Appalachian State University

Department of Economics Working Paper

Number 19-04| February 2019

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Abstract

Decisions vary. They vary in both content and complexity. People also vary. An important way that people vary is how much they think about a decision. Some prior research investigating thinking and decision making largely conflicts with most traditional decision theories. For example, if considering an array of products to choose from, thinking more about the different alternative's attributes should lead to a better decision. However, some research indicates that it may also lead to more focus on irrelevant aspects of the decision situation. We propose that this conflict exists because of a failure to consider the interaction between the individual and the decision task. To test this, we used separate methodologies that enhance or attenuate a person's thinking. In Study 1 we selected people who were especially high or low in need for cognition (Cacioppo & Petty, 1982) and had them complete a robust decision-making inventory, which included both complex and simple tasks. In Study 2 we manipulated participant's level of glucose, which acts as the brain's fuel to enhance or attenuate thinking ability. Both studies support the view that more thought leads to better decisions in complex tasks but does not influence simple decisions, including those that are valence based. These findings show how the individual's thinking interacts with the constructive elements of the task to shape decision choice.

Key Words: Decision making, Thinking, A-DMC, Complex decisions, Need-for-cognition, glucose

Thinking About Decisions: An Integrative Approach of Person and Task Factors

Every decision-making event can be thought of as consisting of two players; the person and the task. Undoubtedly all of us players vary in how much we think about decisions, sometimes thinking more, sometimes less. The other player in the decision event is the decision task *per se*. In as much as people vary, it too is certain to vary. Some decisions are easy, containing elements that can be solved with little effort; others are complex and require a thoughtful analysis. In the current investigation we examine both players; the person and the decision task and explore how they interact within a decision-making event to shape our decision choice.

Thinking and Decisions

There exists a rich tradition in the literature that more thoughtfulness will lead to better decision making (e.g., Edwards, 1954; Kunda, 1990; Miller & Fagley, 1991; Pachella, 1974; Payne, Bettman, & Johnson, 1992). For example, Simon (1957) described the concept of "satisficing" which inherently suggests that, even with our limited resources, we can make better decisions when thinking more. Payne, Bettman, and Johnson, (1988) suggest that people rely on a type of effort-accuracy tradeoff, meaning they can use heuristics to guide their decisions or they may be more thoughtful and overcome heuristics for better decision making. Similarly, Kunda (1990) suggests that motivation leads to more willingness to apply cognitive skills that lead to better reasoning and decision making. Reyna and Brainerd (1995; 2011) suggest that thinking is memory based, ranging from verbatim to gist, and the effortful verbatim is more precise and exact. And more recently, Kahneman (2011) (see also Kahneman, 2003; Kahneman and Frederick 2002) has adopted a System 1 and 2 approach (see Stanovich & West, 2000) that purports most decisions are made by virtue of System 1, which operates automatically with little effortful thought. However, if people are sufficiently motivated and able to process using the more effortful System 2 then alternatives are thoughtfully contrasted, weighed in a deliberative fashion, and more optimal decisions should be reached. Altogether, prior theoretical research in decision making coalesces around the assumption that more thinking will lead to better decision making.

However, there is also research by Wilson and Schooler (1991; see also Schooler, Ohlsson, & Brooks, 1993; Wilson et al., 1993) that challenges this view suggesting that, at times, the opposite may be true. For example, in one study Wilson and Schooler provided participants with several items (e.g., brands of strawberry jam) from which they were to choose. Participants in the motivated thought condition were asked to analyze and think about their preference and be prepared for an evaluation of their decision whereas participants in the control condition were told nothing. Expert ratings were previously obtained so that "better decision making" was operationally defined as being more consistent with expert ratings. Wilson and Schooler speculated that decision makers who think more also consider the alternatives in more depth. Thinking more also focuses attention on irrelevant aspects of the stimuli that are later used when making one's choice. Consequently, more thoughtful decision makers can make worse decisions when they think more about alternatives that have irrelevant characteristics. The overall findings from their study supported this notion, challenging the belief that more thought leads to better decision making.

In a related piece, Pelham and Neter (1995) also investigated the effects of thinking on decisions while including the additional element of task complexity. In several studies they manipulated motivated thinking by telling participants the task was important (e.g., correlated with intelligence) or not (e.g., assesses intuition and judgment). Task complexity (Studies 1 and 2) was manipulated by varying heuristic and biases problems such as *The hospital problem* from Kahneman and Tversky (1982) Wherein people are shown not to consider sample size when considering probabilities, even when it is clearly stated in this case as a comparison between a large hospital with 45 babies and a small one with 15. Participants' decision ability was assessed by their choice of the numerically superior alternative. Their findings showed that in the more thought/high motivation condition, participants made more optimal decisions on less complex tasks but performance decreased on more complex decision tasks. Pelham and Neter interpret their findings by suggesting that the motivation manipulation they used in their study depleted participants' cognitive resources which led to less optimal decision making. As Pelham and Neter state, "when people's cognitive resources are heavily taxed, their attempts to make especially accurate judgments may backfire" (p. 590). Though speculative, this raises the possibility that a lack of cognitive ability may have contributed to the decreased performance in the complex task. Similar results have been found when performance accuracy was attenuated for more complex Bayesian tasks when participants were in a state of sleep restriction rather than well-rested (Dickinson & McElroy, 2019).

Finally, in addition to the studies we have discussed, a summary by Ariely and Norton (2011) points out several ways in which more thinking can harm decision making. Ariely & Norton suggest that considering too many attributes of the alternatives can lead to overweighting of unimportant attributes. Another is thinking can lead to bias towards alternatives that are justifiable or easy to explain to others. Lastly, thinking too much can lead people to consider too many options and simply become "overwhelmed" with the sheer number of options and fail to make a good decision, if they make one at all. This type of *overthinking* of decision situations normally leads to suboptimal decision choices.

Overall, these findings seem to conflict with most theoretical models in decision making which purport that more thinking leads to more optimal decisions. Because of these contrasting views, we believe that a more in-depth analysis is warranted. In the current research program we tested how thinking influences decision making for both simple and complex decisions. To carry out this examination, we used an individual difference methodology to measure motivation to think and a cognitive resource technique to manipulation ability to think.

