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A Review of the Certainty Effect and Influence of Information Processing

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Abstract
This review considers two explanations for behavioral decision-making in reference to the certainty and framing effects. The findings from various paradigms such as a single questionnaire, gambles with repetition, and gambles guided by feedback are explained either by prospect theory or by expected utility theory. Finally this review attempts to account for the different findings and offers a possible explanation for the conflicting results by considering the role of experience which in turn can alter how information in processed as described by fuzzy trace theory which is a dual process theory of reasoning.

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A Review of the Certainty Effect and Influence of Information Processing

In the field of decision-making, there are numerous theories that attempt to explain, predict, and prescribe risk-taking and strategies for making decisions. For each of these theories, there is an attempt to explain results pertaining to the certainty effect (i.e., underestimating a probable option compared with a certain one) which was first recognized in the publication that introduced prospect theory (Kahneman & Tversky, 1979). Prospect theory was important because it offered a solution to the Allais paradox, which questioned the use of classical economic theories to explain how people typically made decisions in everyday situations (Allais, 1953; Kahneman & Tversky, 1979). Each of the results of the various paradigms (e.g., single gamble questions, repeated decision-making, and decisions guided by feedback) that tested the certainty effect may be explained via fuzzy trace theory by accounting for differences in information processes concerning the use of verbatim (i.e., the use of detailed information) and gist processes (i.e., the use of conceptual information) (Reyna, 2004; 2008; Reyna & Farley, 2006; Rivers, Reyna, & Mills, 2008). By using fuzzy trace theory, it may be possible to begin to unify the different decision-making paradigms and explain why decision-makers follow outcomes anticipated by expected utility theory or prospect theory (Reyna, 2004; 2008).

The article that featured the Allais paradox criticized using expected utility theory to describe and predict humanistic risk taking by demonstrating that it failed to account for differences in psychological value compared with monetary value (Allais, 1953). Value in this case is defined as desirability or usefulness of an outcome (Bernoulli, 1738/1954; Von Neumann & Morgenstern, 1964). Additionally, that article criticized the overreliance on axioms to determine option preferences, and the lack of application of expected utility theory outside of economics (Allais, 1953; Von Neumann & Morgenstern, 1964). While the criticism had validity, it should be noted that Von Neumann and Morgenstern did not intend expected utility

theory to predict how people made choices, but to offer a means to make sound economic decisions. They stated that it was a starting point for other researchers and theorist to expand and develop.

Prospect theory accounts for how people tend to make choices that do not follow mathematical optimality, which is traditionally associated with expected utility theory (Allais, 1953; Kahneman & Tversky, 1979; Plous, 1993; Von Neumann & Morgenstern, 1964). This was accomplished by weighting the influence of probability or using decision weights; where outcomes that are improbable seem more likely than they actually are (Kahneman & Tversky, 1979; Plous, 1993). Additionally, Kahneman and Tversky's model demonstrated that gains and losses do not possess the same amount of value for a given dollar amount.

Following prospect theory, research began to consider individual differences such as gender and age and how these factors influence risk taking in relation to the certainty effect (Hartog, Ferrer-i-Carbonell, & Jonker, 2002; Johnson & Gleason, 2009; Reyna & Farley, 2006; Rivers et al., 2008). Research has also began to explore different personality types and consider variations in risk taking that may differ from the results predicted by prospect theory (Sasaki & Kanachi, 2005).

Other modifications to prospect theory have begun to consider the decision-making process when an individual learns from experience (e.g., decisions guided by feedback) as well as having the opportunity to make repeated gambles (e.g., repeated decision-making tasks) (Barron & Erev, 2003; Sasaki & Kanachi, 2005; Shafir, Reich, Tsur, Erev, & Lotem, 2008; Wedell & Bockenholt, 1994). When dealing with repeated and decision-making guided by feedback, issues have arisen concerning the certainty effect, where participants' decisions begin to follow choices that would be predicted by expected utility theory. This outcome is also

referred to as the reversed certainty effect (Barron & Erev, 2003; Sasaki & Kanachi, 2005), leading to a renewed debate as to whether or not the standard for predicting decisions should revert back to expected utility theory. The goal of this paper is to provide a comprehensive review covering topics such as individual differences, decisions with single gambles, gambles with repetition, as well as gambles guided by feedback, and provides a theoretical interpretation that will attempt to explain the various findings that may be attributed to information processing.

Limitations of Expected Utility Theory

Expected utility theory is a decision-making theory that dictates rational choice by a decision-maker using rules or axioms in order to maximize net gains (Camerer, 2003; Plous, 1993; Von Neumann & Morgenstern, 1964). While this theory had its popularity, questions arose about the applicability for describing the psychology of decision-making. Two major phenomena, the Allais Paradox and the Asian disease problem, were able to illustrate how this theory failed to predict how people make decisions by showing repeated violations to the axioms of expected utility theory, which would later result in utility theory falling out of popularity (Allais, 1953; Tversky & Kahneman, 1981).

An Overview of the Allais Paradox

The Allais paradox is a set of problems that results in choices that contradict predictions by expected utility theory. An example of a question from the paradox is illustrated in Table 1 (Allais, 1953).

Table 1

Example of the Allais Paradox Question

Choice A	33% of winning $2,500, 66% of winning $2,400, and 1% of winning nothing at all
Choice B	Win $2,400 for sure
Choice C	33% of winning $2,500 and 67% of winning nothing at all
Choice D	34% of winning $2,400 and 66% of winning nothing at all

When considering the choices made between option A, a 33% chance of winning $2,500, 66% chance of winning $2,400 and a 1% chance of winning nothing at all, compared with B, a sure win of $2,400, the majority of people prefer B, where there is not risk involved despite a higher expected value associated with option A (Kahneman & Tversky, 1979). In the second set of choices, which are also part of the paradox, the majority of participants often chose option C, 33% of winning $2,500 and 67% of winning nothing at all, over D, 34% of winning $2,400 and 66% of winning nothing at all. These results are a violation of the axiom called cancellation which states that a decision maker should base their choices on how options are different and common features should cancel out (Allais, 1953; Kahneman & Tversky, 1979; Plous, 1993). Note this shift in preference is not as prevalent in expert decision-makers.

Framing and the Asian Disease Problem

Another issue raised against expected utility theory is referred to as framing. Framing is how the presentation of choices influences how a decision is made, which includes personal biases such as norms and habits (Cheung & Mikels, 2011; Tversky & Kahneman, 1981). An example of framing is presented in the Asian disease problem, which is a decision-making problem that illustrates the inability of expected utility theory to predict option preference (Tversky & Kahneman, 1981).

