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Chapter 4
A Fuzzy-Trace Theory of Risk and Time Preferences in Decision Making: Integrating Cognition and Motivation

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Introduction

In this chapter, we provide an overview of fuzzy-trace theory (FTT) and its implications for risk and time preferences. FTT is a dual-process model of reasoning, judgment, and decision making, as well as their development from early childhood to old age. The fuzzy-trace interpretation of risk and time preferences brings together concepts from behavioral economics, psychology, and neuroscience. The most important concept is mental representation, specifically verbatim (literal surface form) and gist (bottom-line meaning) representations. The differences between these types of representation determine risk and time preferences, in combination with social values as well as developmental and individual differences. In particular, sensitivity to rewards and inhibitory control vary across the life span and across people.

FTT's conceptualization of sensitivity to reward and inhibitory control, which contribute to impulsivity, contrasts with that of other dual-process accounts. FTT proposes that gist representations, which support fuzzy yet advanced intuition, are unconscious and automatic, whereas verbatim representations support precise analysis. We begin by introducing the foundations of FTT in economics and prior psychological theories. We then review the basic concepts of the theory, and how they explain risk preferences and time preferences, including delay of gratification. We distinguish risk preference, impulsivity versus intuition, temporal discounting (i.e., delay discounting), and delay of gratification, as well as FTT's approach compared to standard dual-process models of judgment and decision making. As we discuss, there are parallels in FTT's explanations of people's willingness to

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tolerate risk as well as their willingness to wait for future rewards. We conclude that FTT yields qualitatively different interpretations of risk preference and time preference compared to other theories.

Risk Preferences

Economic theories provide a useful framework for quantifying overall value of a course of action, with its roots in mathematics and applications to rational self-interest (von Neumann and Morgenstern 1944; see Tversky and Kahneman 1986). Therefore, we begin with a discussion of core economic principles. Expected value is one of the most well-known antecedents of economic theory, and it describes decision making through the use of two variables: probability and outcome. Probability could be the odds of winning a lottery ticket, and outcome would be the amount of money awarded for winning. These two factors form the core of classical decision theory, and they have been probed for decades by asking people to choose between outcomes that vary in risk. A typical question follows:

(A) Winning $100 for sure
(B) 0.50 probability of winning $200 and a 0.50 probability of winning nothing.

Option B is riskier than Option A because the outcome is more uncertain. That is, following the economic definition of risk, Option B has higher variance in its outcomes (Fox and Tannenbaum 2011). A risk-neutral person would be indifferent between these two options because $0.50 \times \$200 = \$100$. If people interpreted probabilities and outcomes linearly, they would be risk neutral. However, after this initial mathematical formulation, it became obvious that most people are not risk neutral. Instead, they prefer Option A over Option B, demonstrating risk aversion.

In an effort to account for risk aversion among other effects, economists developed the theory of expected utility (EUT). EUT represents outcomes nonlinearly as a negatively accelerated function of objective magnitude. In other words, 50% of $200 is worth *less* than $100. This nonlinearity explains the preference for the sure option (Option A), which is discounted less than the larger value in the risky option. The overall expected utility of an option is then a function of its probability and the subjective value of its outcome. von Neumann and Morgenstern (1944) defined rational decision makers as people who *consistently* choose the option with higher expected utility.

In 1979, Kahneman and Tversky reviewed evidence showing that people did not respond to decisions involving losses in the same way that they did to decisions involving gains. Consider receiving $200, but being required to make the following choice:

(A) Losing $100 for sure
(B) 0.50 probability of losing $200 and 0.50 probability of losing nothing.

For losses, most people prefer the risky option (Option B). Because the same person usually prefers the sure option for gains but the risky option for losses, he or she does not have a consistent risk preference. This shift in risk preferences is called a framing effect, as it is caused by the way in which the options are posed.

Kahneman and Tversky (1979) developed an alternative to EUT called prospect theory to account for several effects including framing. Prospect theory retained the idea of a nonlinear perception of outcomes from EUT, and it added a nonlinear perception of probabilities from subjective expected utility theory (Savage 1954). Ultimately, the theory predicted a fourfold effect such that people were risk seeking for gains with small probabilities and risk averse for losses with small probabilities, in addition to the framing effect described above (Tversky and Kahneman 1992). They described gains and losses as shifts away from a reference point, and these differences were often subjective rather than objective. For example, note that in the examples above, the net outcomes are mathematically identical for gains and losses. However, the outcomes described as losses feel different than those described as gains, and they elicit opposite risk preferences.

FTT was built on the foundation of prospect theory, and it carries the notion of distortions of probabilities and outcomes much further through the concept of gist. Gist incorporates both semantic content and context to represent the overall interpreted meaning of the options of a decision. The concepts of verbatim and gist representations and their application to decision making are discussed in more detail below.

Fuzzy-Trace Theory

According to FTT, when people are presented with information, they will, separately and simultaneously, encode it into both types of representations: verbatim and gist (Reyna and Brainerd 2011; Reyna 2012). Verbatim representations capture surface-level, exact details that were present. In contrast, gist representations encompass the general (or "fuzzy") bottom-line meaning of information. Although both verbatim and gist representations are encoded concurrently, they are independent and stored separately. Furthermore, gist is not extracted from verbatim representations (Reyna 2012). Each of these types of mental representations corresponds to, and supports, a different way of thinking. That is, verbatim representations facilitate precise analysis, representation, and calculation, whereas gist representations facilitate fuzzy, impressionistic thinking.

Fuzzy thinking explains many phenomena involving risk and time preferences. When a person is presented with a gamble and the outcome is not guaranteed, the gist representation that a person extracts as the bottom-line meaning of a gamble may be "there is a chance of winning something or nothing in this gamble." In contrast, the verbatim representation would constitute a much more specific and detailed representation of the presented information (e.g., a "0.50 probability of winning $200"). In FTT, the same information is encoded at different levels of a

continuum that varies from gist to verbatim. One end of the continuum represents the simplest, bottom-line meaning (gist), and the other end represents the most precise and detailed (verbatim) representation (Wilhelms et al. 2014). When people are confronted with a decision, they encode both gist and verbatim representations simultaneously, but, depending on individual differences, they rely more on either the gist or verbatim representations of the information (Reyna and Brainerd 2011).

FTT explains phenomena from the decision-making literature through different means than traditional theories. As discussed, prospect theory differentiates between gains and losses in its predictions about decision making, which depend on how the prospects are *framed*, relative to a reference point (e.g., the status quo). The predictions set forth by FTT go beyond traditional theories by incorporating a decision maker's interpretations and implicit connotations behind the presented options, when making decisions (Kühberger and Tanner 2010; Reyna 2012). In FTT, framing is explained using the ideas that (a) people draw out the gist of the choices present in a decision and (b) subsequently retrieve and apply their values to this gist (Reyna 2008; Wilhelms et al. 2015a).

Consider the gain problem presented earlier (i.e., winning $100 vs. 0.50 probability of winning $200; otherwise nothing). Research has shown that the above choice is translated into gist as a choice between "winning some money" versus "winning some money or winning no money" (e.g., Kühberger and Tanner 2010; Reyna 2012; Reyna et al. 2014). Then, in order to make a choice, people apply their values to the decision. In this case, a relevant value is "winning money is good," favoring winning some money over winning nothing and, thus, choosing the sure option. This explains the typical observed preference for risk aversion in the gain frame.