Individual Differences in Thinking and Decisions

There is a commonly held assumption in decision making research that "people are people" and human variability is not considered an aspect of the decision-making process. In his hallmark piece, Edwards (1954) conveyed similar sentiments through his illustration of "economic man", a figurative representation of the "human template" used by decision making researchers to make inferences about the decision process. According to Edwards, the economic man assumed by decision researchers is completely informed, sensitive to infinitesimally small changes in a target's value, and perfectly "rational". While aspects of Edwards's treatise help set the foundation for what would develop into the judgment and decision making area, in many ways decision research still subscribes to the invariate decision maker. As Bruine de Bruin, Del Missier, & Levin (2012) note in their discussion of the field, little has been done to address the topic of individual difference in decision making. As evidence for this we have to look no further than the dominant theory in decision research, prospect theory (Kahneman & Tversky, 1979). Prospect theory is a psychophysical model designed to account for relative changes in the contextual valence of the decision task but is silent as to the varying states and dispositions of the decision maker.

Investigating how factors that vary within the individual influence decision making informs us about the normative nature of decision making and is crucial for understanding how people *think* about the decision (e.g., Levin, 1999; Mohammed & Schwall, 2009). For example, individual limitations in cognitive ability are a likely suspect for much of the variability found within decision tasks (Stanovich & West, 2000). Differences in cognitive ability are also certain to play a role in decisions (e.g., Cokely & Kelley, 2009), though that varies with the type of decision task (Stanovich & West, 2008). More recently, one individual difference variable that has shown promise for shedding light on the decision process is numeracy, or the understanding and ability to work with numbers (Peters, Västfjäll, Slovic, Mertz, Mazzocco & Dickert, 2006). Research has shown that highly numerate individuals possess more optimal decision making skills in a variety of analytically based decision making situations (e.g., Liberali, Reyna, Furlan Stein, & Pardo, 2011; Peters & Levin, 2008; Reyna & Brainerd, 2008). Stanovich and West (2008) have also shown that cognitive ability appears not to influence decision making ability on some classic heuristic and biases tasks. However, they did find that people with higher cognitive ability displayed better performance on some types of decision tasks such as probability learning and denominator neglect, that are arguably more *complex*.

While these individual differences most certainly play a role in decision making, they also share similarities in that they rely on *ability* differences; we believe this to be an equally important part of the decision process, a subject we address more specifically in a later section of the paper. One logical assumption that can be drawn from research on ability differences is that complexity of the decision task matters. To clarify, another way of looking at these findings is that the decision tasks may be more complex for some individuals than for others. A central tenant in this paper is that a greater understanding of the decision-making process can be found when considering the interaction between aspects of the decision maker, such as motivation and ability to think, and the constructive elements of the decision task, whether it is simple or complex. In the next section we discuss need for cognition (NFC), an individual difference variable that measures differences in thinking propensity.

NFC Effects on Decision Making

NFC is defined as a tendency to engage in and enjoy effortful cognitive endeavors (Cacioppo & Petty, 1982). Differences in NFC arise from intrinsic motivation rather than intellect and remain relatively stable across a person's lifetime. For example, individuals high in NFC appear to perform better on memory tasks (Boehm, 1994; Cacioppo, Petty, & Morris, 1983) and are generally more positive toward cognitively difficult tasks (Cacioppo, Petty, Feinstein & Jarvis, 1996). Low NFC individuals have been shown to rely more on peripheral information when forming attitudes and evaluating situations (Cacioppo & Petty, 1982) and are more prone to using contextual cues (Cacioppo, Petty, Feinstein, & Jarvis, 1996). All told, NFC is an index of an individual's preferred level of thinking. Next we sift through the tide of NFC research and focus on studies that highlight how NFC can influence decision making.

Several studies have hinted at how NFC may influence decision making. For example, high NFC individuals spend more effort searching for information in a decision task (Verplanken, Hazenberg & Palenéwen, 1992) and exert more effort overall when making decisions (Verplanken, 1993). In one study looking at decision processes, Levin, Huneke, and Jasper (2000) measured the effects of NFC in a multiple option environment. Participants were faced with the task of narrowing their options (via including or excluding them) and then made a choice from among the available options. They found that high NFC participants narrowed their choices more than did low and they acquired twice as many pieces of information in the inclusion condition but not in the exclusion condition.

Research focusing on susceptibility to biases has also found NFC differences. For example, D'Agostino and Fincher-Kiefer (1992) presented participants with a traditional attitudinal measure in which they were told that another student was forced to write a speech about a particular topic. They found that only participants low in NFC demonstrated what is commonly referred to as the correspondence bias. That is, they made dispositional inferences about the student based on the speech they were forced to give. Further, Ahlering and Parker (1989) found that low NFC subjects were more likely to display a primacy effect. And Peer and Gamliel (2012) found that high NFC individuals were more likely to correctly calculate the normative response for estimating traveling speed whereas low NFC participants relied more on a percentage heuristic, calculating time savings by relying on a proportional increase from previous speed to faster speed.

The decision making area that has received the greatest attention from NFC research looks at how the problem's presentation or "frame" influences choice. Framing can be broadly conceived, but a classification system developed by Levin, Schneider, and Gaeth (1998) organizes framing into three types; risky-choice, attribute and goal framing (See Levin et al.,). In one of the earliest examples, Smith and Levin (1996) measured the effects of NFC on two types of decision tasks. In Study 1 they used a slightly modified version of Tversky and Kahneman's (1981) "ticket problem". They found that participants low in NFC were strongly influenced by the problem presentation (losing a ticket vs. losing an equivalent amount of money *a priori*) whereas high NFC participants showed little to no effect, suggesting effortful thinking plays an important role in mental accounting, in this case recognizing the equivalence of the same outcome expressed in different terms. In their second study, Smith and Levin explored the effects of NFC on a human life problem (McNeil, Pauker, Sox, & Tversky, 1982) by presenting either a "mortality" or "survival" frame. Again, they found framing effects for low NFC participants but little to none for high NFC participants.