A study using 152 participants had them read a passage where they were told that a disease from Asia was going to be in the United States with an expected mortality of 600 lives (Tversky & Kahneman, 1981). Two programs could be selected to fight the illness. One group was presented with two options, program A, 200 lives would be saved if adopted versus program B, where there was a 1/3 chance that 600 lives could be saved or a 2/3 chance that nobody would be saved. In this scenario, the majority of participants preferred program A. For the second group, the options were if program A is selected 400 people will die versus if program B is selected there is a 1/3 chance nobody will die and a 2/3 chance that 600 will die. In this scenario the majority of participants chose program B.

As with the Allais paradox, there is a violation of one of the axioms of expected utility theory, in this case the axiom of invariance, which states that the manner that options are presented should not influence a decision-maker's choice (Plous, 1993; Von Neumann & Morgenstern, 1964). As with the Allais paradox, the framing effect does not have as great an influence on expert decision-makers.

Subtypes of Framing

Since the Asian disease problem's publication, various themes have been used to test the framing effect by changing the scenario. Researchers have since categorized the different versions of the framing effect into three groups (e.g., standard risky choice framing, attribute framing, and goal-framing) (Lauriola, Russo, Lucidi, Violani, & Levin, 2005; Levin, Schneider, & Gaeth, 1998; Simon, Fagely, & Halleran, 2004). The standard risky choice framing paradigm tends to be situations such as the Asian disease problem, whereas attribute framing tends to focus on the attributes or traits of a given situation or item (e.g., car with power windows versus a car without power windows) (Lauriola et al., 2005; Levin et al., 1998; Simon et al., 2004). Finally,

goal-framing focuses on the achievement of a goal or the failure to achieve a goal (e.g., job interview increases income or job interview will result in loss of income) (Lauriola et al., 2005; Levin et al., 1998; Simon et al., 2004). The development of the categories is a response to the various alterations to the framing effect where outcomes still follow the predicted trends.

For both cases of violations of expected utility theory, the Allais paradox and the framing effect, the use of gains and losses with certain outcomes results in the same effect where if gains are involved, a risky prospect or choice is avoided resulting in the well-known certainty effect. This is relevant because this effect is replicable in more than one context (i.e., monetary and life decisions) and can result in two different types of violations to expected utility theory.

Prospect Theory

Prospect theory is a decision-making theory that is designed to predict the choices people make (Cheung & Mikels, 2011; Kahneman & Tversky, 1979). Prospect theory was able to account for why gains and losses are processed differently as seen in the framing effect, and it also accounted for how people are typically biased when assessing probable outcomes where a decision-maker prefers certainty to a gamble despite higher expected value (Kahneman & Tversky, 1979; Plous, 1993;Tversky & Kahneman, 1981). The following section will elaborate on how prospect theory is able to satisfy the Allais paradox and explain how framing influences decisions resulting in the certainty effect.

Prospect Theory and Assessing Probability

Prospect theory captures how probability is processed psychologically resulting in the distorted perception of an event being more or less likely than it actually is when making a choice (Kahneman & Tversky, 1979; Rakow, Demes, & Newell, 2008). As seen in Figure 1, according to prospect theory the weighing of decisions based on probability results in a decision

maker overweighting the unlikely probabilities and underweighting moderate and high probabilities (Kahneman & Tversky, 1979; Li, Rakow, & Newell, 2009; Plous, 1993; Rakow et al., 2008).

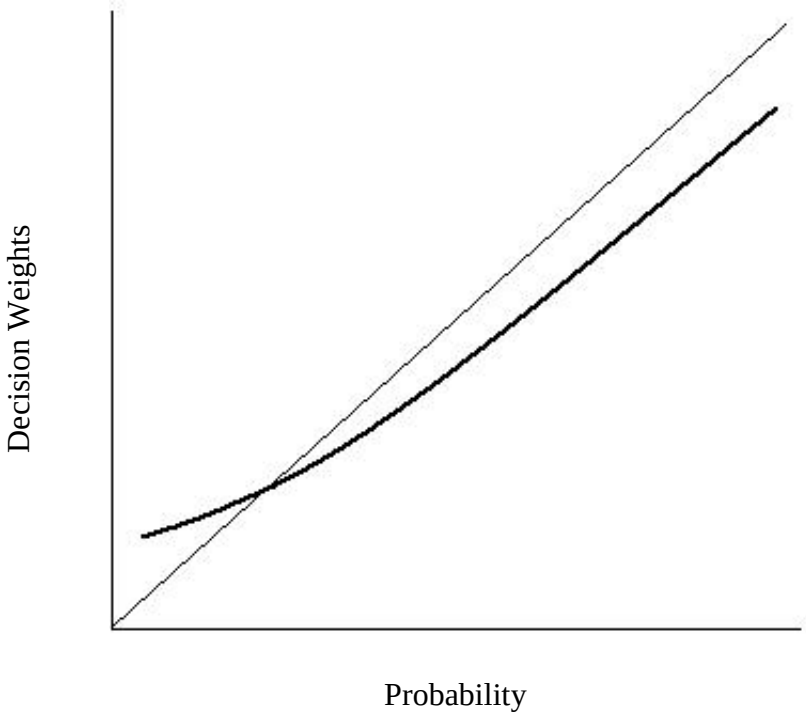

Figure 1. Decision weight curve that visually depicts perceptual differences in how probability is assessed (Kahneman & Tversky, 1979).

Prospect Theory and Assessing Value

Prospect theory has demonstrated that people do not process outcomes equally, but rather focus on whether the choice results in gains or losses, which is directly influenced by reference points as seen in framing (Allais, 1953; Kahneman & Tversky, 1979; Tverksy & Kahneman, 1981). As illustrated in Figure 2, the researchers were able to approximate how value is psychologically processed based on the perception of having a gain, resulting in a concave curve, or a loss, resulting in a convex curve (Kahneman & Tversky, 1979).