Preference for the sure option in the gain frame contrasts with the previously noted preference for the risky option (Option B) when the question is restated as a loss (losing $100 for sure versus a 0.50 probability of winning $200; otherwise nothing). In terms of gist, the choices in the loss frame are interpreted as "losing some money" versus "losing some money or losing no money." Once again, people apply their values, such as "I do not like losing money," to these gist representations of the choices, so now they decide that losing no money, the chance associated with the gamble, is better than losing some money, the guarantee in the sure option, and select the gamble. These gist representations are not arbitrary, but rather capture the simplest distinctions along the dimensions of probability and outcome. Often, multiple gist representations are extracted from the same information. As we discuss below, processing gravitates to the simplest gist representation that accomplishes the task. In this instance, the task is to make a choice between options.

Variations on Framing Effects

According to FTT, decisions can change depending on which values are retrieved and applied to a particular decision, which can be cued by the context (Reyna

2008). This prediction about cued values has been repeatedly demonstrated in both laboratory tasks and in real-life decision making (Mills et al. 2008; Reyna and Mills 2014). There are other differences that can affect risk preferences as in framing effects, too. For example, if both gain and loss frames of identical choices are shown to the same decision maker, the person's decisions and preferences will tend to be more consistent across gain and loss frames. This within-subject consistency reflects metacognitive monitoring and inhibition (Stanovich and West 2008; Liberali et al. 2012). In other words, some people monitor the decisions that are being made and restrain prepotent responses (Reyna and Mills 2007; Stanovich and West 2008; Reyna and Brainerd 2011).

Another variation on framing effects involves truncating the risky option in order to test alternative theories of risk preference (e.g., Reyna and Brainerd 1991, 1995; Reyna et al. 2014). Truncating the risky choice in different ways highlights or de-emphasizes the zero complement. In the previous examples, the zero complements are the 50% chance of gaining $0 in the gain frame and the 50% chance of losing $0 in the loss frame. Truncation is a sensitive theoretical variation of the framing task, which is used to manipulate the type of representation that is relied on. These truncation effects allow for a greater understanding of how framing effects can be altered depending on whether a gist representation is cued or a verbatim representation is cued.

For example, if one were to remove the zero complement from the risky option of the gain frame in a framing task (i.e., leaving only gaining $100 for sure versus a 50% chance of gaining $200), the result would emphasize the trade-offs between probability and outcome and minimize the categorical difference between the choices (winning some money vs. winning some money). Thus, according to FTT, removing the zero complement of the gamble would diminish framing effects. Alternatively, removing the *non*zero complement (i.e., leaving only gaining $100 for sure vs. a 50% chance of gaining $0) highlights the categorical difference between the choices (winning some money vs. winning no money). The theory also predicts that highlighting of a categorical contrast would result in an increase in framing effects. Both of these truncation results have been obtained not only in the context of tests of FTT and prospect theory, but also in independent tests in diverse populations (for a review, see Kühberger and Tanner 2010). All of the experiments on truncation have confirmed predictions of FTT and also disconfirmed predictions of prospect theory (e.g., removing the zero complement eliminates framing effects despite the presence of all theoretically relevant probabilities and outcomes).

Although it may appear that truncation effects are caused or otherwise affected by underlying ambiguity, this is not the case. Chick et al. (2016) conducted a study involving these framing task truncations. In this study, the participants were given clear instructions about how to interpret the omitted portions of the questions. Using our example, these instructions made sure that if participants knew that there was a guarantee of gaining $100 versus a gamble with a 50% chance of gaining $0, the truncated part of this decision must be a 50% chance of gaining $200 and nothing else (i.e., not 50% chance of "about" or "at least" $200). The participants were not only told clear instructions, but they were also quizzed before and after the

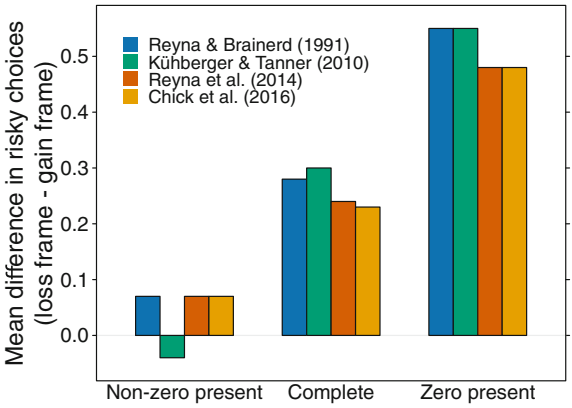

Fig. 4.1 *Bars* represent framing bias yielding a score that could vary from −1.0 (100% risky choices in the gain frame and 0% in the loss frame) to 1.0 (100% risky choices in the loss frame and 0% in the gain frame, standard framing). Framing bias of zero corresponds to no framing effect. Focusing on the nonzero complement (e.g., gain: "1/3 probability that 600 people are saved", loss: "2/3 probability that 600 people die") is presented at the *left*. Both complements are presented (e.g., gain: "1/3 probability that 600 people are saved and 2/3 probability that no one is saved", loss: "2/3 probability that 600 people die and 1/3 probability that no one dies") as shown in the *middle*. Only the zero complement is presented (e.g., gain: "2/3 probability that no one is saved", loss: "1/3 probability that no one dies") at the *right*. Chick et al. (2016) data are for participants who passed the ambiguity quiz

task in order to ensure that they comprehended the choices as the experimenters intended. The participants were also quizzed in order to rule out that filling in the truncated portions of the choices was due to rote memorization of the practice examples rather than true disambiguation of subsequent decisions. The instructions, which were followed by almost all of the participants because they passed the quizzes, controlled for several possible effects of ambiguity and the effects of the truncations remained resilient (Chick et al. 2016). Figure 4.1 shows the average framing effects in four studies on truncation (Reyna and Brainerd 1991; Kühberger and Tanner 2010; Reyna et al. 2014; Chick et al. 2016), all of which show robust effects of truncation as predicted by FTT. In some studies, participants received disambiguation instructions before attempting framing tasks. Presenting the zero risky complement (emphasizing "gist") increased framing, whereas presenting the nonzero risky complement (emphasizing "verbatim") attenuated framing, relative to the standard condition in which both risky complements were presented ("mixed").

Development: Differences and Reversals

FTT posits that both verbatim and gist processing (e.g., through improved analytical and mathematical ability and improved capacity to extract the bottom-line

meaning from information, respectively) develop with age. Moreover, the tendency to rely on gist representations increases from childhood to adulthood even when children have the full capacity to extract the bottom-line meaning from information, for example, using child-normed lists of words for recall (Brainerd et al. 2011). Thus, *preference* for gist processing is developmentally advanced, increasing with age and expertise (e.g., Adam and Reyna 2005; Reyna and Lloyd 2006; Brainerd et al. 2008; Reyna et al. 2014).

