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20 Morals, Money, and Risk-Taking from Childhood to Adulthood: The Neurodevelopmental Framework of Fuzzy Trace Theory

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Overview

Fuzzy trace theory (FTT) explains how cognitive representations of moral and monetary decisions, along with reward motivation and social values, are essential for understanding the adaptive social brain. What this means is that the way people think—whether they focus on exact details (called "verbatim" thinking) or the simple meaning behind those details (called "gist" thinking)—determines social behavior, such as risk-taking or committing crimes against others. Children, and adolescents who take unhealthy risks, rely more on verbatim thinking, but neurotypical adults progress to gist-based intuition, which is reflected in differences in the brain. Adults who do not develop properly continue engaging in unhealthy risk-taking and criminal behavior. We explain how FTT accounts for these developmental disorders. FTT's neurodevelopmental framework distinguishes autism from adult psychopathy, predicting and explaining paradoxes such as how these disorders are associated with fewer thinking biases in the laboratory but worse decisions in life.

Introduction

In this chapter, we provide a framework for understanding how people make moral and monetary decisions and how thinking about decisions changes with development from childhood to adulthood. We also apply this framework to explore developmental disorders such as autism and psychopathy. Our framework is grounded in experiments, mathematical models, neuroscientific, observational, and interventional studies (i.e.,

designing programs that support healthy and socially adaptive decision-making) on FTT (Blalock & Reyna, 2016; Reyna, 2012).

FTT's core assumption is that people mentally represent decision information in two basic ways: verbatim (the literal details) and gist (simple bottom-line meaning). For example, a decision to take a plea deal (accept a lighter sentence rather than risk going to trial) can be thought about in terms of details about potential outcomes, such as the number of years in prison, and their probabilities (the certain option offered by the prosecutor to serve fewer years in prison versus the risky option of going to trial and possibly serve more years in prison). Alternatively, an innocent person might think about the decision in much simpler terms: never plead guilty to something you did not do (Helm & Reyna, 2017).

How people mentally represent their decision options has a tremendous influence on the choices they make. Moreover, mental representation—the degree to which decision-making is based on verbatim details or gist meaning—changes with age and experience. In concert with changes in the brain, reward motivation, and socialization of values, cognitive representations determine whether people take unhealthy and antisocial risks (for a brief review of brain evidence, see Reyna, 2018).

Background

As we discuss below, we argue that neurotypical adults make most moral, monetary, and other reward-related decisions by relying on simple gist, ignoring numerical magnitudes and trade-offs. To be sure, most adults process numbers and trade-offs, and these exert some influence on decisions, but our central point is that simple gist tends to dominate. For example, asked whether you would push an innocent bystander off a bridge in order to divert a trolley so that it would kill one person rather than five people, most adults say "no" even though five is more than one (Bartels & Pizarro, 2011). Such decisions reflect combined influences of cognitive representations (thinking about both verbatim numbers and bottom-line gist), reward motivations (if money or other rewards are involved), and affective social and moral values (money is good; killing people is bad; Broniatowski & Reyna, 2018). (The ability to inhibit rash impulses and delay gratification are also factors but not ones we discuss here; see Reyna & Wilhelms, 2017; Romer, Reyna, & Pardo, 2016).

To preview, research indicates that children lean toward processing verbatim details, trading off objective levels of risk and reward if those are made clear to them (Schlottmann & Wilkening, 2011). Adolescents engage in a mixture of cognitive styles because they are in transition from childhood to adulthood, but those who take unhealthy and antisocial risks tend to engage in thinking about risks that is closer to the verbatim than gist side of processing (Kwak, Payne, Cohen, & Huettel, 2015; Reyna, Estrada et al., 2011). For example, adolescents might attend a party with illegal drugs because the benefits of having fun at the party are perceived to be high while the probability of getting caught (and going to jail) is perceived to be low. Surprisingly, teens often consider details, such as whether the amount of fun offsets the amount of risk, but these teens underemphasize the life-altering gist that they are risking a felony conviction. Thus, with respect to their cognitive representations, adolescent risk-takers frequently think in a younger way because they focus on details rather than the bigger picture (i.e., they are developmentally delayed).