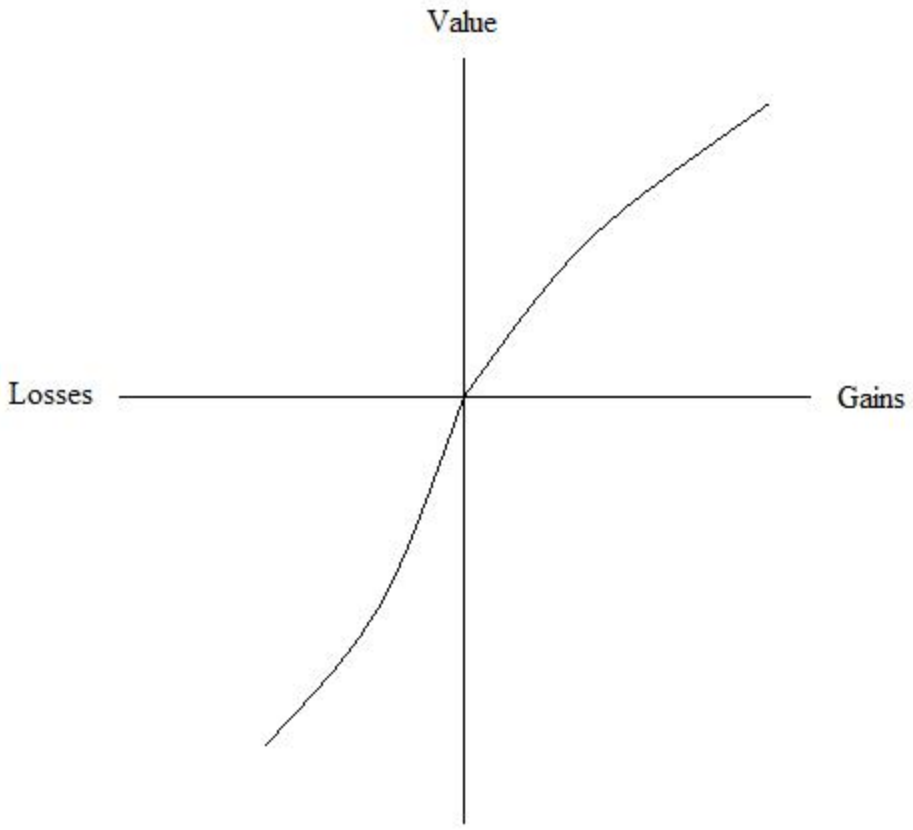

Figure 2. Depiction of how value is assessed psychologically based on whether a choice will result in a gain or a loss (Kahneman & Tversky, 1979).

Their findings in how value is assessed in prospect theory differed from how value was assessed by expected utility theory which is depicted in Figure 3. The major distinction between the two theoretical assessments of value are that the focus for prospect theory is on perceptual magnitudes of gains (e.g., saving 200 out 600 lives) and losses (e.g., losing 400 out of 600 lives) and the focus for expected utility theory is on the final outcome (e.g., 600 – 400 = 200) (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981).

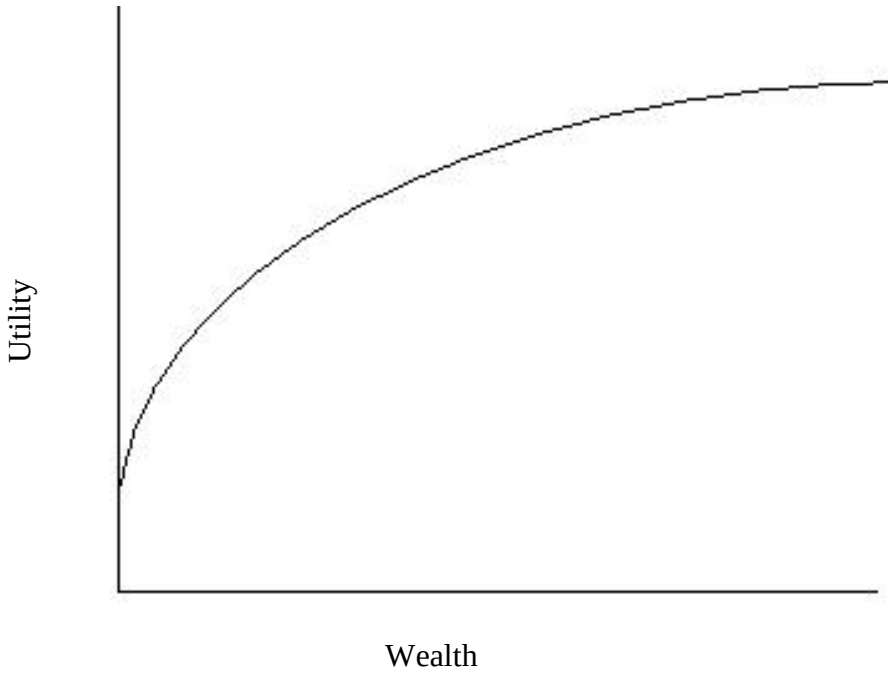

Figure 3. Visual depiction of value based on wealth that was the basis for expected utility theory (Bernoulli, 1738/1954).

Prospect Theory and the Certainty Effect

Accounting for psychological value and perception of probability via prospect theory resulted in a solution to the Allais Paradox as well as an explanation for the framing effect. In doing so, prospect theory introduced the certainty effect, which refers to the decision-maker's avoidance of risk when the other option results in a certain outcome. Prospect theory also predicts that participants change their option preference when answering a similar question concerning certain losses where the change in option preference is also a violation of the cancellation axiom from expected utility theory where this result is called the reflection effect (Kahneman & Tversky, 1979; Plous, 1993). In this case, participants are said to be risk seeking with choices that concern losses (Kahneman & Tversky, 1979). Because of the robustness of the reflection effect, this topic will not be discussed beyond this point in the paper and the focus will be on risk aversion when a decision involves a sure and probable gain.

The certainty effect has become one of the major phenomena tested and retested since its inception. The results of this effect are currently under debate when considering decision-making outside of single gamble scenario. The major problem is the lack of explanation for why the outcomes are not uniform across the various paradigms. The following sections will discuss the other paradigms that examine the certainty effect and offer an introduction to the current direction of decision-making research.

Time, Probability, and the Certainty Effect

Psychological research has shown that risk taking can be assessed in other ways besides using probability, such as using time or delay of reward to observe choice preference (Keren & Roelofsma, 1995; Rachlin, Castrogiovanni, & Cross, 1987; Weber & Chapman, 2005). The researchers of this area believe that it is possible that calculation of time and uncertainty use the same cognitive processes, which explain why the results tend to follow outcomes predicted by prospect theory (Prelec & Loewenstein, 1991; Rachlin et al., 1987).

One such similarity is seen with the immediacy effect where choice preference is for a lower, but immediate, reward (e.g., $100) over a more substantial reward (e.g., $110) after a four week delay (Keren & Roelofsma, 1995). The explanation for the result is that the delay of time has risk associated with the reward, because a decision-maker is unsure whether or not the reward will be available in 4 weeks. By this interpretation, the results follow what would have been predicted by prospect theory following the certainty effect where the immediate reward is processed the same as a sure thing and a 4 week delay is processed as a gamble resulting in choice preference for the reward without a delay (Keren & Roelofsma, 1995; Weber & Chapman, 2005). This line of research is worth touching on because it demonstrates the certainty effect can be found in other situations besides gambling scenarios.