A number of later studies also provide some support for NFC differences in framing. Zhang and Buda (1999) tested for the effects of NFC on an advertising message in the form of an attribute framing task and found that low NFC participants exhibited stronger framing effects. Chatterjee, Heath, Milberg and France (2000) tested mental accounting rules using a type of goal framing task involving furniture prices and found that only low NFC participants demonstrated framing effects but the findings seemed to be limited to the gains situations. In another goal framing study, Steward, Schneider, Pizarro and Salovey (2003) presented participants with a smoking-cessation message and showed that low NFC individuals were also more influenced by the message frame. Simon, Fagley and Halleran (2004) found somewhat similar effects for a risky choice task when they focused on NFC as a moderating variable. However, they found that NFC only influenced framing when combined with either high math ability or a variable designed to induce depth of processing.

Another side to this research story suggests that a person's level of NFC has *no influence* on the likelihood of framing effects. In a paper that singled out NFC to directly test these competing notions, LeBoeuf and Shafir (2003) included a larger sample of participants across multiple studies including seven different framing tasks. Embedded within this design were both risky choice and attribute framing tasks. They tested depth of thinking by having some participants provide justification for their decisions, NFC served as their measure of individual differences in thinking[1]. The findings across both studies failed to support the hypothesis that greater thinking (higher NFC) leads to attenuation of framing effects.

[1]In Study 1 LeBoeuf and Shafir (2003) report an NFC range in their sample -57 to +71, (M=25.1, SD=20.8) and Mdn = 27. In Study 2 they report a range of -68 to +69 (M=19.1, SD=22.3) and Mdn=20. It is also important to note that in this study they also obtained a median split to define high and low NFC.

More support for the LeBoeuf and Shafir (2003) finding that NFC does not influence framing effects can be found in an in-depth analysis by Levin, Gaeth, Schreiber and Lauriola (2002). In this investigation they sought to determine the effectiveness of a within versus between subjects design for framing tasks as well as the viability of the three framing types. Within their design they also incorporated a number of individual difference variables—among them was NFC. Their findings showed that NFC had no significant interactions with any of the variables in this study, including the different types of framing[2]. This study, along with others, show mixed results for the influence of NFC on framing.

A final study that we review specifically addresses the question of whether thinking more will help optimize or hinder performance on *complex* decision tasks. In this study Unnikrishnan Nair and Ramnarayan (2000) measured participants' NFC levels and provided them with a computer-simulated 2 ½ hour task that involved a series of complex problems revolving around a multi-faceted management task involving time and calculable product outcomes. Better decision making was defined as successful performance on several different outcome measures. The findings from this study showed that high NFC individuals were better at solving complex decision tasks across the variety of outcome measures. Further, the findings revealed that high NFC individuals reported that the task was easier, dealt with more decision related information, as measured by total units of information collected for the task, and considered more aspects of the alternatives.

Glucose and the Ability to Think

The human brain is small when compared to overall body mass, representing only about 2% of the total weight of an adult human, yet it utilizes 20-30% of the body's total energy needs

[2] As with other studies we have reviewed, it should be pointed out that the range of possible NFC scores was limited due to the sample size (N=102) and the use of college students in the sample population.

(Benton, 1990). Glucose fuels this massive energy consumer almost exclusively, making it a key variable for autonomic and executive brain functions.

Glucose, simply put, is sugar present in the bloodstream. The level of blood glucose varies considerably because the brain is surprisingly poor at storing it for extended periods and it requires a continuous supply (Benton, 1990; Gonder-Frederick, et al. 1987). Following the consumption of food or drink containing sugar, blood glucose levels normally rise sharply after about 12-15 minutes and return to baseline over the course of about 2 hours. If a shortage of glucose occurs, then the brain cannot function optimally and a variety of cognitive functions will likely be affected.

As evidence of this, glucose demand and usage appear to parallel cognitive thought. This relationship is highlighted in a study by Donohoe and Benton (1999) wherein the researchers used PET scans to observe participants who first consumed a glucose or placebo drink. After consuming the drink, participants performed a cognitively demanding task or they sat in a control room. The PET scans revealed that participants performing the cognitively demanding task had significantly lower glucose levels, indicating a greater usage of blood glucose during the task.

Researchers have also looked at how glucose levels influence a variety of tasks that draw upon more specific cognitive processes. For example, when glucose deprived participants are given a glucose enriching substance, research has shown performance improvements in facial recognition tasks (Metzger, 2000), verbal working memory (Messier, Pierre, Desrochers & Gravel, 1998; Sunram-Lea, Foster, Durlach & Perez, 2001; Sunram-Lea, Foster, Durlach & Perez, 2002) and spatial abilities (Sunram-Lea, Foster, Durlach & Perez, 2001). In a similar manner, glucose deprivation has been shown to inhibit performance in several complex tasks such as mental calculation (Schächinger, Cox, Linder, Brody, & Keller, 2003) and the Stroop task (Benton, Owens & Parker, 1994).

While there is good evidence that cognition depends upon glucose, there is also evidence that the magnitude of glucose's influence may vary with the complexity of the task. For example, in a study by Kennedy & Scholey (2000) the researchers tested glucose effects on tasks varying in complexity including a more complex Serial 7 task which requires a person to count backward from one-hundred by seven, a moderately complex task of Word Retrieval which involves naming words that start with a specific letter and a less complex Serial 3 task. Their overall findings showed that glucose improved performance but only on the *most complex* task. Perhaps the best evidence that cognitively complex tasks are more heavily dependent upon glucose can be found in a study by Scholey, Harper, and Kennedy (2001). In this study, Scholey et al. (2001) included a balanced design, controlling for domain (word tasks) and cognitive demand while manipulating glucose deprivation and measuring blood-glucose levels. Their findings again showed that glucose improved performance on the more cognitively demanding task but not on the simple task. Altogether these studies provide compelling evidence that complex tasks are more dependent upon and affected by glucose level.

