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Thinking About Decisions: An Integrative Approach Of Person And Task Factors

By: Todd McElroy, **David L. Dickinson**, and Irwin P. Levin

Abstract

Decisions vary. They may vary in both content and complexity. People also vary. An important way that people vary is how much they think. 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 alternative's attributes should lead to a better decision. However, some research indicates that thinking more may also lead to focusing on irrelevant aspects of the decision and a less optimal outcome. We propose that this conflict in the literature 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 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 provide insight for understanding our central tenant that more thought leads to better decisions in complex tasks but does not influence simple decisions. These findings show how the individual's thinking can interact with the constructive elements of the task to shape decision choice.

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Thinking about decisions: An integrative approach of person and task factors

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Abstract

Decisions vary. They may vary in both content and complexity. People also vary. An important way that people vary is how much they think. 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 alternative's attributes should lead to a better decision. However, some research indicates that thinking more may also lead to focusing on irrelevant aspects of the decision and a less optimal outcome. We propose that this conflict in the literature 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 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 provide insight for understanding our central tenant that more thought leads to better decisions in complex tasks but does not influence simple decisions. These findings show how the individual's thinking can interact with the constructive elements of the task to shape decision choice.

KEYWORDS

competence, complex decisions, decision making, glucose, need for cognition, thinking

1 | INTRODUCTION

Every decision-making event can be thought of as consisting of two players: the person and the task. Undoubtedly, all people vary (e.g., Eysenck & Eysenck, 1985), and, importantly, we vary in how much we think about decisions, sometimes thinking more, sometimes less (e.g., Kahneman, 2011). 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 on key factors such as complexity (e.g., Lewin, 1936). Some decisions are easy, containing elements that can be solved with little effort; others are complex and require a thoughtful analysis (e.g., Payne, 1976). 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. We tested how thinking relates to 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 manipulate ability to think.

In this paper, prior to describing our empirical studies and their results, we present an extensive literature review leading to development of the hypotheses for the present studies. This includes a review of the role of thoughtfulness on decision making, which presents mixed results; a review of the role of individual differences in decision making; development of hypotheses concerning the joint effects of person characteristics and task characteristics, particularly

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distinguishing between simple and complex decision-making tasks as operationalized in the separate components of decision-making competence; and a review of research with the variables used in the present research—need for cognition (NFC) and glucose level. We test whether more thinking, via glucose enrichment or higher NFC, will lead to better decision making in tasks that are sufficiently complex to incur a *thoughtfulness advantage*. As we discuss in more detail later, enhanced thinking should only produce a decision-making advantage when the decision task contains enough elements amenable to thoughtful manipulation (i.e., the decision is sufficiently complex).

1.1 | Thinking and decisions

There exists a rich tradition in the literature that suggests that more thoughtfulness will lead to better decision making (e.g., Edwards, 1954; Kunda, 1990; McElroy & Seta, 2003; Miller & Fagley, 1991; Pachella, 1974; Payne, Bettman, & Johnson, 1992). Payne, Bettman, and Johnson (1988) suggest that people rely on a type of effort-accuracy trade-off, 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.

Kahneman (2011; see also Kahneman, 2003; Kahneman & 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. Reyna and Brainerd (1995, 2011) present an alternative to psychophysical models and provide evidence that thinking operates in parallel with two kinds of mental representations of information: precise verbatim representations and multiple gist representations. Gist representations capture the meaningful essence of information and are normally relied on preferentially, even when verbatim information is physically present and remembered. In this view, which contrasts with System 1 versus System 2 approaches, monitoring/inhibition is distinct from gist-based thought and from verbatim-based analysis. Research has shown that specific decision biases that have been attributed to mental shortcuts (one definition of heuristics) are instead gist based. Nevertheless, individuals who think more are apt to inhibit those biases when inconsistencies in their decisions are salient (Broniatowski & Reyna, 2018; Reyna & Brainerd, 2008). Altogether, prior theoretical research in decision making coalesces around the assumption that more thinking will lead to better decision making. One focus of this prior research is the concept of decision-making competence and how it relates to cognitive ability.

One of the most widely used measures of decision-making competence is the Adult Decision-Making Competence (A-DMC). In their initial analysis of the A-DMC subsections, Bruine de Bruin, Parker, and Fischhoff (2007) find that the applying decision rules (ADR) was the subsection most highly correlated with the two measures of cognitive ability: the Raven Standard Progressive Matrices 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), especially those most associated with fluid intelligence and numeracy (Del Missier, Mäntylä, & Bruin de Bruine, 2010). As evidence 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. We describe the full A-DMC in more detail later in the paper, and we illustrate the key role played by the ADR component.