Applying these developmental tenets, FTT is able to explain certain findings that alternative theories are unable to shed light on. Multiple studies have found that framing effects grow stronger with age and expertise from childhood to adulthood, as initially predicted by FTT (e.g., adults show larger framing effects than adolescents or children; Reyna and Ellis 1994; Reyna et al. 2011). To illustrate, Fig. 4.2 displays data from three studies (Reyna and Ellis 1994; Reyna et al. 2011, 2014) in which participants of different ages and expertise levels completed framing tasks. Reyna et al. (2014), for instance, recruited college students, post-college adults, and intelligence agents—who were trained in risky decision making about national security—to complete 30 gain and loss decisions. Figure 4.2 shows that framing biases are maintained and can grow as people develop across age and expertise: The largest framing effect is observed among intelligence agents who were the most advanced participants in terms of training and experience regarding risky decision making.

Increases in cognitive biases from childhood to adulthood are categorized as developmental reversals. This is called a reversal because there is an *increase* in error rate with increased age and expertise. Framing effects occur despite the fact that children and adults both have the capacity to determine the expected value of

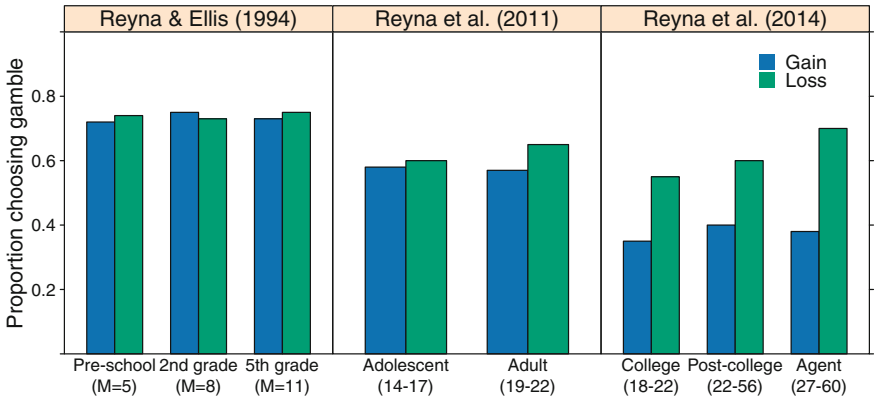

Fig. 4.2 *Bars* represent the proportion of choosing the risky choices in gain and loss frames. The values in *brackets* are either the average age of participants (Reyna and Ellis 1994) or their age range (Reyna et al. 2011, 2014). The values for Reyna and Ellis (1994) are estimated from Figs. 1 and 3 (p. 278) of that article. Reyna et al.'s (2011) values are also estimated from Fig. 2 (p. 1131) of that article

their options by roughly multiplying each outcome by its respective probability (Reyna and Brainerd 1994). In fact, this skill also improves with development from childhood to adulthood (Weller et al. 2011; Corbin et al. 2016). Additionally, older adults and experts show larger framing effects, and they are also more confident in their biased judgments than college students (Reyna et al. 2014). It is apparent, then, that although reliance on gist representations and gist processing is associated with developed reasoning and decision making, this same reliance can facilitate the susceptibility to cognitive biases that are meaning based (Weldon et al. 2013; Reyna et al. 2014). Whereas standard theories would classify these biases as unthinking errors, according to FTT, these biases are expected outcomes caused by an increase in the reliance on the bottom-line meaning, or gist, of information.

The results above, although unexplained by other theories, are consistent with the predictions of FTT. On the one hand, people at more advanced stages of development and expertise (e.g., children vs. adolescents or novices vs. experts) rely more on gist processing, as opposed to verbatim processing. On the other hand, children (and to a lesser extent adolescents) are more likely to rely on precise verbatim details when reasoning or making decisions (Reyna 2011). We are not claiming that children and adolescents are more quantitative when they make decisions (i.e., calculating and using exact probabilities and outcomes; Levin et al. 2007). Computation improves from childhood to adulthood (Reyna and Brainerd 1994). However, less developed individuals are more likely to rely on representations closer to the precise and literal—verbatim—end of a representational continuum. Hence, adults often rely on categorical differences between options in order to make decisions, whereas children make finer distinctions that are within their competence (Reyna and Brainerd 1994, 1995; Reyna and Ellis 1994; Reyna 1996; Reyna and Lloyd 2006; Reyna et al. 2011, 2015a).

Studies on real-life decision making have also supported this theoretical idea about development (Reyna and Farley 2006; Mills et al. 2008; Reyna et al. 2011). The empirical evidence that supports FTT and its predictions includes risk-taking research incorporating eye tracking. This research suggests that before making decisions, adolescents used a more detailed and exhaustive approach to information processing than adults in order to obtain more information about options. This finding supports FTT's hypothesis that adolescents were engaged in more verbatim–analytical processing involving trade-offs and more precise comparisons when making decisions (Kwak et al. 2015).

It is important to note, however, that, if needed, adults are able to and will shift to a more precise gist representation in cases in which the simplest gist is not sufficient to make a decision (Reyna 2012). This shifting can be illustrated using our example: When deciding between winning $100 for sure or a 50% gamble for winning $200 and a 50% of winning $0, the simplest gist representation is winning something versus winning something or winning nothing. A categorical distinction between something and nothing allows a person to make a decision when relying on this representation. In contrast, a choice between a 54% chance of winning $200 and a 46% chance of winning $0 versus a 55% chance of winning $180 and a 45% chance of winning $0 would demand a more precise representation than the

previous, categorical gist representation (because both options offer a chance to win something or nothing; see the Allais paradox as discussed in Reyna and Brainerd 2011): Assuming that 54 and 55% are perceived as similar per Stevens (2016), an ordinal representation would distinguish a chance of winning a higher amount (or nothing) versus a chance of winning a lower amount (or nothing), favoring the former.

By acknowledging the role of the reliance on gist representations, FTT is able to illuminate mechanisms behind developmental shifts in decision making (Reyna and Lloyd 2006; Reyna et al. 2014). Specifically, adolescents often appear more logical and calculating, yet take more risks. Similarly, experts are also more likely to rely on gist processing than novices. When it comes to making choices in a person's field of expertise, experts are more likely to rely on their intuition, whereas novices are more likely to rely on more precise and detailed representations and, in some instances, on rote memorization of verbatim details (Reyna and Lloyd 2006).

These FTT tenets imply that for risky decision making, mature qualitative processing which encapsulates the bottom-line gist is gradually given precedence over precise processing of risks and rewards of decision options as age and experience increase. This shift in preference for gist processing, theoretically, results in a protective effect against unnecessary and unhealthy risks and risk taking, as precise comparisons between risks and benefits (or rewards) give way to principles such as "no risk is better than some" (e.g., Mills et al. 2008; Reyna et al. 2011). As decision makers process information less precisely, they rely more on the core gist of the decision, which, in general, reduces risk taking because the risk–reward ratio is often favorable for single instances of risk taking (Reyna and Farley 2006; Reyna and Mills 2014; Wilhelms et al. 2015b). When relying on gist-based representations and processing, decision makers will also apply a number of principles in order to choose between the options that make up a decision. For example, a person relying heavily on gist processing will apply bottom-line gist principles (e.g., "it is better to be safe than sorry") when making a decision. These principles, being less verbatim and more gist-like by definition, ignore specific details about the potential risks or benefits (e.g., probability or magnitude). When relying on and using verbatim processing, conversely, a decision maker trades off risks and benefits. Because the benefits of risky behavior are higher than the corresponding risks more often than not, verbatim representations objectively favor risk taking (Mills et al. 2008).