Glucose Effects on Decision Making:

Recently, there has been a wide array of interest in how glucose may influence thinking. In this section we focus on research that has examined more closely how glucose affects decision making. By and large there seems to be a discrepancy across studies, with some findings show predictable effects of glucose on decision choice but others show not effects at all. This discrepancy is illustrated in a recent meta-analysis by Orquin, & Kurzban (2016) wherein categorical distinctions among the different types of decision tasks show that glucose effects are not consistent across task domains. Another important finding in their meta-analysis is that some situational variables, most notable food as the reward medium, will have profound effects on the influence of glucose in decision making. Specifically, Orquin, & Kurzban find that "The analysis revealed a significant positive effect of blood glucose levels on decisions style meaning that low blood glucose increases the tendency to make intuitive rather than deliberate decisions on tasks that are not food related." (p.558). For the purposes of our experiment we used the A-DMC, a decision inventory which contains tasks that are amenable to more intuitive or deliberative processing effects. And importantly, our study involved class credit, not food, as the incentive.

In one study McMahon and Scheel (2010) focused on decisions involving probability learning. They found that when transitioning from the more simple maximization strategy to the more thoughtful rule-based probability matching task, participants in the glucose-deprived condition engaged in more simple maximization strategies. Participants in the glucose-enriched condition were also more likely to follow a rule-based probability approach. This finding suggests that a lack of glucose leads to reliance on decision strategies that are less effortful. Related work by Dickinson, McElroy & Stroh (2014) showed similar effects of glucose on decision response times for more difficult Bayesian tasks, suggesting a reliance on the more effortful System 2 for these more difficult tasks.

Masicampo and Baumeister (2008) used a different type of decision task to test glucose effects on decision making. In this study they used an attraction task wherein participants first evaluate two options based on different attributes. A third "decoy" option, which is inferior on all attributes, acts to lead decision makers toward whichever alternative is more similar to the decoy. Prior research shows that reliance on the decoy option reflects more heuristic, less effortful decision making (Simonson, 1989). Masicampo and Baumeister report that glucose deficient participants were more likely to make less optimal choices by relying on the decoy, which again suggests more heuristic, less effortful decision strategies for glucose deficient individuals.

In another investigation, Wang and Dvorak (2010) looked at how glucose influences future discounting, a phenomenon wherein future rewards are seen as less valuable than immediate rewards. Their findings showed that glucose deprived participants were more likely to engage in future discounting whereas enriched participants were better able to regulate the value of expected future rewards versus immediate payoffs in a decision.

Together these studies suggest that glucose deprivation is associated with less thoughtful decision making and more reliance on simple decision strategies whereas glucose enrichment leads to more deliberative, thoughtful decisions. However, it is unclear whether glucose improves decision making across all types of decisions or whether it primarily enhances decision tasks that are more complex as some research has suggested (e.g., Scholey et al., 2001).

Predictions:

Based upon the body of literature, we believe that more thinking should lead to better decision making but decision improvement will depend upon the *complexity* of the decision task. That is, for greater thinking to have an advantage, the normative reasoning task must contain enough elements amenable to thoughtful manipulation, so that more thinking can produce an advantage. In other words, the task must be sufficiently complex (e.g., difficult but solvable math) so that more thinking will give the decision maker an advantage. In our study we chose to use the A-DMC, a decision inventory that contains several subsections specific to different types of decision making. As we describe later, most of the subsections contain decision tasks that are relatively simple in nature, such as a confidence estimate of a true/false response or estimating the percentage of people who would support a socially unacceptable behavior. However, the A-

DMC also contains a subsection that is designed to contain more complex elements: the Applying Decision Rules subsection (ADR).

In their initial analysis of the A-DMC subsections, Bruine de Bruin et al., (2007) find that ADR was the subsection most highly correlated with the two measures of cognitive ability: the Raven SPM and the Nelson-Denny Reading Comprehension subtest which are measures of fluid and crystalized intelligence respectively. Later findings also provide support that ADR is particularly complex showing that ADR is involved with more cognitive aspects of decision making (Bruine de Bruin, Parker, & Fischhoff, 2012) than experiential, especially those most associated with fluid intelligence and numeracy (Del Missier, Mäntylä, & Bruin de Bruine, 2010) Because of the complex nature of the ADR subset, research has also shown that it likely involves executive function components that are different from the other A-DMC subsets (Del Missier, Mäntylä, & Bruine de Bruin, 2012). For example, Del Missier et al., (2010) provide evidence that ADR involves the inhibition function in executive processing; a process that involves active suppression of alternative responses and attentiveness to the goals of a decision while inhibiting items that might interfere.

Based upon our analysis of the available research we formulated the following hypotheses regarding how thinking will influence decisions for complex and simple decisions:

Hypothesis 1: When normative reasoning decision tasks are complex, such as those found in ADR, we predict that more optimal decisions will be observed when the decision maker is more thoughtful.

Hypothesis 2: For normative reasoning decision tasks that are simpler, such as those found in the other subsections of the A-DMC, we predict that more thinking will not affect performance on these decision tasks.

Study 1

Method

Prior research (e.g., LeBoeuf & Shafir, 2003) and our own sampling drawn from a college population show that the data distribution of NFC is highly skewed, leaving most undergraduate participants well above the NFC mid-point. To improve upon previous research that had skewed distributions of NFC scores and relatively few low NFC participants, we chose to screen a large number of participants and select those with high and low NFC scores. By using this method, we were able to balance our design with equal numbers of high and low NFC participants. Also, we wanted to include a measure of decision making that would allow for a thorough assessment of different decision tasks while also allowing us to test our specific hypotheses involving simple and complex tasks. Because of this we chose the Adult Decision-Making Competence Inventory (A-DMC; Bruine de Bruin et al., 2007).

Participants and Design

A total of 1292 participants took part in the initial online NFC screening and a total of 30 high and 30 low NFC participants took part in the final decision making phase; 45 of the participants were female. The conditions were roughly equal in terms of gender with 20 females in the high NFC condition and 25 in the low condition; gender was not a factor in the analysis of this study. All participants were undergraduate students. The experiment utilized the subject variable of need-for-cognition (high or low) and the dependent variables were the participants' overall and subsection scores on the A-DMC. The data collection was carried out over four semesters.