Complexity in the ADR arises from the application of decision rules that vary, and this ability to correctly apply decision rules is a crucial factor when decisions involve multiattribute choices (e.g., Payne & Bettman, 2004). Research suggests that the processing of competing response alternatives involves interference that must be inhibited (Reyna, 2004). For example, in the ADR, choices involve picking an option that obeys the stipulated decision rule (e.g., highest on product reliability and nothing else) and inhibiting choices of the best option that follows some other rule. More generally, this process involves attention to goals (rule application) while inhibiting irrelevant information, commonly referred to as the inhibition function (Del Missier et al., 2010). Some of the decision rules involve mathematic computations and comparisons among alternatives while maintaining the value of alternatives and updating their relative standing. Other decision rules involve comparisons among first level attribute options, and if no clear advantage can be found, comparisons among second level attribute options must follow. For example, if someone is looking to purchase a house, multiple criteria are likely important. Probably, one key attribute is price; lesser attributes might be style and age. If the first level attribute of price is common among several houses, then comparison of the second level attribute of style should follow and potentially continue to the next attribute if all styles are similar. A common factor among the decision rules is that, because of their underlying complexity, greater thinking should give the person an advantage for a more optimal decision choice.

However, not all research has supported the contention that more thinking leads to better decisions. For example, in a series of studies by Wilson and Schooler (1991; see also Schooler, Ohlsson, & Brooks, 1993), the researchers did not test specific theoretical predictions; rather, they examined whether depth of thinking about alternatives will improve or degrade decision performance. 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 obtained beforehand and used to compare with participants' responses to rate the quality of decision making. Wilson and Schooler speculated that decision makers who think more also consider the alternatives in more depth. However, thinking more can focus 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. Although the experiments in this study were ad hoc, the overall findings challenged the belief that more thought always leads to better decision making.

In a subsequent study, Wilson et al. (1993) had participants choose between posters that they were allowed to keep. In the experimental condition, they were asked to provide rationales for their choice that focused participants' decisions on product attributes and changed their choices relative to a control group who simply chose their favorite poster. Interestingly, participants who reasoned about the product's attributes also had more regret over their decision 3 weeks later, suggesting that an initial "thoughtless" decision might have better long-term appeal. Related research testing fuzzy-trace theory (FTT) has shown evidence that decision making and cognitive resources are independent (Reyna & Brainerd, 1995). As we discuss later in the article, decision making is often gist based, which requires very little cognitive resources. This finding stands in contrast to many dual-process theories that rely on working memory as an integral part of the system involved in decisions (Evans & Stanovich, 2013).

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 Tversky and Kahneman (1981), 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 on the more complex tasks. 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 ability to use cognitive resources may have contributed to the decreased performance in the complex task.

Similar results have been found when cognitive ability was compromised through sleep restriction. For example, performance accuracy was attenuated for more complex Bayesian tasks when participants were in a state of sleep restriction rather than being well rested (Dickinson & McElroy, 2019), and similar decision detriments during sleep restriction and circadian mismatch were found for complex decisions involving updating and attentional processes (McElroy & Dickinson, 2019). Sleep preferentially promotes memory for gist over verbatim detail and, under certain circumstances, can promote gist-based false memories over veridical ones (Ellenbogen, Hu, Payne, Titone, & Walker, 2007; Payne et al., 2009). Whereas memories are less accurate (from a verbatim perspective) after sleep, gist memories may, in the end, be more useful because they capture essential information.

Finally, in addition to the studies we have discussed, an ad hoc summary by Ariely and Norton (2011) points out several ways in which more thinking can harm decision making. Ariely and Norton suggest that considering too many attributes of the alternatives can lead to overweighting of unimportant attributes. Another is that thinking can lead to bias toward 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. Despite the evidence for the role of depth of thinking on decision quality, there has been limited research on individual differences that drive these effects.