Repeated Decision-Making

Another area of research, repeated gambles, has began to investigate how choice preference may violate prospect theory and instead follow predictions of expected utility theory (Keren & Wagenaar, 1987; Sasaki & Kanachi, 2005). In repeated decision-making, participants are asked to select their preferred option given that they have multiple chances to win or lose. In this scenario the participant is given the odds of success or failure as well as the amount that can be won or lost. The results from experimental studies have shown that the majority of decision-makers tend to prefer the risky option instead of the sure win for gambles based on the Allais paradox.

In an experiment conducted by Keren and Wagenaar (1987) participants were asked to indicate their preference for two types of gambles that were presented via questionnaire which were based on those used by Kahneman and Tversky (1979) resulting in the certainty effect, see Table 2.

Table 2

Gamble options presented in Keren & Wagenaar, 1987 for single and repeated gambles

Number of Gambles	Option 1	Option 2
1	A.) 50% chance of winning $250	B.) 99% chance of winning $100
1	C.) 10% chance of winning $250	D.) 20% chance of winning $100
10	A.) 50% chance of winning $25	B.) 99% chance of winning $10
10	C.) 10% chance of winning $25	D.) 20% chance of winning $10

Note. Expected value for the set of gambles mirrored one another for total number of gambles in both sets of options.

One set of options had gambles where the participant had a single opportunity to win, and the other set of gambles participants could choose between the two options ten times. The

results of the study revealed that for the single gamble, participants' opted for the sure win but for repeated gambles, the option preference was for the riskier but higher valued gamble. For gamble choices for the repeated and single gambles, the total expected value was identical between the sets of options (e.g., EV for option A or option A x 10 = 125 and option B or option B x 10 = 99). The finding revealed that when a decision-maker had the opportunity to make repeated gambles, their choice preference would be for the option anticipated under expected utility theory. This outcome cannot be explained by prospect theory.

In a similar study conducted by Wedell and Bockenholt (1994) 161 participants were asked if they would be willing to wager $50 with a 50% chance of winning $100. Then they were asked if they would be willing to make a wager with a 50% chance of winning $100 if they had 100 opportunities to make the gamble with each gamble costing $50. The results of the study showed that in the first gamble participants would not take the bet, but when given 100 opportunities their willingness to gamble increased significantly.

For repeated gambles, it is possible that the decision-makers are intuitively aware that there is at least some amount of error when making real-life repeated gambles. In this case the participants may be focusing on the opportunity to have error work in their favor. There is also the possibility of a sense of finality associated with a single gamble which may increase the sense of loss and thereby result in the certainty effect. As a result of these findings, questions have arisen about the universal application of prospect theory outside of single gamble scenarios. Further research is still needed to determine why option preference changes when there are more opportunities to gamble.

Decision-Making Guided by Feedback

Researchers have taken a further step for investigating decision-making with repeated choices, by considering how decision-making and option preference are impacted by a decision-maker having to learn about the odds by experiencing the outcomes rather than being told explicitly or described the chances are for a loss or win (Li et al., 2009; Rakow et al., 2008). The concept for the idea was originated by Barron and Erev (2003) and is focused on low value risk (e.g., $3) rather than risk associated with high value (e.g., $2,400). They reasoned that using smaller values was closer to what people deal with in their day-to-day decisions, such as choosing which route to take to work (Barron & Erev, 2003). Additionally, Barron and Erev (2003) stated that this paradigm is not applicable in situations that involve major life changing decisions (i.e., decisions made for the Asian disease problem).

The Barron and Erev (2003) research had forty-eight participants in two groups making gambles guided by feedback between two options using 400 trials. To reiterate, participants were never explicitly told the odds for success or failure during the experiment. For one group, option L had a sure win of $3 versus option H, which had an 80% chance of winning $4 with a 20% chance of winning nothing at all. For the second group, option L had a 25% of winning $3 versus a 20% of winning $4. The results of the study showed that 63% of participants were more willing to take the risky option than the certain option when making gambles that were guided by feedback. In addition, the preference between the two options for the second group was not significantly different. Barron and Erev compared the preference for the two H options and showed that there was greater selection of option H in the gamble with a certain option (e.g., H with 80% chance of success) than the second set of gambles (e.g., H with 20% chance of success). The findings from this study would be called the reversed certainty effect, which

follow the same expected outcome as the repeated decision-making paradigm, where participant preference was for the gamble over the certain option. Once again, violating prospect theory and following predictions of expected utility theory.

Another study has recently replicated the Barron and Erev (2003) research using the gambles from Keren and Wagenaar (1987) for decision-making guided by feedback; only the researchers investigated gamble preference with all four gambles presented simultaneously (Sasaki & Kanachi, 2005). As depicted in Table 3, the presentation of the gambles had participants using a computer to make gambles guided by feedback by selecting a virtual deck with the click of a mouse. The participants received feedback on the amount that they won or lost, but were never explicitly given the odds for success of failure. As in the Keren and Wagenaar (1987) and Barron and Erev (2003) studies, the findings showed a high preference for the probable gamble when compared with the certain choice (i.e., Deck A was preferred to Deck B).

Table 3

Gambles Associated with Each Option for Sasaki and Kanachi (2005) Decision-Making Task.

Deck A	Deck B	Deck C	Deck D
p(.5), $25	p(.99), $10	p(.10), $25	p(.20), $10

As with the repeated decision-making paradigm, the decision-making guided by feedback paradigm has also shown that predictions made by prospect theory fail to predict option preference, such as predicting outcomes for the certainty effect. The reason for the difference in the two situations is still under debate, but may have an answer in how people consider risk overall and how the implicit as well as explicit information is processed (i.e., limitations in working memory capacity or possibly reasoning of consequences) (Rakow et al., 2008).

The results from the studies using decision-making guided by feedback have given more support for expected utility theory having some validity when people make decisions with multiple chances. The issue that has not been discussed is what processes are taking place that in one situation a decision-maker will be conservative in making a choice as in prospect theory, but follow mathematical optimality (i.e., expected utility theory) when given multiple chances to do so.

Gender, Age and Other Influences on Risk

Since the field of experimental decision-making is relatively new, research for the most part has ignored individual or demographic differences (Von Neumann & Morgenstern, 1964). The following sections will go over general findings, and discuss the results as well as what factors may contribute to the outcome.

Gender and Decision-Making

Investigations of differences in decision-making between males and females in terms of risk-taking are currently receiving more attention by researchers (Johnson & Gleason, 2009; Hartog et al., 2002). In an experiment conducted by Johnson and Gleason, males and females were observed playing *Who Wants To Be a Millionaire?* to investigate possible differences in risk taking among the two genders. The findings have revealed that males made riskier choices than females and had on average higher winnings (Johnson & Gleason, 2009).