Materials

Need-for-cognition (NFC). NFC is one of the most widely investigated individual difference traits and reflects a tendency to engage in and enjoy effortful cognitive endeavors (Cacioppo & Petty, 1982). In order to assess participants' level of need for cognition, we used the NFC scale developed by Cacioppo, Petty and Kao (1984). The measure contains 18 items (e.g., "I only think as hard as I have to"); participants are asked to indicate how much they agree or disagree on a nine-point scale ranging from very strong disagreement (-4) to very strong agreement (+4). Total scores on this scale can range from 72 to -72.

The A-DMC. The Adult Decision Making Competence Inventory (Bruine de Bruin et al., 2007) consists of 134 individual items. The inventory contains six subsections that measure resistance to framing, recognizing social norms, under/overconfidence, applying decision rules, consistency in risk perception, and resistance to sunk costs. The measure is designed to assess competency in decision making. The decision making ability measured by the A-DMC should be considered a trait that varies with respect to the individual (e.g., Stanovich & West, 2000). In support of this, individuals who score higher on the A-DMC report having fewer negative decision outcomes in their lives; they also tend to have higher education levels and greater cognitive ability (Bruine de Bruin et al., 2007).

Resistance to framing. Resistance to framing reflects the extent to which variations in how the problem is presented or framed influence decision choice. Because framing effects represent a form of decision bias, *resistance* to these effects has been taken as a positive indicator of DMC. Resistance to framing is composed of two different types of framing tasks; risky choice and attribute. These two types of framing are measured by seven problems each, with each problem being presented in both a positive and negative frame. Importantly, each type of framing is manipulated within-subjects. Both the positive and negative versions of the task are spaced well apart, appearing after a number of intervening tasks, so as to minimize the chance that participants simply remember and repeat an earlier response when they receive the second version of the same problem. Thus, this subsection represents a balance between risky choice and attribute framing. In the risky choice problems participants are presented with a situation (e.g., the outbreak of a disease) followed by both a sure option and a risky option of equal expected value. The options are framed either positively (people saved) or negatively (people die). In the attribute framing problems participants are presented with normatively equivalent events (e.g., buying ground beef) wherein the key attribute is described in either positive (80% lean) or negative (20% fat) terms. A 6-point scale was used for rating both types of framing tasks, this allows for assessment of even weak preferences toward an alternative (Levin, Gaeth, Schreiber, & Lauriola, 2002). The tasks are scored using the mean absolute difference between ratings for the loss and gain versions so that higher scores represent greater framing effects. Later we describe how we use the combined measure and then a separate measure to test attribute and risky choice framing effects.

Recognizing social norms. Recognizing social norms is a measure of an individual's ability to assess social appropriateness of certain norms and their propensity to engage in these peer related social interactions. In this task participants are presented with 16 different negative behaviors (e.g., Do you think it is sometimes OK to steal under certain circumstances?). They are asked to initially rate the acceptability of the bad behavior and later they are asked to estimate the percentage of people who would support this negative behavior. Performance is measured by the strength of the relationship between acceptability of the behavior and estimated percentage of peer endorsements of the interactions.

Under/overconfidence. Under/overconfidence is a measure of how well calibrated individuals are at assessing the correctness, or accuracy, of their responses. In this section participants are first presented with 34 statements (e.g., Amman is the capital of Jordan.) and asked to indicate whether they believe these statements to be true or false. Next, participants are asked to rate on a 50% to 100% scale how confident they are in their true or false assessment. For example, after answering true or false to the statement "alcohol causes dehydration," participants then rate their confidence in that answer. Performance is assessed by calculating the absolute difference between mean confidence and percentage correct.

Applying decision rules. The decision rules task in the A-DMC was purposely redesigned from earlier versions of the DMC to represent complex decision tasks. This subsection involves having individuals use different decision rules to indicate which of five DVD players they would purchase in a hypothetical situation. Participants are first provided with a hypothetical persons' decision rule (e.g., Brian selects the DVD player with the highest number of ratings greater than "Medium".) and then asked to make a choice among five DVD players. Aspects of the DVD players such as sound quality and brand reliability vary on a five-point scale. Participants' performance is assessed by the percentage of correct DVD players chosen, given the decision rules that should be applied. Thus, the complex nature of the decision tasks in this section may require a comparison among the alternatives of the most important attribute to see if one favorite exists. If no clear favorite emerges, then comparisons for the second most desirable attribute must take place while inhibiting other alternatives and the desire for the most important attribute. This complex and taxing mental comparison, along with the mathematical calculations involved in these decision problems highlights the complex nature of this subsection.

Consistency in risk perception. Risk perception is a measure of a participant's ability to follow probability rules. Participants are asked to rate the likelihood of a given event happening to them (e.g., "what is the probability that you will have a cavity filled during the next year?"). The probability rating ranges from 0% to 100% and the probability of each event is assessed for the "next year" and "the next 5 years" in separate parts of the survey. Each time the frame pair is scored as correct if the probability for the event happening the next year is less than or equal to it happening in the next 5 years. Within each time frame, three item pairs are presented as nested subset and superset events. In order to be accurate, the probability of a subset event cannot exceed a superset event. Additionally, within each time frame two complementary events are presented, as such their combined probability must total 100% to be scored as correct.

Resistance to sunk costs. Sunk cost is a measure of participants' ability to avoid the entrapment of prior investments in a particular target item. In this task participants are presented with ten scenarios (e.g., You are buying a gold ring on layaway for someone special) wherein they have money invested in one option but a monetarily better "new" option is discovered. Participants are asked to rate on a 6-point scale whether they would stick with the less viable option that they had invested in or switch to the new, monetarily advantageous alternative. The scale ranges from "1" "*most likely to choose*" staying with the chosen option (e.g., continue paying at the old store [the sunk-cost option]) to "6" "*most likely to choose*" (buy from the new store [normatively correct option]) where higher scores are indicative of greater resistance to sunk cost.

Procedure

When we designed Study 1 we were mindful of the nature of our study, in particular with respect to two primary factors. First, NFC is not well distributed in the college population, with a negative skew favoring relatively more high NFC participants. Second, pretesting showed that participants needed an approximate time window of 45 minutes to complete the A-DMC. With these factors in mind we balanced our desire to capture the integrity of the NFC variable while being mindful of the practicality of using the thorough but somewhat lengthy A-DMC measure. Based upon these considerations we decided not to use a simple median-split for our study, rather, we chose to increase the power of the investigative variable and utilize a more laborious procedure so that we could include the very low NFC participants who would not otherwise be captured in the skewed distribution of a college sample. The trade-off of this design is that much of the variance in the middle scoring individuals is not captured but, given the skewed nature of the NFC variable in our population and the length of time to complete the study, we decided it was a necessary sacrifice.