1.2 | Individual differences in thinking and decisions

There was 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) notes that when decision researchers of the time applied their theories, it was assumed that the decision maker is completely informed, sensitive to infinitesimally small changes in a target's value, and perfectly "rational." Although Edwards' work helped create a general model of a decision maker, it did not specify how varying human attributes may be accounted for in the decision-making process. As Bruine de Bruin, Del Missier, and Levin (2012) note in their discussion of the field, not enough has been done to address the topic of individual difference in decision making. For example, the dominant theory in decision research, prospect theory (Kahneman & Tversky, 1979), is a psychophysical model designed to account for group effects. Individual differences were not emphasized as a part of this theory, but they were recognized as potential contributors (e.g., on p. 280, differences in the values of the theory's parameters). Thus, different individuals may have different psychophysical functions. Although this acknowledgment was a part of their theory, it was never strongly emphasized, and predictions for how individual differences would influence or interact with theoretical assumptions were never fully developed.

Investigating how factors that vary within the individual are associated with decision making informs us about the normative nature of decision making and is crucial for understanding how people *think* about the decision (e.g., Gamliel & Kreiner, 2019; 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; McElroy & Dickinson, 2010), 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 et al., 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 be associated with decision-making ability on some classic heuristic and biases tasks including base-rate neglect, framing effects, conjunction effect, outcome bias, "less is more" effects, sunk-cost effect, anchoring effects, omission bias, reference-dependent preferences—willingness to accept/willingness to pay, the certainty effect, and myside bias.

However, Stanovich and West (2008) found that people with higher cognitive ability displayed better performance on some types of judgment and decision-making tasks, such as probability learning, that are arguably more *complex*. In a similar line of reasoning but with different results, Bruine de Bruin et al. (2007); Bruine de Bruin, Parker, and Fischhoff (2012) also looked at the relationship between cognitive ability and performance on decision tasks that were less complex. Their results did show a positive relationship between fluid cognitive ability and decision performance. One difference separating these sets of studies is that Stanovich et al. drew from a traditional college population that should be less diverse in cognitive ability whereas Bruine de Bruin et al. (2007, 2012) relied on a community-based sample that was balanced with socioeconomic status, a population that should have been more "cognitively diverse."

Eberhardt, Bruine de Bruin, and Strough (2017) examined two types of individual difference variables: the cognitively oriented numeracy and experience-based knowledge as well as the noncognitive characteristics of emotions and motivation. They examined how these individual difference variables relate to age and financial decision making. For the cognitively oriented variables, their findings showed that numeracy was related to better performance on credit card repayment whereas experience-based knowledge was relevant to better performance on resistance to sunk costs and money management. Together, both numeracy and experience-based knowledge were associated with higher performance on a decision outcome inventory that focused on financials. In terms of the noncognitive variables, higher levels of motivation were marginally associated with better performance on resistance to sunk costs whereas less negative emotions about financial decisions were marginally associated with better performance on an outcome measure of financial decisions.

One common individual difference characteristic is how people's decisions are influenced by lifespan changes in cognitive development (e.g., Casey, Giedd, & Thomas, 2000; Gozdas, Holland, & Altaye, 2019). For example, adolescence is often characterized by increased risk taking, but research shows that this may be due to differences in adolescent mental representations of the potentially risky options (Reyna, Wilhelms, McCormick, & Weldon, 2015). Relative to younger adults, older adults may be more prone to emotional changes that then affect their decision making (Bruine de Bruin, 2017; Eberhardt et al., 2017), and experience can lead to a better intuitive gist of risky situations and allow avoidance of risky, and potentially harmful, behavior (Reyna & Reyna & Farley, 2006). For example, they report less negative and more positive emotions after losses (Bruine de Bruin, van Putten, van Emden, & Strough, 2018; Samanez-Larkin & Knutson, 2015), appear to make more suboptimal choices in financial risk taking, and are less likely to choose a maximizing decision strategy (Bruine de Bruin, Parker, & Strough, 2016; Samanez-Larkin & Knutson, 2015).

1.3 | Motivation for the current study

Although 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. 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 tenet 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 NFC, an individual difference variable that measures differences in thinking propensity and is a factor singled out for the present Study 1.

1.4 | Association between NFC and 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 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 et al., 1996). All told, NFC is an index of an individual's preferred level of thinking that is intertwined with decision-making quality (e.g., Bruine de Bruin, McNair, Taylor, Summers, & Strough, 2015). Next, we sift through the tide of NFC research and focus on studies that highlight how NFC is associated with decision making.

Several studies have hinted at how NFC may be associated with 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 association of NFC with 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.