The issue that currently exists in this area of research surrounds the explanation of why females are more conservative in terms of risk compared with males, which is also seen during childhood (Hoffrage, Weber, Hertwig, & Chase, 2003). Currently, there is a question about how the population is sampled which may influence the results. It is also possible that the motivation for gambling is different between the genders and therefore females appear to be less risk-

seeking than males. This could be a product of acculturation, where males are encouraged to engage in risky behavior which is associated with social status and females typically play a more conservative risk-taking role as the nurturer and caregiver. Additionally, the difference in risk taking may be attributed to evolution because men typically are risk seekers in terms of seeking and hunting for food resources as well as attempting to find multiple mates for increased chances of reproduction. Females are thought to be more conservative because they need mates who will stay and care for their offspring.

Age and Decision-Making

Decision-making is also focusing more on age related differences in risk-taking. There are many accounts for differences in how the elderly, children, and adolescents consider risk compared to adults. The most studied reason has to do with the ability to understand the long-term outcomes associated with decisions. This subsection will consider variations in decision-making considering limitations of memory capacity as well as how information is used when deliberating on a decision.

Assessment of Framing and Age Related Differences

While the certainty effect has been seen in many contexts, the role of age in determining which option to make (i.e., a sure win versus a gamble) is still under debate as to whether or not option preference can be influenced by an individual's life experiences as well as capacity for cognitive processing(Wantanabe & Shibutani, 2010; Woodhead, Lynch, & Edelstein, 2011). The literature for the framing effect considers how age may influence the degree of risk perceived when making a choice.

A study conducted by Woodhead et al.,(2011) had 40 young (age range of 18-24) and 40 old (age range of 65-89) participants respond to framing questions about which method would be

preferred to treat cancer. The goal of the experiment was to focus on what type of information was used to determine option preference in the different framing situations. As seen in Table 4, the participants were given a set of scenarios where the outcomes resulted in the same ratio of survival versus mortality where the manner of description was the only manipulation similar to the classic Asian disease problem.

Table 4

Survey Questionnaire Given to Participants

Survival Frame	Death Frame
Out of 100 patients, 77 live after one year of radiation therapy and 22 live more than five years.	Out of 100 patients, 23 die after one year from having radiation therapy and 78 die after five years.
Out of 100 patients, 90 live through treatment, 68 live more than one year, and 34 live more than five years	Out of 100 patients, 10 die through treatment, 32 die by one year, and 66 die by five years.

Note. Questions were presented to both old and young participants to test for susceptibility to the framing effect (Woodhead et al., 2011).

The results of the study revealed that participants based their decision either on the data given from the scenarios or their own personal experiences. For the younger participants, 71% based their decisions only on the data provided, none focused solely on personal experience, 10% based their decision on personal experience while referencing the data, and 19% based their choice on the data after referencing the personal experience as well. For the older participants 40% based their decisions only on the data provided, 30% used only personal experience, 14% base their decision on personal experience while referencing the data, and 16% based their choice on the data after referencing personal experience. These results demonstrate that one of

the reasons that there are differences in decision-making among age groups is reliance on personal experiences and the type of information that participants focus on.

In another study, 829 Japanese participants responded to a mailed questionnaire that had them respond to positive or negative framed questions based on the classic Tversky and Kahneman (1981) Asian disease problem. The respondents were divided by age group with young participants (age range of 20-64) and older participants (age range of 65-92). The results of the study showed that older adults tended not to be as susceptible to the framing effect, while younger respondents follow outcomes predicted by Tversky and Kahneman's work.

As previously stated, there is not a consensus for why differences may exist between younger and older decision-makers when responding to gambles versus a sure outcome. The literature for this area of research is broad and has many conflicting outcomes, which have yet to be resolved. It is possible that there are many individual factors (e.g., prior exposure to loss of a loved one, intelligence, problem-solving skills, and degree of emotional sheltering from parental figures) that play a role when determining whether or not to make a choice that is safe or uncertain. Two areas of research that may offer some resolution are memory processing and reasoning.

The Impact of Age on Memory and Decision-Making

Research has focused on how children performed on a decision-making guided by feedback task (Rakow & Rahim, 2010). As seen in Table 5, the design had 152 children and adults responding to presentations of gambles on a computer screen where some gambles were described as in Kahneman and Tversky's research and the other set of gambles required ten selections from two options to learn about the outcomes before selecting a preferred gamble.

Table 5

Gamble Options for Single and Gambles Guided by Feedback in Rakow & Rahim, (2010).

Option 1	Option 2
A.) 90% chance of winning $10	B.) Sure win of $9
A.) 80% chance of winning $10	B.) Sure win of $8
A.) 60% chance of winning $10	B.) Sure win of $6
A.) 50% chance of winning $6	B.) Sure win of $3

Note. Participants select for each set of gambles as a described or experience where they were able to make ten selections and then determine which choice they preferred.

The results of the study replicated findings showing option preference for the gamble compared with a sure win as in the Barron and Erev (2003) research and replicated the findings of described gambles (i.e., Kahneman and Tversky) that resulted in the certainty effect. The researchers were not able to demonstrate a significant difference in decision-making for children compared with adults when assessing the two paradigms. These findings were relevant because it means that age difference in working memory did not play a significant role when making a decision based on feedback or experience.

The Impact of Age on Reasoning and Decision-Making

A second caveat to the impact of memory and decision-making has considered a different manner that the information is being processed, meaning that reasoning may be the major age related difference when comparing adults to children. One of the most influential theories that attempts to account for differences in understanding and working with information is fuzzy trace theory. As previously stated, fuzzy trace theory is a dual process theory for information processing and reasoning. The theory describes two major processes, gist (general abstract

knowledge or wisdom) and verbatim (detailed information). For the purpose of this section fuzzy trace theory will be touched on, but explained in detail later on.

As depicted in Figure 4, an experiment conducted by Reyna and Ellis, 1994, had 111 children answer problems using a board game type spinner that resulted in either a gain (i.e., win nothing) or loss (i.e., lose something) frame.

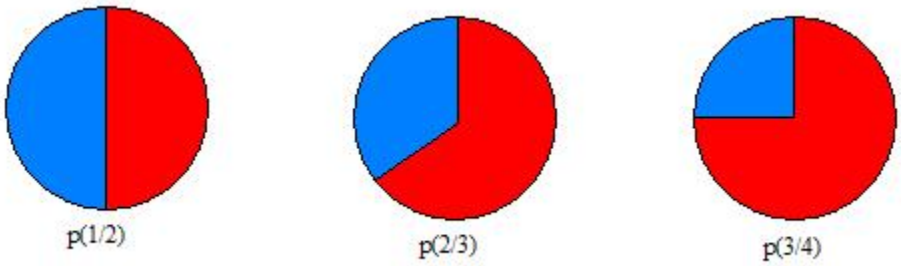

Figure 4. Visual depiction of the gambles that children could use to make their choices (Reyna & Ellis, 1994).