The reason for this unhealthy risk-taking is not that gist thinking is inherently risk-discouraging and verbatim thinking is inherently risk-promoting. Rather, it is because many unhealthy risks are characterized by large rewards with low probabilities of bad consequences for a single act of engagement (Reyna & Farley, 2006). For example, many crimes go unpunished, addiction does not routinely occur with the first use of illicit drugs, and human immunodeficiency virus (the virus that causes AIDS) is unlikely to be transmitted even with unprotected sex. Engaging in these behaviors once is unlikely to be punished. Therefore, thinking about magnitudes of risk and reward, and trading these off as economists recommend, is likely to promote unhealthy and antisocial risk-taking. People who think this way about crime, addiction, and AIDS tend to have bad outcomes. If rewards were low (e.g., small amounts of money were at stake) and the probability of bad consequences were high (e.g., high chances of getting caught for committing a crime such as stealing the small amount of money), verbatim thinking would *discourage* risk-taking. Commonly, however, verbatim thinking is about high rewards and low probabilities of bad consequences, which encourages risk-taking. In fact, many crimes seem to reflect such technically "rational" considerations of risk and reward (though other crimes are impulsive; Matsueda, 2013).

Building on this foundation of research on neurotypical development, we argue that autism is characterized, in part, by a greater reliance on

verbatim as opposed to gist thinking, which generally characterizes younger children, but without the heightened reward motivation that characterizes adolescents or psychopaths (Reyna & Brainerd, 2011). That is, those with autism would take the plea deal if the risk-reward ratio were favorable, regardless of factual guilt or innocence. Adolescents would be unduly influenced by the prospect of freedom even if going to trial was risky. Adolescence, in addition to being a period of cognitive transition, is characterized by an increase in sensation seeking or reward motivation (e.g., for fun, freedom, and other rewards), which combines with cognitive representations to further promote risk-taking for rewards, including social rewards (e.g., impressing peers; Steinberg, 2008). Thus, risk-taking and antisocial behavior are normative for teenagers in the sense that these behaviors increase during normal adolescence for both cognitive and social motivational reasons. For most individuals, these behaviors decline in adulthood, hence the term "adolescent-limited" antisocial behavior (Moffitt, 1993).

Adolescent-limited is contrasted with life-course persistent antisocial behavior (Moffitt, 1993). The latter individuals who engage in persistent antisocial behavior are characterized by continued high sensation seeking (beyond adolescence) and impulsivity, among other traits. This unhealthy risk-taking may progress in severity to *criminal* antisocial risk-taking in adulthood because of high reward sensitivity (e.g., characterized by higher activation in reward centers, such as the ventral striatum, in decision-making tasks) and/or inability to control reward-related impulses (e.g., deficits in executive processes that reflect trauma or developmental disorders in the operation of frontal control networks in the brain) (Bjork & Pardini, 2015; Glenn & Raine, 2014). Thus, FTT anticipates two routes to risk-taking in adolescence and adulthood: (a) a "hot" kind in which emotion, temptation, and passion dominate (risks that, on reflection, people often regret and would not want to take again) and (b) a "cold" one in which decision makers take "rational" risks to gain rewards, calculated risks they would want to take again, even if they turned out badly, as long as the odds and outcomes were favorable (Reyna & Farley, 2006).

When risk-taking occurs in the absence of empathy for the feelings of others, it can be particularly dangerous to society. Life-course persistent antisocial risk-takers include psychopaths, who also lack empathic caring, the ability to care about the feelings of others (Decety & Yoder, 2016). There is some neural evidence that the brains of adult psychopaths resemble those

of younger people (Shannon et al., 2011), suggesting a developmental disorder related to reward motivation and, we speculate, to developmentally inappropriate reliance on verbatim representations. An important lynchpin in this argument is Bartels and Pizarro's (2011) finding that utilitarian thinking in the trolley problem mentioned above is related to psychopathy. Utilitarian thinking is, by definition, maximizing the risk-reward ratio as stipulated in economics; in our earlier example, the utilitarian solution is to save more people by murdering one. In other words, both options entail little risk (the options are presented as involving sure outcomes), but one option saves more lives and thus is preferred according to utilitarianism. The developmentally normative response for neurotypical adults, however, is to reject quantitative comparisons of numbers of lives in favor of qualitative, categorical thinking: no amount of lives can compensate for murder of an innocent person (Reyna & Casillas, 2009).