1.4.1 | Framing effects

The decision-making area that has received the greatest attention from NFC researchers looks at how the problem's presentation or "frame" is associated with decision 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. In one of the earliest examples, Smith and Levin (1996) measured whether NFC was associated with 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 affected by the problem's presentation (losing a ticket vs. losing an equivalent amount of money a priori) whereas high NFC participants showed little to no effect, suggesting that 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 whether NFC was associated with decision responses to 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 whether NFC was associated with 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 also responded more strongly to 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 was only associated with strength of framing when combined with either high math ability or a manipulation designed to induce depth of processing.

Another side to this research story suggests that a person's level of NFC is not associated with 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.

More support for the LeBoeuf and Shafir (2003) finding that NFC level is not associated with 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 examining 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, shows mixed results for the question of whether NFC is associated with framing effects. We explore this issue further in the current Study 1.

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 2.5-hr task that included a series of complex problems revolving around a multifaceted 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

[1]In Study 1, LeBoeuf and Shafir (2003) report an NFC range in their sample from −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.

[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 as the sample population.

decision-related information, as measured by total units of information collected for the task, and considered more aspects of the alternatives.

Throughout these studies, an important aspect of their design is what constitutes better or maximizing performance. Determining optimal performance is a function of the nature of the task, and in many laboratory tasks, better performance is noted by processing more details. It is important to note that laboratory experiments may not be consistent with real-world situations, especially when processing amounts of information determines decision performance. For example, research on FTT suggests that people who process a greater quantity of trivial details will perform "better" if the laboratory task or performance measure gives credit for processing arbitrary trivial details, as psychological and neuroscientific studies sometimes do (e.g., see Reyna & Brainerd, 2011). Although verbatim processing is often considered advanced in laboratory research, gist processing has been associated with advanced cognition and better decision making in real life—as FTT predicts (Reyna & Reyna & Farley, 2006; Reyna et al., 2011). One factor that influences real-world decision making is the decision maker's current satiation level, which plays a profound role in the ability to think, operationalized in our Study 2 as blood glucose level.

1.5 | Glucose and the ability to think

The human brain is small when compared with 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 (Benton, 1990). Glucose fuels this massive energy consumption 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 min and return to baseline over the course of about 2 hr. 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 positron emission tomography 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 positron emission tomography 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; Sünram-Lea, Foster, Durlach, & Perez, 2002), and spatial abilities (Sunram-Lea et al., 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). Another way of observing the impact that glucose may have on cognition is through dietary intake. Specifically, there is a large body of research that suggests that eating a nutrient sufficient breakfast can increase subsequent cognitive performance (Hoyland, Dye, & Lawton, 2009; Pollitt & Mathews, 1998).

Although 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 and Scholey (2000), the researchers tested glucose effects on tasks varying in complexity including a more complex Serial 7 task that requires a person to count backwards from 100 by 7 s, a moderately complex task of Word Retrieval that involves naming words that start with a specific letter, and a less complex Serial 3 task that involves counting down from 100 by 3 s. 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.

1.6 | Glucose effects on decision making

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 showing predictable effects of glucose on decision choice but others showing no effects at all. This discrepancy is illustrated in a recent meta-analysis by Orquin and 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 notably with food as the reward medium, will have profound effects on the influence of glucose in decision making. Specifically, Orquin and 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 "reversal finding" fits well with predictions of FTT (e.g., Reyna & Brainerd, 1991). Specifically, as highlighted in FTT, simple gist-based intuition (rather than verbatim analysis) is the more advanced mode of operation for adults. In the instance of McMahon and Scheel, the simpler strategy of optimization, which should rely on gist extraction and comparison, is actually superior. The more complicated probability matching strategy should require verbatim processing while yielding a lower payoff. Further research is needed to explore the mechanisms behind this effect. For example, it is unclear whether participants might experience a lack of motivation because of past conditioning with high glucose levels (i.e., feeling full from food consumption) while also having the brain glucose enriched or whether it may involve less working memory capacity (Gaissmaier & Schooler, 2008).

This finding suggests that a lack of glucose leads to reliance on decision strategies that are less effortful. Related work by Dickinson, McElroy, and Stroh (2014) is consistent with this viewpoint. In their study, glucose enrichment increased response times, and these longer response times improved accuracy on more difficult Bayesian choice tasks, which suggests glucose promoted more effortful decision strategies necessary for success in more difficult choice environments.

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. Later research has also supported this finding by showing that glucose consumption reduces delay discounting and makes future options more attractive (Wang & Huangfu, 2017).

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).