As an example, the exact (verbatim) probability of contracting HIV from a single act of unprotected sex is very low relative to the potential gains that one may perceive (Wilhelms et al. 2015a, b). This is particularly true when considering the difference in risk between committing one action, such as unprotected sex, versus repeating the same action multiple times (cumulative risk; Mills et al. 2008). These precise, verbatim comparisons and the associated trading-off between risks and rewards stand in stark contrast to the gist representation of the situation, however. The gist of this decision whether or not to take the risk associated with this one act would be that there is some chance of HIV versus no chance of HIV. Most people would categorize this risk as "bad" and a related gist principle might be "it only

takes once to get HIV," indicating that unprotected sex (and the extreme risk associated) should be avoided categorically (Reyna 2008; Wilhelms et al. 2014). The connection between risk taking and the reliance on gist processing and gist principles has been supported by empirical findings which have shown that increases with age are associated with increased reliance on gist processing, more frequent agreement with and use of gist principles, and that risk preference decreases from childhood to adulthood (Reyna and Ellis 1994; Rivers et al. 2008; Defoe et al. 2015). We will delve deeper into developmental differences and FTT's explanation for these differences (compared to standard theories) in the following section on impulsivity and intuition.

Intuition and Impulsivity: FTT Versus Standard Dual-Process Theories

A major difference between FTT and standard dual-process theories is the distinction between intuition and impulsivity. In FTT, intuition and impulsivity, the latter operationalized as the failure of self-control or inhibition (Reyna and Mills 2007), are seen as separate and distinct from one another. Instead of being collapsed with an array of evolutionarily primitive System 1 processes, intuition is considered an unconscious, parallel, and impressionistic kind of processing that relies on gist representations, which is developmentally advanced.

In standard dual-process theories of risk taking, there is an emphasis on the conflict between impulsive and deliberative thinking (see Cokely and Kelley, 2009; Reyna and Rivers 2008). This emphasis is within the context of a dual-systems account that discriminates between two types of processes. System 1 processes are quick and general, whereas System 2 processes are deliberative and logical (Epstein 1994; Steinberg 2008; Kahneman 2011; Casey and Caudle 2013; see also Type 1 and 2 processes in Evans and Stanovich 2013). Intuitive and impulsive thinking (as these concepts are collapsed in standard theories) is often considered less advanced, attributed to children and traditionally linked to errors in judgment and decision making, and generally giving way to complex and analytical processing in adulthood. In other words, the deliberative, calculating thinking found in System 2 processes is analytical and can correct for the errors made by intuitive thinking and is associated with more advanced reasoning (see also Peters et al. 2006). This analytical thinking is also the type that, according to standard theories, develops with age and expertise. More recently, standard dual-process theories have also classified a third kind of processing, which is associated with reflection and inhibition (i.e., "the reflective mind"; Evans and Stanovich 2013). It is also important to note that these systems in standard dual-process theories are default interventionist (see De Neys and Vanderputte, 2011). This means that System 2 processes, and the thinking associated with them, are invoked if an anomaly is detected (i.e., when System 1 thinking requires overriding; Kahneman 2011; Evans and Stanovich 2013). Developmental dual-process theories similarly assume that

impulsivity is the source of unhealthy risks in adolescence. Thus, standard dual-process approaches attribute age-related differences in decisions to adolescents' heightened levels of sensation seeking, impulsivity, and lack of self-control (Wilhelms and Reyna 2013).

In FTT, risk taking concerns more than simply System 1 and System 2 thinking. Although standard dual-process theories have described the analytical thinking present in System 2 as advanced reasoning, FTT also incorporates intuitive reasoning using gist representations in its predictions. As gist-based processing is fuzzy and qualitative rather than exact and analytical, it is discussed in terms of intuition. This type of reasoning based on intuition is not categorized as impulsivity; however, gist-based intuition *is* developmentally superior, as reliance on gist processing increases from youth to adulthood and from inexperience to expertise. This shift facilitates making healthy decisions and avoiding unnecessary risks. FTT posits that it is this type of reasoning that most adults use when making judgments, inferences, and decisions about risk. Reliance on gist and gist-based processes and intuition is an advanced mode of thinking based on the underlying meaning of data and information instead of literal details (Adam and Reyna 2005; Reyna and Lloyd 2006).

Because reliance on qualitative, intuitive decision making is associated with impulsive decision making and risk taking in standard dual-process theories, FTT's predictions may be seen as counterintuitive. In other words, the idea that intuitive processing develops with age and expertise and is the foundation for higher-level cognition, as opposed to more deliberative processing, may seem somewhat improbable. Yet, empirical evidence and laboratory tasks support this prediction and highlight the advantages of intuition. This idea that gist-based intuition is developmentally advanced and cognitively superior has been supported by research showing that not only does reliance on gist-based processing encourage accurate decision making in realistic scenarios (Reyna and Lloyd 2006), but gist-based intuition underlies sophisticated and accurate cognition (Usher et al. 2011; Rusou et al. 2013). In contrast to standard dual-process theory, FTT would not classify the intuitions of experts with impulsivity found in children as the same type or system of reasoning (Reyna et al. 2015a). Thus, according to FTT, experts rely on educated intuition, which has been linked to superior decision-making behavior as assessed by agreement with practice guidelines and other evaluation rubrics (Reyna and Lloyd 2006; Reyna et al. 2015a). More generally, gist-based intuition has been associated with healthier decisions, and as assessed in randomized experiments, inducing such intuition improves the quality of decision making and reduces unhealthy choices (e.g., Reyna and Mills 2014; Fraenkel et al. 2015; Wolfe et al. 2015).

In sum, by distinguishing between intuition and impulsivity, as well as taking into account the distinct role of cognitive representations, FTT sheds light on the increase in risk taking that occurs during adolescence despite a decrease in risk preferences. This theory both predicts and rationalizes counterintuitive observations, for example, that children make risky choices more than adolescents under controlled conditions in the laboratory, contradicting standard dual-process theory.

In standard dual-process theory, impulsivity and intuition are collapsed into System 1 processes (e.g., Steinberg 2008; Casey and Caudle 2013), but research shows they diverge predictably. FTT conceptualizes impulsivity and intuition as divergent processes that develop independently and affect behavior differently (Reyna 2013; Reyna et al. 2015b). According to FTT, developmental trajectories of impulsivity and intuition proceed in opposite directions: Impulsivity decreases from childhood to adulthood, whereas cumulative experience in life—either as people age or progress from being a novice to an expert—enhances gist-based intuition (Reyna and Lloyd 2006; Reyna and Rivers 2008; Reyna and Brainerd 2011). Thus, research not only refutes the view that intuition is a developmentally primitive process (Barrouillet 2011), but it shows that gist-based intuition underlies developmentally advanced thinking.

Time Preferences

Armed with our distinctions grounded in research on risk preferences, we now apply these to time preferences. Time preferences involve preferences for immediate versus later rewards, and, more generally, future orientation (Frederick et al. 2002; Stevens 2016). In this context, impulsivity refers to the inability to wait for greater rewards, succumbing instead to immediate pleasures. As we discussed, the literature on risk preferences shows that different presentations of the same information (i.e., information that describes the same objective consequences, such as winning $100) elicit different mental representations, which in turn modulates risky choices. We argue that similar factors are at work in time preferences. Thus, cueing different mental representations of rewards by presenting the reward in different ways (e.g., *a delicious salad* instead of a *low-calorie salad*) would be expected to shape the gist of rewards, effectively mediating the relationship between reward sensitivity and unhealthy choices by changing the meaning of options (see also Ochsner and Gross 2008; Zayas et al. 2014). Moreover, as discussed in detail below, different levels of representation would be expected to influence time preferences by focusing processing on simple gist distinctions that promote insightful intuition.

