigates how WMC interacts with the framing of a decision problem using Tversky and Kahneman's (1981) Asian disease problem. Two competing hypotheses make distinctly different predictions for how working memory may influence decisions in a risky-choice scenario. 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. Alternatively, research by Delaney & Sahakyan (2007) indicated that people with high WMC are more context dependent than those with low WMC. Since risky-choice decision tasks such as the Asian disease problem are more contextually developed, 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), and with the inference from developmental increases in both WMC and framing effects.

2 Methods

2.1 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 due to procedural problems, leaving the number of participants at eighty-five.

2.2 Materials

The Turner and Engle (1989) 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 participants judged the truth of the math problem, they were presented with a letter to remember. The

Table 1: The Asian disease problem framed as gains and losses.

Problem	Gains	Losses
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 A is adopted, 400 people will die.
	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.	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.

operation-letter pairings were presented in sets of two to seven items. Following each complete set, the participants were 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. 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 ordinal position.

2.3 Procedure

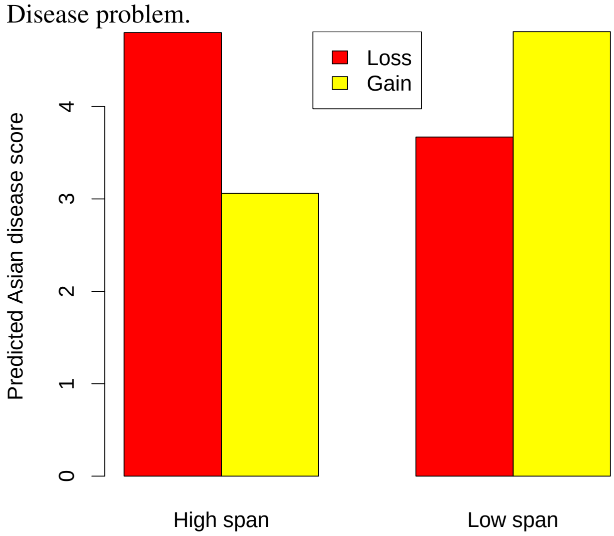
Participants entered the research lab, signed informed consent, and were asked to complete the OSPAN on the computer. When they finished the task, they were given the Asian disease problem (see Table 1) and asked to rate their decision on a 7-point scale ranging from 1 (Definitely would recommend A)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

3 Results

First, an independent samples t-test was run in order to determine whether or not there was a significant impact of the frame on decisions. This analysis shows a significant framing effect t(82) = –2.67, p = .009, the level of risk-seeking was higher in the loss condition (M= 4.28) than the gain condition (M = 3.33). In order to look at the effect of working memory on framing, participants' OSPAN scores were entered into a general linear model as a covariate, with frame as the independent variable and their decision as the dependent variable. The interaction between frame and OSPAN score was significant F(1, 84)= 5.35, p = .023, while the addition of the OSPAN score to the model rendered the framing effect non-significant F(1, 84) = 1.336, n.s.[1]

[1]The data are included with the article in this issue of the journal.

Figure 1: Modeled decision for high and low WMC participants (calculated as 1 SD from the mean) in the Asian Disease problem.



Another way of looking at the data is to explore participants in the high and low ends of the sample. To do so, we constructed a model, calculating high and low working memory scores by adding and subtracting a standard deviation from the OSPAN mean (M = 40.18, high = 56.72, low = 23.66). Each value was entered into a regression equation to predict one's decision on the Asian disease problem based on WMC. Surprisingly, for those with high WMC, the model predicted large framing effects (Gains = 3.06, Losses = 4.8) whereas a reversal was predicted for those with low WMC (Gains = 4.81, Losses = 3.67) (see Figure 1).

4 Discussion

This experiment explored the impact of working memory capacity 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 the framing effect is absent among those with low WMC.

Our 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 generally posit that individuals construe information in two different ways. 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).

Similarly, 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 through importance, will influence the likelihood of biases and decision making fallacies such as the framing effect (e.g., Biswas, 2009; Igou & Bless, 2007; Meyers-Leny & Maheswaran, 2004; McElroy & Seta, 2003). Future research in this area should consider how effort may influence an individual's ability to perform decision making tasks in light of working memory. It may be the case that importance and effort can both facilitate improvement and overload working memory, depending upon personal and situational factors.

In related work, Stanovich and West (1998, 1999, 2000) have explored whether rational choice may be tied to intelligence. Recently, Stanovich and West (2008) were surprised to find that there was a small interaction between SAT and framing, where those with higher scores displayed slightly larger framing effects (opposite to their predictions). Since working memory 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. As Stanovich points out, the MRM is to be differentiated from cognitive ability or intelligence. As Stanovich points out, the MRM can be differentiated from cognitive ability and intelligence. However, the current data suggest that cognitive abilities, such as working memory capacity, can in some cases predict MRM activities.

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 working memory. Similar to need-for-cognition, numeracy has also been shown to be a predictor of how prone individuals are to biases and decision making fallacies (Peters & Levin, 2008; Peters et al., 2006).

One question that deserves further investigation is how our findings may be reconciled with those of Cokely and Kelley (2009). It is clear that the two studies rely on different methodologies, both involving a type of framing, yet producing different findings. Differentiating specific factors that may be leading to the different findings is beyond the scope of this paper. However, a couple of factors seem to be reasonable starting points.

First, it would seem prudent to examine whether the equality of expected values among the alternatives interacts with WMC and framing. 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 distinction is the format of the decision task; numeric or verbal. 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.

In sum, we have examined the differences that exist in risky-choice decision making between those with higher verses lower cognitive ability, as measured through WMC. Our results 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, individuals higher in WMC may 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 possibility 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.

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