1.7 | Predictions

Based upon the body of literature, we believe that more thinking, as revealed by glucose or NFC, 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.[3]

1.8 | Identification of simple and complex tasks

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, as we have previously discussed, the A-DMC contains the more complex subsection of ADR.

Based upon our analysis of the available research, we formulated the following hypotheses regarding how thinking will be associated with decision-making outcomes 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 such as when they are high in NFC or are glucose enriched.*

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, such as being high in NFC or glucose enriched, will not affect performance on these decision tasks.*

[3]In the current analysis, we differentiate between more thinking, in terms of level of thoughtfulness as opposed to insightful thinking as discussed in FTT (e.g., Reyna & Brainerd, 2011).

2 | STUDY 1

2.1 | Method

2.1.1 | Participants and design

A total of 1,292 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. 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 NFC (high or low), and the dependent variables were the participants' overall and subsection scores on the A-DMC.

2.1.2 | Materials

Need for cognition

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 NFC, 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 9-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

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 A-DMC inventory (Bruine de Bruin et al., 2007).

The A-DMC 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, ADR, consistency in risk perception, and resistance to sunk costs. The combined 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). All seven components as well as the combined score have demonstrated good validity by their significant associations with measures of cognitive ability and decision-making styles (Bruine de Bruin et al., 2007). In support of its predictive validity, research has shown that individuals who score higher on the A-DMC report having experienced fewer negative decision outcomes in their lives and they also tend to have higher education levels (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 decision competency. 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 positive and negative frames. 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 et al., 2002). Later, we describe how we separate the attribute and risky choice measures to present a resistance score for the respective types of framing.

Recognizing social norms. Recognizing social norms is a measure of an individual's ability to assess social appropriateness of certain social 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. It should be pointed out that this subsection is different from other decision subsections in the sense that it measures social knowledge and adherence to a normative standard rather than a particular bias. Further, "morality" is not measured in a right or wrong sense; the scale reflects social knowledge of appropriate behavior and the individuals' self-reported likelihood of engagement.

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 was adapted from an earlier version of the A-DMC (originally called the DMC). In the current A-DMC, the decision rules task is purposely constructed to be a more complex decision task relative to the other subsections. 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 5-point scale. To obtain a "correct" response score, the participant must apply the correct decision rule and choose the alternative that optimizes the hypothetical person's goal. The decision rules used in this task are derived from research by Payne, Bettman, and Johnson (1993) and include elimination by aspects, satisficing, lexicographic, and equal weights. Furthermore, the task contains an interference aspect, in that respondents are required to use the stipulated rule while suppressing other options, including the decision alternative that might initially appeal to them the most. 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. Consistency in risk perception reflects a person's consistency across risk judgments and 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. 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 (see FTT's class-inclusion account of gist and verbatim representations; for a theoretical account, see Reyna, 2004; Reyna & Brainerd, 2008). 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 10 scenarios. In one example, "You are buying a $200 gold ring on layaway for someone special, you have a $100 deposit on the ring," but a monetarily better "new" option is discovered (e.g., same ring can be purchased for $90 at another store). However, you will lose your original deposit if you purchase the ring for $90. 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.

2.1.3 | 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 more high NFC participants (e.g., LeBoeuf & Shafir, 2003). Second, pretesting showed that participants needed an approximate time window of 45 min 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 et al., 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 1,292 participants ranged from −52 to 70 with a mean 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 (see Figure A1).

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 min; 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 toward their class experiential learning requirement.

2.2 | 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 or 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 difference from those scoring low 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 as well as the results of the respective analyses.

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 the resistance to framing subsection. An important aspect of this subsection is that it contains a purposeful 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., 2015; Levin, McElroy, Gaeth, Hedgcock, & Denburg, 2014), we analyzed the risky choice and attribute framing tasks separately. To do so, we created an average of the seven positively valenced tasks and a separate average of the seven negatively valenced tasks for both types of framing. We then obtained a difference score by subtracting the negative framing average from the positive for both attribute and risky choice (see Table 1 for means). The difference scores of the valence averages for each of the respective framing typologies served as separate indexes for our analysis. This analysis revealed no significant differences for NFC thinking style for either type of framing (see Table 1).

Next, we examined the *complex* decision rules, which allowed us to test Hypothesis 1. The results of this analysis are also presented in Table 1. In this subsection, we predicted that those high in NFC would make 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 ADR subsection is in the predicted direction for complex decisions, providing evidence that high NFC individuals perform better on *complex* tasks but not simple ones. Thus, complex decisions but not simple decisions display a pattern consistent with much of the theoretical work in decision making and supports our Hypothesis 1 prediction.