FTT proposes two distinct routes to risky decision making and unhealthy behavior: One is deliberative, analytical reasoning that we have discussed, which relies on superficial, verbatim mental representations of choices that emphasize trading-off risk for reward. The second route to unhealthy choices is impulsive reactivity that accompanies a dopaminergic response to reward (e.g., food or alcohol; Reyna and Farley 2006). Impulsivity has been implicated in a range of health outcomes, including sexual health, substance abuse, and obesity (Metcalfe and Mischel 1999; Reyna and Farley 2006; Weller et al. 2008).

With regard to time preferences, impulsivity, as a multifaceted construct, has been operationalized as both a preference for smaller, immediate rewards over larger, delayed rewards and a tendency to take risks (Dalley et al. 2011). However,

correlations are negligible or nonexistent between risky decision making and choices between immediate and delayed reward (de Water et al. 2014). In spite of the partial overlap between the neural correlates of temporal discounting and risk preference, distinct neural systems are involved (see Robbins and Dalley, this volume). The regions showing more activity during risky choices, relative to those between immediate and delayed rewards, are the lateral prefrontal cortex (PFC) and the parietal cortex (Weber and Huettel 2008). In contrast, the activity of posterior cingulate cortex (Weber and Huettel 2008) and the middle occipital areas (Peters and Buchel 2009) is higher for choices between immediate and delayed rewards than for risky choices. However, neural correlates are not definitive evidence for distinct processing. Instead, empirically supported theoretical distinctions are needed in order to interpret neural activity. Therefore, we discuss the theoretical underpinnings of time preferences.

First, we compare and contrast temporal discounting with delay of gratification. Then, we discuss the implications of steep discounting and evaluate the evidence on the malleability of discounting tendencies. This discussion is followed by an in-depth review of FTT's predictions regarding the manipulation of temporal discounting. We show how standard dual-process models fail to capture the whole picture about the mechanisms involved in the manipulation of temporal discounting. More specifically, we discuss the role of cueing gist principles and, consequently, gist-based processing on altering temporal discounting and present specific hypotheses based on FTT. We wrap up with a review of recent findings that show qualitative, gist mental representations of core social and moral values (i.e., gist principles) are stronger predictors of delay of gratification than verbatim, analytical processing.

Temporal Discounting Versus Delay of Gratification

Although the operationalization of temporal discounting and delay of gratification and the tasks used to measure them are superficially similar, they do not measure the same thing. To illustrate, delay of gratification is often defined as the extent to which one can wait for a larger reward, which is distinct from preference for it (Peake, this volume), whereas temporal discounting, defined as the tendency to weigh delayed rewards with less subjective value than immediate rewards, characterizes the degree to which later rewards are preferred to sooner ones (Frederick et al. 2002; Zayas et al. 2014). Thus, temporal discounting is traditionally conceptualized as a continuous trade-off between different quantities of reward and time (Doyle 2013) that reflects the degree to which the magnitude of delayed rewards compensates for the time until their delivery (Prelec and Loewenstein 1998; Zimbardo and Boyd 1999; Dai et al. 2014). Therefore, whereas temporal discounting tasks measure time preferences using a series of choices between immediate rewards and larger delayed rewards, delay-of-gratification tasks measure

the ability to sustain an initial choice and resist temptations over time in order to obtain a larger reward (Reynolds and Schiffbauer 2005).

Discount Rate as an Index of Impulsivity

The main index of temporal discounting, which is argued to be a stable individual difference (Kirby 2009), is called *the discount rate*, which measures the rate of discounting over time. Participants respond to a series of questions in which they choose between an immediate reward (e.g., $100 now) and a larger delayed reward (e.g., $200 in 30 days). Modeling techniques use these choices to calculate an indifference point at which certain magnitudes of time and delayed reward induce indifference between the immediate and delayed options. Different mathematical models have been put forward that quantify the relationship between the delay to the receipt of some reward and its present value (Koffarnus et al. 2013). The most popular of these is the hyperbolic model (Mazur 1987) in which the discount parameter (k) is calculated using the following formula: $V = A/(1 + kD)$. V is the subjective value of reward A at the delay of D, and k is a free parameter related to the rate at which later rewards are devalued as a function of delay (Koffarnus et al. 2013). Discounting rates systematically decrease as a function of development (Green et al. 1994), with the most notable drop being between the ages of 20–30 years, after which the discount rate remains relatively stable (Green et al. 1996). Given that a high discount rate indicates a preference for smaller, immediate rewards, the age-related decrease of discount rate is taken to reflect changes in overall impulsivity.

Heightened discount rates have been linked to a range of unhealthy behaviors including tobacco, drug and alcohol abuse, obesity, as well as gambling problems, and low academic achievement (Petry and Casarella 1999; Weller et al. 2008; Bickel and Mueller 2009; Bickel et al. 2012, this volume; Johnson and Bruner 2011). Steep discounting, which acts as a trans-disease process and operates as a biomarker across a range of clinical conditions (Rachlin et al. 1991; Bickel and Mueller 2009; Bickel 2012), is linked to many modifiable health-related behaviors that contribute to major causes of preventable death and disease (Sheffer et al. 2016). Given that excessive discounting underlies choices that lead to negative health conditions (Koffarnus et al. 2013), it is important to question whether discount rates are modifiable, in order to improve choice behavior, which, in turn, would enhance health and quality of life. The traditional view is that such rates are not modifiable because they represent traits that distinguish types of people, although they vary across development.

Malleability of Discount Rate

Temporal discounting has been linked to various social and cultural factors including attitudes toward time (Hsee 1999; Weber and Hsee 1999), socioeconomic

status (Sweitzer et al. 2008; Griskevicius et al. 2011; Sweitzer et al. 2012), age (Green et al. 1999; Steinberg et al. 2009), and education (Jaroni et al. 2004). Thus, an important question is whether discounting is a result of the current environment and a stable trait or is a modifiable pattern of behavior, one which can be regarded as a state variable (Odum 2011). Existing literature suggests that temporal discounting may indeed be a stable trait due to the fact that discount rate has a high test–retest reliability for periods of up to one year (Simpson and Vuchinich 2000; Baker et al. 2003; Ohmura et al. 2006; Takahashi et al. 2007; Beck and Triplett 2009; Kirby 2009; Black and Rosen 2011) and that discount rates of different commodities are highly correlated (Bickel et al. 2011b; Odum 2011).

However, certain interventions and environmental manipulations have been successful in altering patterns of discounting (for a review see Koffarnus et al. 2013). Among these are intensive therapeutic interventions such as working memory training (Bickel et al. 2011b) and stimulations of dorsolateral PFC (Cho et al. 2010; Sheffer et al. 2013). Less intensive interventions include those that cue future thinking by evoking future events specific to each participant (Peters and Buchel 2009), align delayed reward to a specific date (e.g., "15th of July" instead of "in 30 days") (Read et al. 2005), as well as reframing choices to emphasize the "hidden zero" in the traditional format of temporal discounting choices (Magen et al. 2008; Radu et al. 2011; Magen et al. 2014). The latter manipulation of the hidden zero in temporal discounting problems is the most obviously connected to the tenets of FTT. FTT offers the promise of changing attitudes and behaviors by changing mental representations of choices (Reyna et al. 2015a).