Children were given the choice of using the spinner or taking a sure option. Based on their choices, they received (i.e., the gain frame) or lost (i.e., the loss frame) a prize at the end of the experiment. The results of the study revealed different outcomes based on the age of the children (e.g., preschoolers, second graders, and fifth graders). For the preschoolers the choice was mostly for the sure options regardless of the frame. For the second graders their choice shifted to the sure option when gambles were p(2/3) and had a reverse framing pattern with a p(3/4), meaning that smaller loses and larger gains were preferred. Finally, the fifth graders were more risk averse as risk increased with their choice preference following the framing effect as outcome size increased. Similar findings of reasoning and age related differences are also seen in memory research as well where there is greater reliance on gist representions for information as children increase in age (Odegard, Cooper, Lampinen, Reyna, & Brainerd, 2009).

Personality and Decision-Making

This section will discuss the methods used to assess personality in decision-making research and provide findings that help to explain variation in outcomes associated with the certainty effect. The topics covered will be the traditional personality variables examined in decision-making as well as recent research that investigates variables typically assessed in personality psychology.

Need for Cognition and the Certainty Effect

One type of personality variable that is extensively assessed is called *need for cognition* or NC. A person high in NC enjoys effortful thinking and cognitive activity, and a person low in NC tends to engage in cognitive tasks only when it is required (Carnevale, Inbar, & Lerner, 2011; Simon et al., 2004). A study by Carnevale et al., (2011) has shown that individuals who are high in NC also tend to be less influenced by framing. This means that when a person is high in NC, their answers will not deviate from one set of questions to the other when responding to the Asian disease problem.

Another study has investigated 233 participants' susceptibility to the framing effect while assessing NC and math skills (Simon, et., al, 2004). The results of the study revealed a significant 3-way interaction among framing, math skill, and NC. The results showed that high NC individuals who were susceptible to the framing effect also tended to be low in self-reported math skill.

A possible reason for why NC plays a role in framing effect may reveal a willingness of those who are high in NC to consider the actual odds, rather than relying on the possible negative affect that could be associated with losses which may explain tendencies of those who are low in NC. There is a question about why this effect would be so pronounced especially when a reader

considers that for a low NC person the situations given to participants tend to have profound consequences (e.g., lives lost or dying during surgery). This is important because the criteria for determining who is high and low for NC are still not clear based on how the variable is defined in literature (i.e., low NC will use effortful thinking only when it is required or necessary). One could argue that there is greater effort required to make choices that may result in life or death.

Personality Psychology and the Certainty Effect

Decision-making research has begun to investigate traditional personality variables such as those typically seen in personality psychology (Lauriola et al., 2005; Sasaki & Kanachi, 2005). Traits of interest tend to focus on neuroticism, impulsiveness, hostility, locus of control, and antisocial tendencies. This line of research has mainly focused on the framing effect and how susceptible individuals are to this effect based on the before mentioned personality traits (Lauriola et al., 2005; Sasaki & Kanachi, 2005). The literature covering this topic is expanding in availability and is becoming extensive in terms of the types of personality scales used in combination with decision-making tasks.

A study by Lauriola et al., (2005) assessed differences in risk taking when a decision-maker had to deal with a loss or a gain while taking personality into account using forty-two participants. The scales used to assess personality were the Eysenck personality questionnaire and Gray's basic traits of personality by the Behavioral Inhibition System-Behavioral Activation System scales and a version of the Barratt Impulsivity Scale. The participants were asked to respond to a questionnaire that presented the subjects with the three different types of the framing effect. The results showed that risky-choice and attribute framing lead to greater framing effects than goal framing. The role of individual differences and the scales that predict risk tendencies differed based on the framing type (i.e., risky-choice, attribute, and goal

framing). For risky choice and attribute framing, temperamental traits and health-related tendencies were not significant predictors for participant risk-taking. For goal framing, impulsiveness negatively predicted the impact that the framing message had on the participant. Personality traits overall were a stronger predictor for participants during a loss frame than during a gain frame.

The overall meaning to consider with personality and the certainty effect is that the types of decisions people make are not only influenced by how they are presented or the mental processing of probability, but are also influenced by how a person sees and interacts with the world. A person with a negative outlook on life may see odds as less in their favor than they actually are, just as a person with a positive disposition may not be preoccupied with success when making a gamble. Understanding and predicting risk-taking still has much to learn when it comes to personality. The previous examples offer a brief introduction into an ever-expanding field of research in psychology.

Affect and Decision-Making

Another area to consider that influences how people take risk is the role that affect or emotions plays when making a decision (Pham, 2007). In the past two decades, literature has accumulated and repeatedly demonstrated that emotions influence how likely or unlikely we believe a gamble will be in our favor (Cheung & Mikels, 2011). This means that how positive (e.g., happy, joyful, elated) or negative (e.g., sad, unhappy, angry, upset) an individual is can help predict the amount of risk that they are willing to take (Pham, 2007). The literature at this time notes that there is increased risk aversion when a decision is being made while in a positive mood and increased risk taking for decision-making during a negative mood (Mano, 1994).

A study by Cheung and Mikels (2011) investigated how framing could be impacted by affect. Sixty-five participants were divided into three groups (e.g., control group who were given no instructions, emotion-focused group who were told to make choices based on their emotions and an emotion-regulated group who were told to make choices that were not based on their emotions). The participants made 96 repeated gambles where 32 were gain framed, 32 were loss framed and 32 were catch trials. The control group was risk averse in the gain frame and risk seeking in the loss frame. For the emotion-focused group, the results followed similar trends. Interestingly, participant in the emotion-regulated group selected the gamble more often for both gains and losses. The results indicated that emotion focus could increase the likelihood for a decision-maker to select the gamble, meaning that focusing on emotions may increase risk taking impacting the ability to predict outcomes that typically result in the certainty effect.

Decision-making is influenced a great deal by emotions when selecting an option. While there are numerous studies that assess risk taking from the perspective of affect, it is well beyond the scope of this article to discuss them all. For readers interested in affect and decision-making, a recent review that addresses this topic that may be of interest [Pham (2007)].

Concluding Remarks about Individual Differences

While topics such as personality, affect, age, and gender may offer a fuller understanding of the processes involved with decision-making, many of the articles that cover these topics fail to examine how these variables may influence outcomes for the certainty effect. It is because of this that some research which is relevant to the field of decision-making (i.e., Barbara Mellers and colleague's decision affect theory as well as Paul Solvic and Ellen Peter's affect as information hypothesis) was not presented because the paradigms used to assess differences are too far removed from the topic of interest.