TABLE 1 Means and *SD*s of nonstandardized A-DMC scores for need for cognition and analysis of A-DMC component scores and composite score, one-tailed *t* test for need for cognition levels

	Need for cognition						
	High[a]		Low[a]				
A-DMC score	M	SD	M	SD	*t* (60)	p	d
A-DMC composite	1.27	0.12	1.26	0.11	−0.47	.32	0.09
Recognizing social norms	0.51	0.21	0.44	0.18	−1.2	.117	0.36
Under/overconfidence	0.88	0.06	0.89	0.14	1.68	.95	0.09
Applying decision rules	0.79	0.16	0.67	0.16	−2.9	.003	0.75
Consistency in risk perception	0.64	0.11	0.62	0.12	−0.79	.22	0.17
Resistance to sunk costs	4.10	0.12	3.97	0.60	−0.83	.21	0.30
Attribute framing resistance	0.11	0.59	0.14	0.52	0.22	.59	0.05
Risky choice resistance	−0.42	0.51	−0.46	0.6	0.69	.75	0.07

Note. The A-DMC composite is calculated by averaging nonstandardized 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. Mean values for attribute and risky choice framing resistance were obtained by using a difference score of the average of the seven positive frames from the average of the seven negative frames.
Abbreviation: A-DMC, Adult Decision-Making Competence.
[a]*n* = 30.

In the final analysis, 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, and resistance to sunk costs), the analyses revealed that NFC level had no effect on decision-making performance in these subsections. The finding that effortful thought does not improve performance on simple decision tasks supports the Hypothesis 2 prediction.

3 | STUDY 2

3.1 | 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 that 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 A-DMC scale (Bruine de Bruin et al., 2007) to measure ability effects on simple and complex decision tasks.

3.1.1 | Participants and design

One hundred and thirty-eight glucose-deprived participants (fasting for >3 hr 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-g sugar) or sugar-free lemonade (placebo, 0-g sugar). The dependent variables were aggregate scores on the A-DMC.

3.1.2 | Procedure

When participants initially signed up for the study, they were provided with basic information including the need to fast for at least 3 hr 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 sign-up and the study start time was 24 hr 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 3 hr before their study session was set to begin. To help participants comply with the fasting requirement, experimental sessions took place during the morning hours. Upon arrival, participants were presented with informed consent and again reminded of the fasting aspect of the study, and they confirmed that they had complied. Thus, all participants 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.[4] After consent was obtained, participants were instructed to drink the lemonade that had been placed on the study 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 15 min. 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-in. 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.

3.1.3 | Materials

Glucose manipulation

To test the effects of glucose level, we relied on a procedure utilized in prior research to experimentally manipulate blood glucose levels (e.g., Masicampo & Baumeister, 2008; McMahon & Scheel, 2010). In this procedure, a sugar drink or placebo is consumed, and a postconsumption distractor task takes place for 10–15 min.[5] This distraction period gives the sugar sufficient time to be absorbed into the bloodstream. Research has shown a sustained increase in participants' blood glucose for at least 45 min postdistraction period (Kennedy & Scholey, 2000).

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

[4]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.

[5]Wang and Dvorak (2010) show that a 10-min wait period is sufficient to significantly increase blood glucose levels after sugared soft drink consumption.

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.

3.2 | 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 the overall decision score, each of the A-DMC subsections as well as separate analyses for attribute and risky choice framing resistance. The means and standard deviations for each subsection, subdivided framing subsection, and overall scores are presented in Table 2. The results of the analysis for each section and overall score are also presented in Table 2.

In our analysis of the findings, we first tested whether participants in the glucose-enriched condition made normatively better choices as reflected in the overall A-DMC composite score. As can be seen in Table 2, there was no significant difference in this composite score. Glucose enrichment did not improve decision making in the simpler normative reasoning decision tasks of recognizing social norms, under/overconfidence, consistency in risk perception, sunk costs, and the risky choice resistance subsection. The attribute framing subsection was significant. More importantly, more thinking, as operationalized through glucose enrichment, did improve decision making in the section of ADR, the subsection that contains more complex decision tasks.