The initial screening for NFC was conducted through an online survey using SONA software. During this first screening, participants were informed about the nature of the study, including potential participation in a follow up session. Participants were then asked to complete the NFC scale (Cacioppo, Petty & Kao, 1984). After completion, they were awarded credit and this concluded the initial screening stage. Because our investigation relied on contrasting those who were especially low to those especially high in NFC, we used our first semester sampling of 535 participants (Mdn=16, M= 15.97) to establish criteria for categorizing high and low NFC throughout the study recruitment phase. To establish categories we used the upper and lower 10% quantiles of this first semester distribution, which yielded a categorization of ≥ 42 as high NFC and ≤ -11 as low NFC. These criteria also served as the recruitment rubric for the remaining three semesters.

The NFC scores in the total screening sample of 1292 participants ranged from -52 to 70 with an average score of 14.7 and median of 16. Standardized recruitment emails were sent out each semester inviting participants to take part in the decision making study. Over the course of four semesters a total of 253 eligible participants were invited to take part in the decision making phase of the study. For those who responded, an experimenter attempted to schedule a time for the follow-up lab meeting. As is common in this type of selection process, a number of qualified participants had already obtained their needed credit or had scheduling conflicts with available lab times. The high NFC participants who took part in the decision making phase had scores ranging from 42 to 62 and low NFC participants had scores ranging from -11 to -39.

Selected participants who agreed to take part in the follow-up session were first provided with informed consent and were then instructed to begin the A-DMC. The task was presented via paper and pencil. Any remaining instructions were consistent with the validated version of the task and compensation was not dependent upon performance (Bruine de Bruin et al., 2007). The entire task lasted approximately 45 minutes; participants were instructed to wait quietly until everyone had completed the task. Participants were then debriefed about the study, provided with an opportunity to ask questions, and thanked for their participation. All participants were awarded credit to be applied towards their class experiential learning requirement.

Results

After completion of the study the data were organized, and each subsection was combined into a unified measure as outlined in the A-DMC (see also Parker & Fischhoff, 2005). To investigate our hypotheses, we then performed separate analyses on each of the subsections, the overall A-DMC score and a division of the framing tasks. The categorization of NFC (high, low) served as the subject variable for all analyses. Because the A-DMC is standardized so that higher scores are indicative of better decision making, we were able to hypothesize that the enhanced thought of high NFC participants should lead to higher scores on complex decisions tasks, and little or no change on simpler tasks. To test this we performed separate one-tailed t-tests on participants' choices in each of the A-DMC subsections as well as the overall decision score. Means and standard deviations for each subgroup and overall scores are presented in Table 1, the results of the respective analyses are presented int Table 1.

In the first analysis we compared the overall A-DMC composite score for the two groups, as can be seen in Table 1, this analysis was not significant. Next, we examined whether overall resistance to framing scores differed by level of NFC. The results of this analysis involving absolute difference scores revealed that high and low NFC participants did differ significantly on this measure. As can be seen in Table 1, high NFC participants exhibited stronger framing effects as indicated by lower resistance to framing scores. However, an important aspect of this subsection is that it contains a balance between attribute and risky choice framing tasks. Because evidence strongly suggests that these tasks are fundamentally dissimilar (Levin, et al., 1998; Levin, et al., 2002) and more recent evidence shows a clear distinction in underlying processes (Levin, et al., 2013; Levin et al., 2014), we extracted them from the A-DMC task and used algebraic difference scores to separately analyze the NFC effect on attribute versus risky choice framing.

If thinking more is leading individuals to be more or less influenced by the frame, then we should expect to see an interaction between NFC level and frame. To test this, we created an average of the seven positively valenced tasks and a separate average for the seven negatively valenced tasks for both attribute and risky choice (See Table 1 for means). Using these newly formed variables we performed analyses on these data with NFC level (high, low) as a between factor and Frame (positive, negative) as a within factor. For risky-choice framing this analysis revealed no significant interaction between Frame and NFC F (1, 58) = .03, $p >. 8$, $\eta^2 =.001$, nor did it reveal a significant main effect for NFC $F(1, 58) = .81$ $p >. 36$, $\eta^2 =.005$, but frame was significant F (1, 58) = 18.2, $p <. 001$, $\eta^2 =.135$. We next performed a similar analysis for attribute framing; the results of this analysis also did not reveal a significant interaction between Frame and NFC F (1, 58) = .02, $p >. 88$, $\eta^2 =.001$, nor did it show a significant effect for neither Frame F (1, 58) 1.5, $p >. 2$, $\eta^2 =.012$ nor NFC F (1, 58) = 2.12, $p <. 15$, $\eta^2 =.018$. Taken together, these analyses indicate that neither type of framing effect, taken by itself, differed between those scoring high and low on NFC.

Next, we tested the subsections that contain normative reasoning decision tasks that are simpler than the complex Decision Rules subsection and are aligned with Hypothesis 2 predictions. The results of these analyses are presented in Table 1. Across all of the subsections containing simple decision tasks: recognizing social norms, under/overconfidence, consistency in risk perception resistance and sunk costs; the analyses revealed that NFC level had no effect on decision making performance in these subsections. These findings support the Hypothesis 2 prediction that more thinking does not improve performance on simple decision tasks.

In the final analysis we examined the *complex* subsection of decision rules which allowed us to test Hypothesis 1. The results of this analysis is also presented in Table 1. In this subsection, we predicted that more thinking would lead to better decisions. Consistent with this hypothesis, we found highly significant differences between high and low NFC thinkers. As can be seen in Table 1, the pattern of results in the Applying Decision Rules subsection is in the predicted direction such that high NFC individuals made better decisions than low NFC participants, a pattern that supports much of the theoretical foundations in decision making.