As we will discuss, similar noncompensatory thinking—in which tradeoffs are rejected in favor of qualitative, categorical thinking—also characterizes developmental differences in the singularity effect. The singularity effect is, for example, donating more money to one identifiable victim (e.g., the victim of a disease who needs expensive therapy) than to a group of eight identifiable people that includes the same one victim (Kogut & Ritov, 2005). When these two scenarios are presented together, people donate more to eight victims than one victim; they know that eight is more than one. However, when the scenarios are not presented together, adults give more to the single victim, responding based on qualitative gist rather than verbatim quantitative details.

In contrast to adults, younger children give more of their candies to more children compared to one child, contrary to the singularity effect. Children gradually reverse their donations as they get older and move toward adulthood; they become less technically rational, less utilitarian, and less verbatim in their thinking—eventually exhibiting the singularity effect as adults (Kogut & Slovic, 2016). As we will discuss, this developmental reversal echoes other results predicted by FTT in which literal verbatim thinking, which is more objective and reflects reality, is gradually replaced by gist-based thinking that foments specific cognitive biases and turns quantitative comparisons on their head.

In both the trolley car example and the singularity effect, the role of emotion seems obvious and explanatory: psychopaths feel little emotion

for others (i.e., empathic caring) and so they are willing to murder one person whereas neurotypical adults feel emotion more intensely for one identifiable victim than for eight (Kogut & Ritov, 2005). However, although the effects of emotion are probably real, they do not fully explain the results. Why do people feel more emotion for one than for eight? Donating more to one person compared to eight (or saving one person compared to five) cannot be explained by saying that this is just a failure to think deliberatively—why would that kind of thinking *increase* from childhood to adulthood, as shown in myriad studies (Weldon, Corbin, & Reyna, 2014)? Why does longer deliberation produce greater biases under specific circumstances (Duke, Goldsmith, & Amir, 2018), and worse decision-making, compared with gist-based reasoning (Abadie, Waroquier, & Terrier, 2013)? These puzzles and paradoxes, from the perspectives of standard theories, are explained by FTT.

There are three reasons we know that this kind of processing and decision-making has a cognitive representational component rather than *only* an emotion-versus-control component. First, gist and verbatim thinking independently predict real-world self-reported risk-taking when sensation seeking is controlled for statistically (Reyna, Estrada et al., 2011). In other words, gist and verbatim thinking predict unique variance in risk-taking in addition to what sensation seeking predicts. Second, behavioral and neural differences that correlate with risk-taking are elicited when the evidence indicates that decision makers are processing risky options in a more verbatim as opposed to gist way (Reyna, Helm et al., 2018); these comparisons are within-subjects, meaning that the same people are compared with themselves under different conditions that elicit different kinds of cognitive processes. Within-subjects comparisons control for differences in types of people, which rules out a host of alternative explanations, such as that differences across people in sensation seeking or emotionality wholly explain the results. Third, differences in verbatim and gist processing that replicate behavioral patterns of risky choice can be induced with purely cognitive manipulations (again, within the same experimental session and within the same people) that do not involve any variation in sensation seeking or any manipulation of emotion. Neurotypical adults can be induced to make choices that resemble those of children or adolescents simply by using manipulations predicted by FTT to change cognitive representations (Kühberger & Tanner, 2009; Reyna, Chick, Corbin, & Hsia, 2014).

In summary, we implement three constructs from FTT: (a) verbatim/gist cognitive representations; (b) individual and developmental differences

in reward motivation (i.e., sensation seeking); and (c) affective valences associated with social and moral principles stored in long-term memory. Verbatim and gist representations underpin processing that varies from a focus on precise details (verbatim-based analysis) to one on overall simple gist-based intuition (see table 20.1). Although FTT assumes that both kinds of representations are usually processed, the balance of these representations in decision-making varies developmentally. FTT is the only theory that predicts that reliance on intuition *increases* from childhood to adulthood, causing gist-based biases to increase. This developmental trend has been predicted and found in diverse domains of cognitive development such as false memory (remembering events that are consistent with the gist of what happened although those events never actually happened) and many other cognitive biases. Next, we explain how FTT predicts such biases in children versus adults, which shapes risk preferences. We then extend FTT to explain predictions for those with autism, adolescents, adult criminal risk-takers, and psychopaths.