4 | 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 and 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, it appears that enhanced thinking has less influence on decision making. Overall, this investigation provides a way to organize empirical findings and formulate a coherent message about how thinking relates to 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. A lingering question is whether more thinking will be beneficial or even advantageous in life. 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 dentists surveyed recommend this brand over the leading brand." If enhanced thought is focused on the more complex details of the ingredients and health information on the

TABLE 2 Means and *SD*s of nonstandardized 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* (138)	p	d
A-DMC composite	1.22	0.13	1.24	0.12	−0.99	.16	0.011
Recognizing social norms	0.48	0.17	0.44	0.20	1.12	.13	0.018
Under/overconfidence	0.76	0.09	0.78	0.09	−1.26	.11	0.01
Applying decision rules	0.76	0.13	0.54	0.24	−1.70	.05	0.04
Consistency in risk perception	0.67	0.13	0.67	0.09	−0.19	.43	0.002
Resistance to sunk costs	3.93	0.65	4.00	0.49	−0.62	.27	0.03
Attribute framing resistance[b]	−0.10	0.45	0.12	0.51	−2.6	.006	0.46
Risky choice resistance	−0.48	0.61	−0.58	0.80	0.9	.80	0.14

Note. A-DMC total is the average of the nonstandardized 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. Mean values for attribute and risky choice framing resistance were obtained by using a difference score of the average of the seven positive frames from the average of the seven negative frames.

Abbreviation: A-DMC, Adult Decision-Making Competence.

[a] $n = 69$.

[b] A separate set of analyses revealed that positive attribute framing was rated as less positive in the glucose-enriched condition ($M = 3.61$) than the placebo ($M = 3.83$), $t = -2.71$, $p < .004$, $d = 0.45$, but there was no significant difference in the negative frame condition, $t = -0.07$, $p < .47$, $d = 0.02$.

back labels, then will the individual make a 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, whereas if more decision information such as probabilities based upon disease progression, patient specifics, and other outcome-relevant information were included, effortful thought should produce an advantage. It is also important to consider whether more detailed analytic thinking is even desirable in some real-world decisions. For example, according to FTT, humans developmentally change and come to rely more on meaningful gist than verbatim analysis. Further, gist reliance increases alongside enhanced knowledge and experience within a domain, which acts to further improve the "goodness" of the gist and should lead to more biases but also better real-world decisions (Blalock & Reyna, 2016; Reyna, 2018).

These findings also hold insight for theoretical questions as well. For example, Levin et al. (2014, 2015) suggest that attribute framing may involve decision processing that is more emotionally driven whereas risky choice framing may involve a more cognitive type analysis because it requires the integration of probability and outcome magnitude. The findings from the current set of studies show that, at least in terms of Study 2, attribute and risky choice framing were differentially affected by our manipulation and this may reflect underlying processing differences. This finding also seems to suggest that the ability (glucose levels) to overcome or inhibit the more emotional attribute frame response may be more impactful than the motivation to do so, as defined by NFC. We found no differences in the strength of risky choice framing for either of our thinking manipulations. According to FTT (Reyna & Brainerd, 1991, 1995), verbatim information quickly fades in memory, and decisions are usually based on gist representations. In this case, leveling more thought toward the gist representation of "mostly good" or "a little bad" should not change the outcome of the person's choice. However, there is research showing that when information is presented per attribute (Abadie, Waroquier, & Terrier, 2017) or when gist memory is better organized via relevant decision information (Abadie, Waroquier, & Terrier, 2013), decision making may improve.

There is also the question of whether a person is "bound" by usage of a particular heuristic when making decisions or whether task-specific heuristics may be created. Research by Gigerenzer and colleagues (Gigerenzer, 2008; Gigerenzer & Gaissmaier, 2011; Todd & Gigerenzer, 2012) suggests that rather than having one set of "generic" heuristics for all situations, they propose that individuals rely on a set of "building blocks" that are unconscious intuitive rules that allow the construction of heuristics to fit the environment. Essentially, these heuristics involve a "search" for relevant cues in the environment, "stop" or inhibit a search for more information in the environment, and "make decisions," a choice based on the information obtained. This approach suggests that rather than generic heuristics being the source of decision processes, more general principles built within a constructive context is the basis for decision strategies people employ. As Gigerenzer and colleagues point out, these "fast and frugal" heuristics rely on information in the environment rather than complicated calculations. Because complex decision modeling can contain multiple parameters with different goals, a decision maker may be overwhelmed and become confused whereas the simple, yet effective decision strategies remain effective.