An Overview of Fuzzy Trace Theory

The final area to be discussed focuses on how information is processed in relation to reasoning, which is accomplished via fuzzy trace theory (Reyna, Lloyd, & Brainerd, 2003). To reiterate, fuzzy trace theory is a dual process theory that states that information is processed by two pathways simultaneously and independent of one another (Reyna, 2008; 2004). The two pathways process information in different manners, where the verbatim pathway processes information focusing on details and is typically associated with recent or initial encounters with a situation or problem (Reyna, 2008; 2004; Reyna & Ellis, 1994; Reyna & Farley, 2006; Reyna et al., 2003; Rivers et al., 2008). The gist pathway processes information in a more abstract manner focusing on the general concepts which are typically seen with people who have experience or expertise with the situation or problem (Reyna, 2008; 2004; Reyna & Ellis, 1994; Reyna & Farley, 2006; Reyna et al., 2003; Rivers et al., 2008).

How the two processes function together can be explained by considering how people learn to count. As children, we are taught to pair objects with symbolic representations (e.g., three circles paired with the number 3, or four circles paired with the number 4). Children first start out by counting the objects, which is a form of verbatim processing and simultaneously begin to develop a gist rule base about quantities and symbols. Eventually children learn that the symbols represent an abstract form of the objects. The ability to mentally represent larger numbers increases with expertise, meaning that the use of verbatim and gist processing is constantly evolving and being refined.

In situations with a single gamble, a decision-maker only has a mental representation to account for the probability of success or failure versus a certain outcome. This has been demonstrated by Reyna when explaining how people mentally represent odds in the Asian

disease problem (Cheung & Mikels, 2011). According to fuzzy trace theory, people in the single gamble situation are faced with two sets of options, which are processed as some chance of winning versus a sure win. For this scenario, a decision-maker will automatically select the option with a sure win because they are relying on gist processing of information (Cheung & Mikels, 2011). It is my belief that fuzzy trace theory explains why there is a change in option preference for repeated gambles and decisions guided by feedback, because the theory accounts for how people use their experiences to refine their choices.

Fuzzy Trace Theory and Repeated Decision-Making

Unlike the single gamble paradigm where there is only one chance to win or lose, the repeated gamble paradigm offers a chance for a decision-maker to make multiple gambles with the same odds (Barron & Erev, 2003). As discussed previously, this paradigm presents the decision-maker with the odds of winning as well as the amount that stands to be won for the two options (e.g., 80% to win $4 compared with 100% to win $3 with 10 opportunities to make the gamble). This means that when a decision-maker is presented with this type of problem they stand to win in either situation.

Given that the odds of losing all gambles in a scenario with a probability of .8 wins are less than 2% with ten repeated gambles, it makes sense that the mental calculation ceases to be possible win versus sure win as previously explained when using gist processing (i.e., single gambles), and is instead perceived as sure win versus improbable loss. The only uncertainty that exists then is the amount that will be taken home (e.g., 8 wins X $4 = $32 versus 10 wins X $3 = $30). From this perspective, neither gamble is risky so selecting the option with the highest payout makes sense. The issue here is not purely utilitarian or prospect by nature but based on the how people represent the potential gain, meaning that it is a reasoning based issue.

Another perspective to explain why there is a preference shift comes from cognitive experiential self-theory or CEST, which is also a dual process theory that accounts for reasoning based on an analytic-rational and an intuitive-experiential system (Kirkpatrick & Epstein, 1992; Krauss, Lieberman, & Olson, 2004; Pacini & Epstein, 1999). The analytic-rational system is a slow acting, deliberative process that is reliant on learned rules (Kirkpatrick & Epstein, 1992). The other system, intuitive-experiential system, is a fast acting low effort process that results in automatic responses (Kirkpatrick & Epstein, 1992).

The issue using CEST to interpret the outcomes is that it does not account for the shifts in option preference when given the opportunity to make repeated gambles rather than single gambles. Based on how the theory works, the rules of logic in the analytical-rational system have not changed from one situation to the other, meaning that the perceptual expected value for the two situations would be seen as identical. Additionally, the theory is not capable of explaining why the intuitive-experiential system would result in selection of the sure gain and later result in preference for the gamble with repetition, because detailed assessment would show that the only difference in the two situations is the number of gambles. While people may encounter the two problems (i.e., single gambles and repeated gambles) by attempting to calculate the expected gains to determine which choice is preferred, the theory cannot explain why or predict that a shift will take place.

Fuzzy Trace Theory and Experience Based Decision-Making

The next paradigm of decision-making to consider is decision-making guided by feedback. As in the single gamble and repeated gamble situations, a decision-maker can choose between a risky choice and a sure win. In this situation, decisions guided by feedback, the option

preference for a decision-maker tends to be for the risky gamble rather than the certain or sure gain. This decision-making problem lends itself to fuzzy trace theory for many reasons.

Consider that a decision-maker must begin with a few gambles recognizing that one option pays out more than the other one (e.g., option A you win $3 versus option B you win $4), which could be the initial use of verbatim processing. Next, the decision-maker, after repeated gambles, recognizes that while one gamble pays out more, it is also possible to not win anything at all, which results in the combined representation of verbatim and gist processes. With more gambles (i.e., 400 potential trials as in Baron and Erev [2003]), a decision-maker recognizes that the number of gambles that do not pay out are offset by the higher winnings over time, resulting in reliance on gist-based reasoning. Thus, a decision-maker, when asked which choice they prefer, reports that they would select the risky option over the sure thing because mentally they have developed an understanding that the gamble is of greater value when compared with the sure win. Since there has been a great deal of repetition, they have developed an understanding that losing on the risky gamble is very unlikely therefore the psychological risk has been minimized and their choices begin to reflect what would be predicted by expected utility theory.

Using CEST, the initial encounter with the experienced based gambling tasks would result in the decision-maker basing their decisions on the detailed information that was presently available (e.g., option A pays out $4 and option B pays out $3). After a few repetitions, the decision-maker would experience not winning anything at all, so in this dual process theory, the experiential system would note the lack of winning and the constant wins. After continuing to gamble the decision-maker would learn that one option pays more and has losses and the other pay less but is a sure win.

For this situation, CEST cannot explain how people begin to develop an understanding of the relatively low risk involved with the gamble compared with the sure win, because their reasoning is dominated by heuristic rules that they have developed. Also, CEST does not explain how reliance on heuristics or intuition would guide the decision-maker towards the choice predicted by expected utility theory. If anything after a few gambles there should be an increased reliance on heuristics to guide the choices, which would mean selecting the option that requires the least amount of mental effort (i.e., sure win). This makes sense because there is no guessing if a gamble will result in a win or a loss. Additionally, according to CEST, the value of winning influences how the decision-maker feels about himself or herself. This means that the affective experience will also assist in guiding their choices towards the sure win.