Decision Biases in Children and Adults: Framing and Singularity Effects

Framing biases occur when people make inconsistent choices when confronted with two different versions of the same problem. One version presents the decision dilemma in a gain frame, while the other presents it in a loss frame. An example of the framing task is Tversky and Kahneman's (1986) dread disease problem, in which participants are informed of a disease that is expected to kill 600 people and then are presented with a gain and a loss frame dilemma about saving these people. In the gain frame, they choose between saving 200 people for sure or one-third chance of saving all 600 people and two-thirds chance of saving none. In the loss frame, they choose between either 400 people dying for sure, or a one-third chance of no deaths and a two-thirds chance of 600 deaths (see table 20.1 for a similar money problem). When confronted with such a problem, people will typically choose the *safe* option in the gain frame—saving 200 people for sure—but choose the *risky* option in the loss frame—gambling on the chance of no deaths—thus being inconsistent with themselves. These inconsistencies are described as "cognitive biases" because the number of people saved in the end is the same in the gain and loss versions (e.g., 600 lives minus 400 who die equals 200 saved).

According to FTT, this gain–loss framing bias is predicted because people use simple gist to reason and make decisions. Therefore, they mentally

Table 20.1
Verbatim and Categorical Gist Representations of Gain–Loss Framing Problems and Associated Social and Moral Principles (Affective Values)

Decision Problem	Verbatim Representation	Gist Representation	Affective Values
Gain Frame			
Option A: Saving 200 people for sure	Option A: 200 people saved	Option A: Saving some people for sure	Saving people is good.
Option B: 1/3 chance of saving 600 people and 2/3 chance of saving none	Option B: $1/3 \times 600 = 200$ people saved Preference: Indifference because expected values are equal	Option B: Saving some people or saving none Preference: Option A because saving some is better than saving none	
Loss Frame			
Option C: 400 people dying for sure	Option C: 400 people dying	Option C: Some people dying for sure	People dying is bad.
Option D: 2/3 chance of 600 people dying and 1/3 chance of none dying	Option D: $2/3 \times 600 = 400$ dying Preference: Indifference because expected values are equal	Option D: Some people dying or none dying Preference: Option D because none dying is better than some dying	
Gain Frame			
Option A: Winning $200 for sure	Option A: Win $200	Option A: Winning some money for sure	Gaining money is good.
Option B: 1/3 chance of winning $600 and 2/3 chance of winning none	Option B: $1/3 \times \$600 =$ Win $200 Preference: Indifference because expected values are equal	Option B: Winning some money or none Preference: Option A because some money is better than none	
Option C: Losing $400 for sure	Option C: Lose $400	Option C: Losing some money for sure	Losing money is bad.
Option D: 2/3 chance of losing $600 and 1/3 chance of losing none	Option D: $2/3 \times \$600 =$ Lose $400 Preference: Indifference because expected values are equal	Option D: Losing some money or none Preference: Option D because losing no money is better than losing some	

Note: Loss framing problems are usually preceded by a preamble (e.g., 600 people are expected to die or $600 has already been won) such that the gain and loss net outcomes are equivalent. When these decisions are presented to children and young adolescents, the outcomes are prizes (e.g., stickers) and the probabilities are represented by colored areas of spinners.

compare saving some people to saving none, favoring saving some, and none dying to some dying, favoring none. (This prediction is supported by separate evidence from separate tasks about how people represent information in their minds.) Gist supports "fuzzy" intuition, which is argued to be an advanced form of thought in FTT because it captures the meaning of information, not just memorized meaningless words or numbers (Reyna, 2012).