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.

In Study 2, we found that glucose enrichment did have a significant effect on attribute framing resistance, but not risky choice. When we did a more focused analysis, we found that this effect was largely due to differences in the positive attribute framing condition revealing a less positive attribute framing average under glucose enrichment. Although beyond the scope of these studies, it would be interesting for future research to examine this challenging finding and, if replicable, to further explore why glucose enrichment decreases attribute positivity responses only in the positive framing condition. Inquiries of this question should ask whether glucose enrichment might be decreasing overall positivity or whether it may be supporting a more thoughtful analysis that is sensitive to key information leading to less frame-biased responses. This question resembles recent work (Levin et al., 2014, 2015) that has suggested that attribute framing is more affectively driven whereas risky choice is more cognitive in nature. Future researchers may want to consider this as part of their design.

As a final note, we should point out some limitations that constrict the applicability of our findings. First, we used NFC as a measure of thinking. NFC is a measure of *motivated thinking*, and, because college students vary little in cognitive ability, using cognitive ability as a control variable would likely not have affected the findings of Study 1. This should be noted in future research. Further, we used NFC ranges that represented very high and very low scoring individuals from a college population. Although most sampling methodologies (e.g., online samples, convenience samples, and in-house sleep lab studies) have their inherent limitations, our method did allow for sampling of both high and low individuals. We caution future researchers who might be investigating NFC to thoughtfully consider whether relying on a median split drawn from a college sample will suffer from a lack of power and representation. We encourage researchers in the area to strive for more diverse and representative samples for research involving individual differences. Lastly, it is possible that some of the null findings for the less complex tasks may have occurred because of low sample sizes and could manifest in larger samples. This raises the possibility that NFC and glucose may play a stronger role in complex tasks but may also be influencing less complex decision tasks to a lesser extent. A final limitation that should be noted is that our current analysis does not distinguish between thinking more and thinking more insightfully, a point that future research may want to consider.

5 | 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 two hypotheses surrounding this view. First, we predicted that, for complex decision tasks, more optimal decision choices would be found when the decision maker is more thoughtful. Second, we predicted that, for simpler decision tasks, decision-making performance would not be affected by the thoughtfulness of the decision maker. The findings across two methodologically different but conceptually similar studies support this view. 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 allow 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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APPENDIX A

NFC distribution

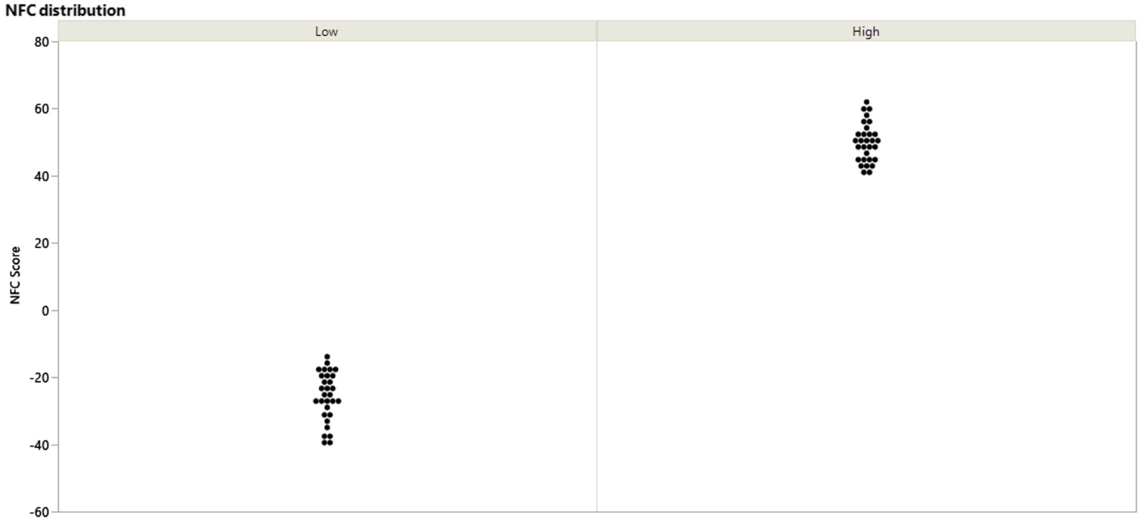

FIGURE A1 Distribution of NFC scores for high and low NFC participants [Colour figure can be viewed at wileyonlinelibrary.com]