Specifically, Magen et al. (2008) first demonstrated that adding the hidden zero into the choice task (e.g., "$100 today and $0 in 30 days or $0 today and $200 in 30 days" instead of "$100 today or $200 in 30 days") significantly reduced discount rates in their sample. From the perspective of FTT, adding hidden zeros to both parts of the problem emphasizes good and bad categorical distinctions for immediate and delayed choices—that is, this manipulation facilitates categorical distinctions between *some now but none later* versus *none now but some later* using gist representations of choice options. The reframing effect of adding the hidden zero into the temporal discounting choice task is similar to that of Allais paradox in which adding a win of $0 to the two choice options results in strikingly different risk preferences compared to having a win of $0 in one choice option (Reyna and Brainerd 2011). That is, the Allais paradox involves two choices, one between A and B and another between C and D:

A. A sure win of $1 million,
B. 89% chance of $1 million, 10% chance of $5 million, and 1% chance of $0,
C. 11% chance of $1 million and 89% chance of $0, and
D. 10% chance of $5 million and 90% chance of $0.

Many people choose A over B but also choose D over C, reflecting inconsistent risk preferences (e.g., see Tversky and Kahneman 1986). Note that the choice between A and B is explained by FTT just as risky choices in the gain frame are by

assuming that the simplest gist guides preferences: winning some money versus winning some money or winning nothing. However, the choice between C and D cannot be resolved with the simplest gist; both options boil down to winning some money or winning nothing. Therefore, based on similarity (Rubinstein 1988; Leland 1994; Stevens 2016), probabilities are assimilated but outcomes are distinguished at the ordinal level; the choices become a low chance of less money (or nothing) versus a low chance of more money (or nothing), favoring D. As we discuss below, the hidden zero operates analogously to the zeros in risky choice problems. Additionally, the hidden-zero effect is also analogous to the truncation effect seen in risky choice framing tasks, linking the two types of impulsivity (risk preference and time preference) through similar qualitative manipulations.

Given the widespread effect of steep discounting on problem behaviors, even small increases in the valuation of delayed rewards could have a significant clinical impact (Sheffer et al. 2016). Indeed, the association between discount rate and health-related choices is incremental, in that small changes in discounting are linked to a greater likelihood of successful treatments and lower frequency of behaviors that put one's well-being at risk (Yoon et al. 2007; Sheffer et al. 2012; Stanger et al. 2012; Bickel et al. 2015). Therefore, it is of crucial importance to understand the mechanisms through which interventions may alter discounting because such knowledge facilitates the design of more effective interventions or the improvement of existing ones. Next, we will compare and contrast interpretations of discounting mechanisms from the perspectives of standard dual-process theories and FTT and demonstrate how the explanations based on standard models do not tell the whole story about how discount rate may be manipulated.

FTT Versus Standard Dual-Process Theories: Different Takes on the Underlying Mechanisms of Discounting

McClure et al. (2004) used a temporal discounting task in which rewards of different magnitude ($5–$40) were presented using different levels of immediacy (i.e., from *today* to *6 weeks*). People's choices for immediate rewards on this task were linked to activity in limbic and paralimbic areas (i.e., the ventral striatum, the medial orbitofrontal cortex [OFC], medial PFC, and posterior cingulate cortex), whereas choices for delayed rewards were associated with the activation of lateral prefrontal regions (i.e., the dorsolateral PFC, the ventrolateral PFC, and the lateral OFC). This finding is similar to that of other functional magnetic resonance imaging (fMRI) studies of delay discounting in which (a) the *impulsive* system showed higher levels of activity during the choice of immediate rewards (Kable and Glimcher 2007, 2010; McClure et al. 2007; Monterosso et al. 2007; Bickel et al. 2009b; Xu et al. 2009) and (b) the *executive/control* system showed more activity for the choice of delayed rewards (e.g., McClure et al. 2007; Monterosso et al. 2007; Hoffman et al. 2008; Bickel et al. 2009a; Xu et al. 2009; Meade et al. 2011).

In a similar vein, Knutson and others (Knutson et al. 2005; Ballard and Knutson 2009) demonstrated that when delay and reward amounts are presented at separate times, activity in the limbic and paralimbic regions is associated with the magnitude of reward, whereas activity in the lateral prefrontal regions is associated with the magnitude of delay. Knutson and colleagues argued that these two distinct neural systems affect choice behavior by influencing the attribution of value of choice options in a temporal discounting scenario. This explanation and the results of the aforementioned fMRI studies are in line with the standard dual-process models of decision making (Jentsch and Taylor 1999; Bechara 2005; Bickel et al. 2011a; Kahneman 2011; but see Wood and Bechara 2014) in that delay discounting is linked to the relative activation of two distinct neural systems, the *impulsive* and the *controlling* (see Bickel et al., this volume).

FTT incorporates the aforementioned cognitive and socioemotional factors (e.g., self-control, impulsivity, and planning), but it predicts that meaningful gist-based intuition also enhances the ability to refrain from unhealthy risky choices (Reyna et al. 2015a) and delay immediate gratification (Reyna and Wilhelms, 2016). As we have noted, this view is in direct contrast with that of standard dual-process models that consider both intuition and impulsivity as dimensions of System 1 or Type 1 processes (Evans and Stanovich 2013). Based on FTT, meaningful, intuitive understanding associated with gist representations of response options influences mental representations of choices, which in turn affect behavior in a risky decision making or a temporal discounting/delay-of-gratification task. Therefore, gist-based intuition, as opposed to verbatim-based processing and deliberative analysis, which is the ideal of dual-process models, can act as a protective mechanism which increases the likelihood of healthier choices. However, the protective effect of gist-based processing relies on one's ability to accurately understand and encode the advanced gist of choices and be able to retrieve and process that gist at the moment of deciding (Wilhelms and Reyna 2013). Next, we will discuss how an understanding of the gist of response options or cueing such gist-based processing may predict and alter one's discounting tendencies.

The Effects of Gist-Based Processing on Temporal Discounting

According to FTT, core social and cultural values (e.g., "sacrifice now, enjoy later") are represented in the form of fuzzy, yet meaningful long-term memories. However, these gist representations are not mindless memorized rules applied universally. Rather, they are fuzzy guidelines that reflect a construal or interpretation of choice options (Reyna and Wilhelms, 2016). Evoking these gist principles, via meaningful cues in a context, may reduce arousal, and consequently impulsivity, by altering one's interpretation of a situation (Reyna and Brainerd 1991). Although people encode both verbatim and gist representations in parallel (Reyna et al. 2012),

as development progresses and people gain experience, gist representations become more influential in decision making than precise, analytical processing associated with verbatim representations (Reyna and Farley 2006; Reyna and Lloyd 2006; Reyna et al. 2011, 2014). Gist representations are encoded along a hierarchy ranging from the simplest possible gist denoting categorical distinctions (e.g., "some money now" versus "no money later"), through ordinal distinctions (e.g., "less money now" versus "more money later"), and on through more finely grained distinction (e.g., "$100 now vs. $200 in 30 days"). If a decision can be made by relying on the simplest gist, mature adults rely on this categorical distinction and only proceed to more precise higher levels of the hierarchy if lower levels prevent them from making a decision between two or more choices. This reliance on the simplest gist increases from childhood to adulthood (Reyna and Brainerd 2011).