In a critical test of framing biases in children, FTT also predicted that intuitive gist-processing increases with age. Early work (reviewed in Reyna & Farley, 2006) showed that children are indifferent when making decisions in a framing task. The youngest children, preschoolers, did not have framing biases. Children focused on the final outcomes of the decision tasks, regardless of whether the problem was presented in a gain or loss frame. Unlike adults, their responses were not biased. Children were paying attention; for example, they gambled less as the risk (chances of gaining none or losing some) increased, regardless of gains or losses (see examples of similar decisions in table 20.1). Children's thinking showcases what most theories would regard as rational decision-making, not exhibiting gist-based biases in their decision-making process—therefore, technically behaving more like rational actors than adults do.

From childhood to adolescence, a different pattern of preferences emerges: reverse framing, or framing-inconsistent behavior when outcomes are large (Reyna & Farley, 2006). In contrast to standard framing effects in adults, or no framing in children, reverse framing consists of a preference for the *risky* option in the gain frame and the *sure* option in the loss frame. For example, in the money problem in table 20.1, adolescents are more likely to prefer the risky option that offers the chance to win $600 compared with winning $200 for sure. They are also more likely to prefer losing $400 for sure compared with taking a chance and losing $600. This pattern of preferences occurs during adolescence, especially for large quantitative differences in rewards, such as $600 versus $200 as opposed to $6 versus $1 (Reyna, Estrada et al., 2011). Reverse framing reveals a more precise analysis of a decision problem in which quantitative differences in outcomes matter, rather than the simple gist that adults rely on (see gist in table 20.1). In terms of complexity of quantitative processing, this reverse-framing processing lies between processing both risk and reward quantities, as young children do, and processing simple gist, as adults do, and involves processing mainly reward.

Thus, reverse framing is choosing the higher magnitude of outcome in the gamble for the gain frame and the lower magnitude in the sure loss for the loss frame. This more precise kind of thinking, compared with gist thinking, is called "verbatim" processing because it relies on precise words or quantities (the latter if quantities are presented). Many scholars assume that adolescence is a period when reward sensitivity and not-yet-fully-developed inhibition lead to risk-taking (Reyna & Farley, 2006). We agree. However, FTT also predicts this reverse-framing pattern for adolescence, which cannot be predicted by just higher reward sensitivity and lower inhibition. Furthermore, this pattern of reverse framing is associated with greater real-life risk-taking (Reyna, Estrada et al., 2011). Thus, ideas about cognitive representations (verbatim and gist) are required to understand the development of risky choices.

FTT explains that adolescents approach risky decision dilemmas in a way that is closer to verbatim than adults do, concentrating on the literal facts instead of reaching for the gist, the bottom-line meaning (Mills, Reyna, & Estrada, 2008; Reyna & Farley, 2006). When confronted with a decision, they trade off risks and rewards to determine which choice is more attractive to them. In other words, they engage in an implicit cost–benefit analysis of their options, relying on the representations of the superficial information as known or presented to them. Presented with a framing task, which involves risky decision dilemmas, adolescents who take risks reverse frame more than adults do. Most adolescents are not reverse framers, but this varies cross individuals; they show less standard framing than adults do. Note that reverse framing does not equal more risk-taking overall, but more risk-taking when rewards (gain outcomes) are higher and risk avoidance when loss outcomes are lower, all else being equal.

Hence, adolescent risk-taking is a multifactorial process. Sensation seeking (reward sensitivity) and behavioral inhibition, both contributing factors, have been shown to be related to age. Inhibition gradually rises throughout adolescence; sensation seeking that draws teens to rewards rises and then falls (Reyna, Estrada et al., 2011; Steinberg, 2008). When these age-related factors are controlled for, gist and verbatim processing were shown to still predict unique variance in adolescent risk-taking. FTT indicates that how young people think, as assessed by their framing patterns, explains crucial aspects of adolescent risk-taking.