Study 2

Method

In Study 2 we examined the part of our hypothesis that focuses on the ability of the decision maker. We adopted a standardized method using a sugar drink to increase blood-glucose levels which should enhance a decision maker's ability to think as well as a placebo non-sugar drink for comparison. Consistent with Study 1, we used a computerized version of the Adult Decision Making Competence Scale (A-DMC) (Bruine de Bruin, Parker, & Fischhoff, 2007) to measure ability effects on simple and complex decision tasks.

Participants and Design

One hundred and thirty-eight glucose deprived participants (Fasting for >3 hours before breakfast) (98 females) took part in the study. Participants were all undergraduates and were recruited using the Sona software system. Participants received credits toward fulfilling a requirement for an undergraduate psychology course. The design of the study included the independent variable of glucose level (enriched or deprived), which was manipulated via random assignment of either regular (sugar sweetened) lemonade (40 grams sugar) or sugar-free lemonade (placebo, 0 grams sugar). The dependent variables were aggregate scores on the A-DMC.

Procedure

When participants initially signed up for the study they were provided with basic information including the need to fast for at least three hours before the study began. Participants who had glucose sensitivity were asked not to sign up for the study. The minimum amount of time allowed between study signup and the study start time was 24 hours so that participants could prepare for fasting. The evening before the study was to take place, participants were emailed and reminded again not to eat or drink anything for at least three hours before their study session was set to begin. Study sessions took place during the morning hours to help participants comply with the fasting requirement during their academic day. Thus, all participants who followed instructions should have arrived in a glucose-deprived state.

Each study session included one to three participants. Participants were seated at an individual study carrel that contained a standard computer setup with monitor and keyboard. Upon arrival, participants were first provided with informed consent[3]. After consent was obtained, participants were instructed to drink the lemonade that had been placed on the study

[3] Because of the double-blind procedure, one participant was granted credit and dismissed from the study due to concerns about the contents of the drink.

carrel in front of them. After completing consumption of the lemonade drink, participants were presented with several unrelated filler tasks that had been devised to take approximately fifteen minutes. The purpose of these filler tasks was to provide enough time for the glucose to be absorbed into the bloodstream (e.g., Masicampo & Baumeister, 2008). After completing the filler tasks, participants were given instructions to begin the computerized A-DMC task that was presented using a standard Optiplex computer and 20-inch monitor. Remaining A-DMC instructions were provided within the computerized version of the task. After completing the A-DMC, participants were instructed to wait quietly until everyone had finished the task. Participants were then debriefed about the study, provided with another opportunity to ask any questions, and thanked for their participation.

Materials

Glucose manipulation. To manipulate glucose level we used a procedure conceptually similar to prior experiments investigating glucose levels (e.g., Masicampo & Baumeister, 2008; McMahon & Scheel, 2010). In this procedure a sugar drink or placebo is consumed and a distractor task takes place for 10-15 minutes giving the sugar time to be absorbed into the bloodstream. Well in advance of our study, a research assistant who did not act as experimenter prepared the drink manipulation. This preparation consisted of covering the drink can with a gray foam cover and black electrical tape so that no part of the can's label could be seen by participants. The drink was then coded with a subject number. The condition (glucose or placebo) was recorded separately and stored in a password-protected spreadsheet not accessible to the experimenter. This double-blind procedure allowed us to be confident that neither the participant nor the experimenter was aware of any individual participant's assigned condition.

To manipulate glucose we used a Minute Maid® Lemonade drink that can be purchased at most grocery stores. We chose to use this standard drink because it is something that participants would commonly experience, and pretesting indicated that the sugar-free lemonade drink tasted very similar to the regular lemonade. Both drinks were in 12 oz. cans. The regular Lemonade contained 40 g of sugar and the Light Minute Maid Lemonade contained 0 g of sugar. To maintain consistency in time of consumption, participants were instructed to drink the lemonade as quickly as possible.

Results

We hypothesized that glucose enrichment would not improve performance in simple decision tasks, but it should lead to more optimal decision making in complex tasks. To test this, we again performed separate analyses on each of the A-DMC subsections as well as the overall decision score. The means and standard deviations for each subsection and overall scores are presented in Table 2. The results of the analysis for each subsection and overall score are presented in Table 2.

In our analysis of the findings we first tested whether participants in the glucose enriched condition made normatively better choices in the overall A-DMC composite score. As can be seen in Table 2, there was no significant difference in this composite score. Consistent with the findings of Study 1, glucose enrichment did not improve decision making in the simpler normative reasoning decision tasks of: resistance to framing[4], recognizing social norms, under/overconfidence, consistency in risk perception and sunk costs. More importantly and also consistent with the findings of Study 1, more thinking, as operationalized through glucose

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[4] Although this subsection was not significant, to maintain consistency with Study 1 we extricated the attribute and risky choice framing tasks and performed an analysis comparable to Study 1. The attribute framing analysis yielded no significant effects nor interaction. In the analysis of risky choice framing the only significant effect was a main effect for Frame: t (136) 5.72, $p < .0001$.

enrichment, did improve decision making in the section of Applying Decision Rules, the subsection that contains more complex decision tasks.

Discussion

Knowing whether more thought will lead to better decision making is important, foremost because it represents what most people believe, and also because it lies at the heart of most decision making theories. Yet this assumption has been shadowed by research showing that depth of thinking has no effect on decision making (e.g., LeBoeuf & Shafir, 2003) or may even make it worse (e.g., Wilson & Schooler, 1991). In the current investigation we explored this fundamental question while considering both the individual's propensity and ability to think as well as the complexity of the decision task. First, we show that, as most theoretical models in decision making suggest, more thinking does lead to better decision making but this effect is limited to tasks that are sufficiently complex. In other words, the decision task must contain constructive elements through which more thoughtful analysis can lead to a more optimal decision choice. For simpler decision tasks that do not have sufficient elements to produce an advantage with greater thought, depth of thinking appears to have no effect on decision making. Finally, for valence based decision tasks we found that when attribute and risky choice tasks were investigated independently, depth of thinking had no effect on the strength of the framing effect. Overall, this investigation provides a way to organize empirical findings and formulate a coherent message about how thinking influences decision making.