According to FTT, enabling one to focus on the simple gist of a decision facilitates the retrieval of gist principles (i.e., representations of relevant social and moral values such as "sacrifice now, enjoy later"), which in turn affect behavior choices (Fujita and Han 2009; Reyna and Wilhelms, 2016). Given that gist representations are more resistant than verbatim ones to interference (e.g., high arousal), and have been shown to endure over time (Rivers et al. 2008), cueing gist-based intuition may counter the negative effects of impulsivity. Therefore, similar to the predictions of FTT for risky decision making (e.g., Kühberger and Tanner 2010; Reyna et al. 2014), advanced thinking about temporal discounting or delay of gratification is not trading off exact quantities (e.g., "$100 now vs. $200 in a 30 days"), but understanding the simple bottom line of core social and moral values (e.g., "sacrifice now, enjoy later") and how they apply to different situations (Reyna and Wilhelms, 2016). In other words, gist-based thinking, which focuses on the qualitative meaning or bottom line of choices, promotes better decision making by decreasing unhealthy choices such as risk taking or opting for smaller, immediate rewards (Mills et al. 2008; Fukukura et al. 2013; Reyna and Mills 2014). Indeed, the gist of many economic and health-related decisions is that it is advantageous to sacrifice now and reap the benefits later.

Given that people—particularly mature adults—rely on the simplest possible gist in different situations to make decisions, FTT proposes that emphasizing gist-based processing, and more specifically cueing categorical gist about the choice options in a temporal discounting task, may alter discounting behavior. People generally prefer to rely on the simplest, least precise gist; that is, if both categorical and ordinal gists apply to a choice, the categorical gist is relied on to make a decision (Wilhelms and Reyna 2013). The traditional format in which temporal discounting choices are presented (i.e., "$100 now vs. $200 in 30 days") does not enable one to make clear categorical distinctions between the response options as the two choices are viewed as "some money now versus some more later." However, the inclusion of a hidden zero in either part of the choice facilitates the ability to easily extract the categorical gist of the decision. To illustrate, the question of whether one wants "$100 now and $0 in 30 days, or $200 in 30 days" draws attention away from "now" and cues categorical thinking about the consequences of choice for future—that is, "nothing later versus something later." The very simple fact that having

some money is better than having none could encourage people to choose the latter option. Likewise, including a zero in the second part of the question (i.e., "$100 now, or $0 now and $200 in 30 days") draws attention away from "future" and cues the following categorical gist: "something now versus nothing now." Once more, given that having something good is qualitatively better than having nothing, one would assume that people will be more inclined to choose the former option (i.e., "$100 now").

It is worth noting that these proposed changes in discounting behavior indicate that gist-based processing does not necessarily always lead to a healthier choice. On the other hand, including a hidden zero in both parts of the choice (i.e., "$100 now and $0 in 30 days vs. $0 now and $200 in 30 days") may not be as effective as having zero in either part of the problem because this manipulation does not cue clear categorical distinctions—that can sway people's response to either immediate or delayed reward—because the gist of the choice is narrowed down to "some now and nothing later versus nothing now and some more later." Given that temporal discounting is traditionally perceived as trading-off magnitudes of reward with magnitudes of time (verbatim processing of trade-offs), one would not expect to observe changes in discounting rate as a result of adding hidden zero because the choices are still mathematically the same. However, FTT predicts that the aforementioned manipulations (i.e., adding zero to either part of the problem) modify discounting tendencies by facilitating the comparison of qualitative categories (gist processing).

The proposed changes in the presentation of temporal discounting choices suggest that cueing simple categorical gist of options may change people's preferences due to modifying their mental representations of the options which in turn facilitates the ability to apply gist values and principles to the response options. The impact of this modification is similar to the omitting of (or including) mathematically uninformative zero complements from the risky choice options in loss and gain frames which either emphasizes or de-emphasizes focus on categorical gist of decision and alters framing effects (e.g., Reyna et al. 2014). The observed changes in risky decision making and the hypothesized manipulation of temporal discounting choices—based on specific FTT predictions—cannot be explained by standard dual-process models because the options are mathematically equivalent with and without the zero. *Eliminating* the hidden zero from the temporal discounting choice in one option or including the hidden zero in both response options simulates what FTT predicts children (and to a lesser extent adolescents) would do—that is, it encourages a more precise processing of response options (toward the verbatim end of the cognitive continuum) and minimizes the likelihood of retrieving the relevant gist principles and relying on gist-based intuition, thereby increasing proneness to the interference of arousal and impulsivity. Thus, unlike standard dual-process theories, FTT emphasizes the power of gist representations to alter the salience of either immediate or delayed rewards, which modifies people's apparent discount rate. In other words, cueing the categorical gist of response options in a temporal discounting task facilitates the reinterpretation of the gist of choices through cognitive reframing (Zayas et al. 2014). Next, we will review

recent findings that show how qualitative, gist representations of delay of gratification influence decisions.

The Gist of Delay of Gratification

Just as in any other scenario, people encode both the verbatim (e.g., "one marshmallow now versus two marshmallows in an hour") and gist (e.g., "some food now versus some more food later") representations of options in delay-of-gratification tasks. Given that people—especially adults—tend to retrieve the simplest relevant gist required to attempt a task, FTT suggests that qualitative, gist distinctions in choice options tend to have a greater influence on decisions than quantitative, verbatim ones. One hypothesis is that the qualitative distinction or gist of options in a delay-of-gratification task has a greater predictive validity for unhealthy behaviors than precise, elaborate, and mathematical processing because the underlying gist of delay-of-gratification situations is more likely to be relevant to other decisions (e.g., monetary, health-related) in everyday life. Thus, according to FTT, the predictive validity of measures that are based on gist principles and cue gist-based intuition is higher than that of measures relying on verbatim processing.

To test this hypothesis, Reyna and Wilhelms (2016) compared the predictive validity of a measure—called Delay-of-Gratification Gist scale (DG-Gist)—that directly assesses people's beliefs about the qualitative gist of delay of gratification, with the predictive validity of traditional measures of temporal discounting and impulsivity that are based on verbatim processing. DG-Gist is a new 12-item FTT measure that captures a single dimension of delay of gratification. Items (e.g., "I spend more money on having fun today and don't worry about tomorrow") do not involve quantitative trade-offs and are scored on 5-point Likert scale ranging from "strongly disagree" to "strongly agree." A lower score indicates a better ability to delay gratification. Reyna and Wilhelms examined the convergent and divergent validity of DG-Gist with other potentially related scales such as Future Orientation, Propensity to Plan, Time Perspectives Inventory, Spendthrift–Tightwad, Sensation Seeking, Cognitive Reflection, Barratt Impulsiveness, and the Monetary Choice Questionnaire (temporal discounting). Although DG-Gist was correlated with the aforementioned scales, it explained unique variance—in predicting self-reported problem behaviors such as overdrawing bank accounts and substance abuse—beyond sensation seeking and inhibition (see Fig. 4.3). This finding indicates that the qualitative gist of delay of gratification, as a social and moral value, cannot be reduced to either a dualist distinction—between reward-related approach motivation, including sensation seeking, and inhibitory faculties, including cognitive reflection—or quantitative conceptions of temporal discounting (Reyna and Wilhelms, 2016).