Discussion

For nearly a decade now decision-making has been debating the usefulness of prospect theory compared to expected utility theory when attempting to explain people's decisions. The debate is still ongoing in regard to whether one theory (expected utility theory) is more applicable in real-life situations (repeated and decision-making guided by feedback) compared to laboratory experiments that use single gambles to assess which choice a person will make (i.e., problems accounted by prospect theory). This paper gave an overview detailing the manner that the various decision-making problems are presented as well as the general results pertaining to the psychological phenomenon known as the certainty effect. To reiterate, the findings generally have shown that for single gambles people are risk averse when they have the opportunity to have a guaranteed win, whereas if there is an opportunity to make the gamble multiple times the decision-maker will choose the riskier option over a sure gain. This paper attempts to consider why there is a change in option preference and may offer a means to unify the paradigms by

considering the role of information processing and the human ability to reason which is accomplished using the principles of fuzzy trace theory.

With the information presented, it is reasonable to believe that both theories are capturing two different aspects of the decision-making process in terms of mental calculations and assessment of risk. Consider that in any field of psychology, be it learning, memory, or neuroscience, repetition functions similarly to practice resulting in improved performance across all forms of psychological tasks. It is reasonable that as people make more decisions their choices will begin to reflect some sort of expertise, meaning that they understand or recognize the risk associated with a choice in a more precise manner. This has been illustrated in research that specifically looks at decision-making competency (Parker & Fischoff, 2005). Additionally, it makes sense that people rely on gist representations when given a single gamble. Unlike the repeated gamble, a single gamble does not allow the decision-maker to regain any of the losses that may occur. As described by fuzzy trace theory, a sure gain compared to a possible loss is less valuable when considering the potential alternative, especially in a life or death situation.

These lines of research have included gender, personality, age, affect, and memory, but none of these factors offer an explanation for why a person will choose a sure thing in a single gamble while preferring the risky option for repeated or feedback driven gambles. These variables more than likely contribute to the ability to predict the degree of risk aversion in a gain scenario, but do not offer an explanation of why. When considered under the scope of reasoning, fuzzy trace theory explains the role of memory and age, but the theory cannot account for gender, affect, or personality.

Affect is an independent line of research at this time and the field is now beginning to consider the contribution of both affect and reasoning in decision-making situations which may

be guided by attentional processes (e.g., selective attention) determining the memory trace (i.e., verbatim or gist) that will result in a persons final decision (Levine, 2012). As is, Fuzzy Trace Theory is incomplete, because it does not state what is driving attentional focus. Personality and gender tend to be neglected areas of research in decision science. Even though there is a lack of theoretical explanation, it is not reason enough to dismiss their contribution to the decision-making process.

Gender, specifically, is an area of research that would benefit from increased investigations. As of yet, there is not an explanation for why men tend to take greater risk than their female counterparts in decision-making experiments. So far the best guess has been attributed to possible differences in mental accounting or possible differences brought about by evolutionary demands. Based on the material covered, one of the biggest issues is that much of the literature that notes an influence from gender was not specifically looking at risk taking for males and females and thus the results lack theoretical explanations. I believe that this area would benefit greatly from using brain-imaging techniques which may offer a better understanding of how probability is being calculated among females and males.

For personality, there is a plethora of information about the influence of personality, the ability to use the various scales can be complex because some of the personality scales measure the same thing, some account for individual differences that others do not, and the ability to know which is more reliable than the other requires a higher level of expertise in personality assessment. While the topic was briefly discussed, differences attributed to personality when considering risk-taking or decision-making are more suitable for an independent review.

For memory, the foundation of decision-making theory has functioned on the idea that people rely on mental averaging, heuristics, or intuition, because there are limitations in the

working memory system (Reyna, 2004). This has been conventional knowledge for the past 15 years when fuzzy trace theory demonstrated that memory processes and reasoning function independently of one another (Rivers et al., 2008). The explanation given by Reyna (2004) and Rivers et al., (2008), is that when a situation requires reasoning people tend to use gist-based processing. This means that when forming a judgment or making a decision, people typically are relying on abstract representations rather than focusing on the details or verbatim processes as typically seen in exams or tests. This has been mathematically demonstrated via models by Reyna et. al., (2003).

In terms of age related difference, it is well established that decision-making tends to be less optimal for those who are young and older compared with those who range in age from approximately 25 to 30. Fuzzy trace theory is able to explain why decision-making differs for the age groups because of how information is processed. First with youth comes a limitation of expertise which means that for a young decision-maker much of the information is reliant on verbatim processing. This means that children tend to focus on different aspects of a decision-making problem resulting in maximized decision-making neglecting the potential losses that may ensue. For the elderly population there is an overall shift in decision-making processes, where the information is focused on their life experiences rather than attending to the specific problem. In other words, there is reliance on gist processing to a fault as demonstrated by Woodhead et al., (2011).

Finally, what is known about affect has been adequately discussed in a review by Pham (2007) and offers some predictions about positive and negative affect when people are taking risk. The current issue is that much of the literature that exists does not go over the classic paradigms (i.e., Allais paradox and framing effect problems). Whether or not affect can

influence the certainty or reflection effect is still not clear. Additionally, this line of research has yet to consider affect's contribution to repeated and decision-making guided by feedback. For all three paradigms, this is an area that should not be neglected and is currently under investigation by Ramirez and Levine.

The paper has demonstrated that fuzzy trace theory can explain why there is a shift in option preference for single, repeated, and decision-making guided by feedback specifically for the certainty effect. When compared to a competing reasoning theory, the explanations for preference shifts fail to explain the events. While fuzzy trace theory can account for variations in age and memory, the theory cannot account for individual differences such as personality and gender at this time.

Based on the literature review there are a few areas of research that still need further investigation. Specifically, the role of affect for repeated gambles and gambles guided by feedback in the form of subjective value. Does the emotionality of a gamble change the degree of acceptable risk? Additionally, there is a greater need to understand how and why expert decision-makers tend to differ from their novice counterparts. Is it possible that in repeated gambles and gambles guided by feedback the novice perceives risks in a similar manner as an expert decision-maker would? Testing such differences could be accomplished via brain imaging by studying areas of activation associated with risk perception. Finally, it is important to determine if the outcomes for repeated and gambles guided by feedback only occur for numerical gambling tasks. It is possible to test choice preference using gambles that result in positive or negative stimuli that are comparable to monetary gambles in terms of value assessment similarly to those that were used to develop the value curve for prospect theory.

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