The findings we have discussed likely play out in numerous everyday decisions and, while most of the time their consequences are benign, sometimes their consequences may be of great importance. For example, consider the simple choice of deciding between two types of toothpaste. A thoughtful individual may not make a better choice when faced with the common front-label information of "90% of dentists recommend this brand over the leading brand" versus

"180 out of 200 dentist surveyed recommend this brand over the leading brand". Only if enhanced thought is focused on the more complex details of the ingredients and health information on the back labels will the individual make the healthier choice. Alternatively, imagine the more serious scenario of someone considering an elective surgery. If the only information available to the person is the surgery success rate of 85%, then more effortful thought may not help with better decision making. Only if he or she is willing and able to consider the complex array of information about the surgery will more thinking give an advantage and lead to a better decision regarding the surgery.

Limitations and Future Research

In both studies we chose to use the A-DMC for two reasons. First, it was the broadest, most comprehensive and well validated decision-making inventory available to decision researchers. Second, it was designed to contain both complex and simple decision tasks that would allow us to test our specific research questions. However, along with this strength there was also a limitation in that we were confined to the tasks represented in the A-DMC design. If we had chosen to design a set of decision tasks, we could have structured a more balanced design between simple and complex normative decision tasks. Future research should consider designing tasks that focus more directly on how this dimension of complexity affects decision making while holding constant factors such as decision domain. It is our belief that designing such an inventory would be ideal for future research exploring how thought interacts with the type of decision task.

Related to this is the lack of continuity between the complex and more simple decision tasks. The fact that the decision rules subsection of the A-DMC was purposefully designed to be more complex than previous versions of the DMC was very valuable for this investigation. However, future research should consider developing a progression of tasks ranging from simple to complex to help explore the boundary between the two. In a similar vein, this study also has a limited definition of complexity, which can come in many different forms such as verbal reasoning or spatial challenges.

It should also be noted that the glucose manipulation in this study was by no means extreme. Short fasting intervals and soft drinks are common in many diets. It may be that larger variations in glucose levels, such as those experienced by individuals with certain medical conditions, will have a greater influence on decision making. Nevertheless, the findings from our study add to a growing body of research that focuses on understanding how physiological and psychological factors interact to form the decision-making process.

As a final note we should point out that in Study 1 of this investigation we used NFC ranges that represented very high and very low scoring individuals. We urge future researchers who might be investigating NFC or some related thinking variable to thoughtfully consider whether relying on a median split drawn from a college sample will suffer from a lack of power and representation. Future researchers should note that our method, though limited, allows for inclusion of extreme scores; unless less thoughtful individuals can in some way be over sampled, a very large sample size seems warranted.

Conclusion

These findings tell a tale of two players, one player is the person who varies in how thoughtfully he or she considers a decision; the other is the task, which varies with respect to complexity and simplicity of its constructive elements. We tested and provide evidence for this view from two different types of studies. In Study 1 we measured the individual difference variable of NFC and in Study 2 we used a manipulated variable of glucose level. Between these studies we describe how the thoughtfulness of the person and the constructive elements of the task allows for a more complete understanding of how thinking interacts with the decision task.

In a sense, the task is dependent upon the thoughtfulness of the person and the person is constrained by the constructive elements of the task. When evaluating normative reasoning decision tasks that are simple, the person is limited by the elements of the task and greater depth of thought gives little advantage. When normative tasks are more complex and contain elements that allow more thinking to yield advantages, then more thoughtful persons can obtain better decision outcomes. In this paper we portray a decision-making event in which each player- task and person- has a powerful influence on decision choice, but an accurate depiction of the event cannot be found without knowing the interactive nature of the two.

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Tables

Table 1

Mean and SD's of Non-standardized A-DMC Scores for Need-for-cognition and analysis of A-DMC Component Scores and Composite Score one-tailed t-test for NFC levels

	Need for Cognition						
	High[a]		Low[a]				
A-DMC score	*M*	*SD*	*M*	*SD*	*t*(60)	*p*	*δ*
A-DMC Composite	1.27	0.12	1.26	0.11	-.47	.32	-0.24
Resistance to Framing	0.71	0.35	1.00	0.41	2.95	.005	.144
Recognizing Social Norms	0.51	0.21	0.44	0.18	-1.2	.118	.03
Under/overconfidence	0.88	0.06	0.89	0.14	1.68	.95	.013
Applying Decision Rules	0.79	0.16	0.67	0.16	-2.9	.006	0.06
Consistency Risk Perception	0.64	0.11	0.62	0.12	-.79	.22	.01
Resistance to Sunk Costs	4.10	0.12	3.97	0.60	-.83	.21	.06
Attribute frame negative	3.87	0.56	3.57	0.66			
Attribute frame positive	4.00	0.47	3.70	0.46			
Risky-choice frame negative	3.05	0.57	3.16	0.66			
Risky-choice frame positive	2.63	0.50	2.70	0.52			

Note. The A-DMC composite is calculated by averaging non-standardized component scores. [a]*n*=30. The subsections containing a negative t value were not statistically significant in the opposite direction for either the one-tailed or two-tailed test.

Table 2

Means and SD of Non-standardized A-DMC Scores and analysis of A-DMC Component Scores and Composite Score, one-tailed t-test for glucose condition

	Condition						
	Glucose[a]		Placebo[a]				
A-DMC score	*M*	*SD*	*M*	*SD*	*t*	*p*	*δ*
Resistance to Framing	1.01	0.46	1.02	0.54	-0.06	0.47	.01
Recognizing Social Norms	0.48	0.17	0.44	0.20	1.12	0.13	.018
Under/overconfidence	0.76	0.09	0.78	0.09	-1.26	0.11	.01
Applying Decision Rules	0.76	0.13	0.54	0.24	-1.70	0.05	.04
Consistency in Risk Perception	0.67	0.13	0.67	0.09	-0.19	0.43	.002
Resistance to Sunk Costs	3.93	0.65	4.00	0.49	-0.62	0.27	.03
A-DMC Total	1.22	0.13	1.24	0.12	-0.99	0.16	.011

Note. A-DMC Total is the average of the non-standardized component scores. The subsections containing a negative t value were not statistically significant in the opposite direction for either the one-tailed or two-tailed test.

[a]*n*=69