Cueing gist-based intuition and expressing delay of gratification in the form of gist principles—as opposed to verbatim analyses of precise numbers—provided new evidence for the role of long-term, fuzzy mental representation of social and

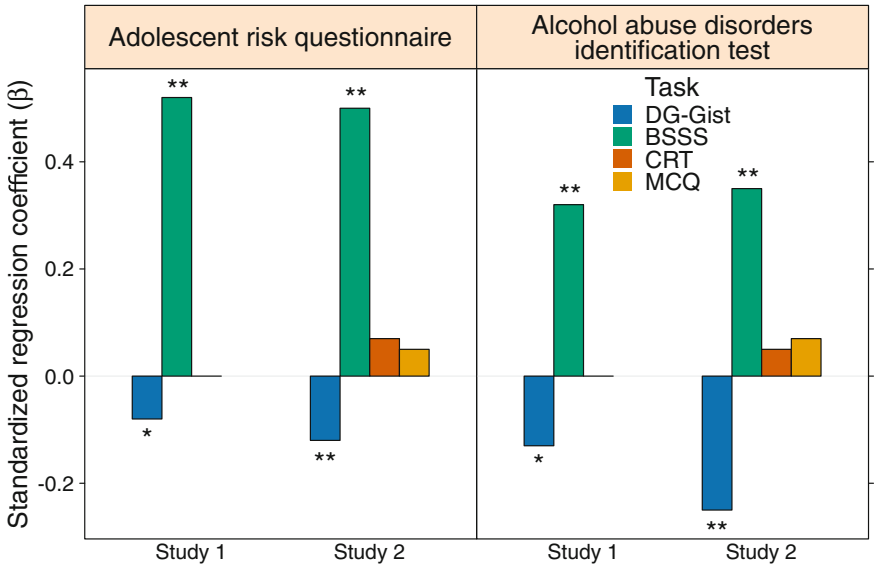

Fig. 4.3 Standardized regression coefficients showing DG-Gist accounted for unique variance in risky behaviors beyond measures of sensation seeking (BSSS), inhibition (CRT), and temporal discounting (MCQ). The measures of risky behavior were the Adolescent Risk Questionnaire (ARQ; Gullone et al. 2000), which records the frequency of engaging in 22 activities (e.g., drinking and driving, unprotected sex, and drug use), and the Alcohol Use Disorders Identification Test (AUDIT; Babor et al. 2001), which is a 10-item survey of alcohol use and dependency. *DV* Dependent variable; *DG-Gist* Delay-of-gratification Gist; *BSSS* Brief Sensation Seeking Scale; *CRT* Cognitive Reflection Test; *MCQ* Money Choice Questionnaire. *$p < 0.05$, **$p < 0.01$

moral values in deferring gratification and resisting risky behavior. Thus, unlike the predictions of standard dual-process models, empirical evidence (e.g., Mills et al. 2008; Reyna and Wilhelms, 2016) has shown that making finer distinctions (i.e., verbatim, analytical processing) is not necessarily associated with better, healthier outcomes. On the contrary, it is the gist-based intuition which is linked to fewer risky behaviors and an enhanced ability to delay gratification.

Conclusion

The evidence reviewed in this chapter shows how FTT—as an integrative framework—facilitates the understanding and prediction of risky behavior. One of the basic tenets of FTT, which is a theory of reasoning, judgment, and decision making, is that gist-based processing and reliance on bottom-line meaning of choices support advanced cognition. A recurrent finding is that as people age, they rely more and more on bottom-line intuition. The reliance of children and, to a lesser extent, adolescents on literal, surface, and verbatim representations of choices

(Reyna et al. 2011, 2015a) underlies immature decision making such as unhealthy behavior and risk taking. However, it is worth noting that gist-based processing is linked to systematic cognitive biases such as framing (Reyna et al. 2014). To illustrate, we discussed how children's and adolescents' lower reliance on gist reasoning enables them to outperform adults on particular cognitive tasks. This pattern of "developmental reversal" is due to the focus of younger people on precise details of options which results in the attenuation of framing effects in children and adolescents (Reyna and Ellis 1994; Reyna and Farley 2006). This chapter also compared and contrasted FTT predictions about risk preference with that of standard dual-process theories and discussed how standard dual-process models fail to capture the whole picture about the underlying mechanisms of risky decision making. Moreover, we contrasted the conceptualizations of intuition and impulsivity from the perspectives of FTT and standard dual-process theories and reviewed evidence (e.g., developmental trends) showing that gist-based processing and intuition is developmentally advanced and often a healthier mode of thinking.

In addition to literal analytical reasoning, which relies on superficial and verbatim representations of choices, FTT proposes impulsive reactivity as the second route to unhealthy choices. This kind of impulsivity is linked to both a tendency to take risks and a tendency to choose smaller, immediate rewards over larger, delayed ones. After a discussion of risk preferences, our chapter turned to this latter aspect of impulsivity that involves time preferences. We distinguished temporal discounting from delay of gratification, described how discount rate is often assumed to index impulsivity, discussed the implications of steep temporal discounting, and evaluated evidence supporting the claim that discount rate is a stable trait. However, research suggests that discounting is indeed malleable and that particular interventions and manipulations have been successful in altering patterns of discounting.

Our focus then turned to the underlying mechanisms of temporal discounting from the perspective of FTT and, more specifically, the impact of cueing gist principles and gist-based processing via truncating the choices in temporal discounting problems. We discussed how the inclusion of a hidden zero in either part of a temporal discounting problem theoretically modulates discounting by modifying a decision maker's mental representation of the options. When they emphasize categorical gist contrasts with receiving no reward ($0), these hidden-zero manipulations facilitate the ability to apply gist values and principles to the response options, thus evoking less impulsive choices. When zeros are in both options, they facilitate a more evenhanded approach to immediate versus delayed rewards, which can increase or decrease impulsivity relative to a no-zero baseline, depending on individual and developmental differences. In other words, if people are highly impulsive, emphasizing good and bad in each option can reduce impulsivity and conversely.

Finally, we presented recent evidence (Reyna and Wilhelms, 2016) on the role of long-term, fuzzy mental representations of social and moral values in deferring gratification and resisting risky behavior. To illustrate, DG-Gist, which is a 12-item self-report measure of people's agreement with the qualitative gist of delay of

gratification, explained unique variance in problem behaviors over and above standard measures of impulsivity and delay discounting that are based on verbatim processing. We conclude that the qualitative gist of delay of gratification, as a social and moral value, cannot be reduced to either a dualist distinction—between reward-related approach motivation and inhibitory faculties—or quantitative conceptions of delay discounting.

In sum, FTT's explanations for the role of gist and verbatim mental representations in reasoning, judgment, and decision making account for a wide range of phenomena (e.g., framing effects, reverse framing, truncation effects including framing problems, and the hidden zero in temporal discounting and delay of gratification) that other theories fail to fully account for. The examination of the neural underpinnings of reward sensitivity, subjective value, numeracy, risky choice, and mental representations not only enhances our understanding of the underlying mechanisms of judgment and decision making, but also facilitates the design of interventions that reduce unhealthy behavior.

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