This thinking is particularly evident in sexual risk-taking, a domain in which adolescents might be assumed—falsely—to underestimate the risks,

even though data show that they are very well aware of and overestimate risks (e.g., for sexually transmitted infections; Reyna & Farley, 2006; Reyna & Mills, 2014). Non–risk-taking adults are more likely to categorically refuse to have unprotected sex even if the chances of being infected by the AIDS virus are very low, relying on their gist representations (no risk is better than some risk of AIDS) which cue core values (getting AIDS is bad). In a similar scenario, adolescents would attempt to trade off risks and benefits. For example, having sex is an important reward that might outweigh the risks of possible sexually transmitted infection (STI), especially since statistically the probability of an STI is low. In other words, in their decision-making, adolescents are less likely to use the categorical distinction "no risk is better than some risk of AIDS" or "it only takes once" to be infected by an STI (Reyna, Estrada, et al., 2011). Because they weigh risks and rewards, they might lean toward the much-sought reward of having (unprotected) sex—the slight chance of getting infected by an STI is not downplayed, but its effect is swamped by the magnitude of benefits. This rational process, which is distinct from after-the-fact rationalization (Cushman, 2019) is objective, but would ultimately lead adolescents to risky behavior, with potentially severe repercussions for their long-term health (Reyna & Mills, 2014).

Similar to framing biases, the singularity effect emerges and becomes stronger with age, from childhood to adulthood, consistent with FTT. Research has shown that adults donate more money to, and are more affectively moved by, one identifiable victim in distress compared with a group of people who includes that same one victim (Kogut & Ritov, 2005). This preference toward the identifiable unity versus the more numerous group is called the *singularity effect,* and like the framing effect it is a cognitive bias. Contrary to the assumption that people would consistently help a group of people more than they would help one individual, the singularity effect indicates an increased insensitivity toward quantitative magnitudes—to *greater numbers* of people—and a preference to help one identifiable individual.

The economically rational prediction that, given the choice between helping one individual or a group of eight, most people would choose to help the group because it consists of more people—it is quantitatively larger—is inconsistent with the experimental observations of the singularity effect. This rational vision implies that people will process this dilemma in a verbatim way, processing one versus eight; in other words, that they will cognitively represent the single individual also as a number. Research has

shown that most adults tend to approach similar moral dilemmas in a gist-based fashion and thus show a consistent preference to help the one identifiable person in lieu of the larger number, the group. Most adults would not think one as opposed to eight; instead, when they see a single person they think categorically about personhood, meaning they would represent the unit as a categorical gist. Eight people invites more exact calibration of the number of people with the number of candies or dollars (Reyna, 2012). Focusing on such numerical details supports verbatim-based analysis.

Conversely, as Kogut and Slovic (2016) showed, younger children donated or shared less candy with one identifiable child compared with six children who included that one. However, this tendency begins to reverse as children get older, when their donations become more consistent with the singularity effect; they share more with the single individual than the group. The single individual stands for a category; it is qualitative and not a mere number like "6," which is a quantitative representation. As with framing, the singularity effect becomes greater with age, from childhood to adulthood, as people mature cognitively and become less sensitive to quantitative differences in outcomes (less scope sensitivity). This is another example of developmental reversals in cognitive representations from childhood to adulthood, indicating an increase in reliance on gisty categorical thinking as age progresses.

These effects are not due to an overall tendency to share or to be selfish. The overall tendency to help or share with other people also increases with age. The youngest children share less of their candy than their older counterparts overall—whether with the single individual or the group (Kogut & Slovic, 2016) and are therefore more selfish, extreme in psychopaths. However, selfishness alone does not explain why the singularity effect emerges and increases with age. Cognitive representations, and a preference for gisty intuitions versus verbatim quantitative thinking, explains why the singularity effect becomes more common.

Criminal Risk-Taking, Autism, and Psychopathy

This FTT theoretical framework contrasting gist and verbatim representations has been extended to nontypical development—namely, to criminal risk-taking and autism (e.g., Reyna & Brainerd, 2011). Regarding criminal risk-taking, research suggests that there are two kinds of risk-taking, with overlapping but distinguishable brain substrates (Reyna, Helm et al., 2018).

Noncriminal risk-taking behavior, linked to impulsivity and reward sensitivity, was associated with more activation in the amygdala and striatal areas, areas of emotional processing and reward motivation. Criminal risk-taking was associated with these kinds of areas but also with activation in temporal and parietal cortices, their junction, and insula, areas related to moral cognition, risk preference, and numerical processing.

Moreover, all of this activation was detectable when adults engaged in reverse framing—that is, choosing risky gambles in a gain frame and sure losses in the loss frame (Reyna, Helm et al., 2018). Thus, when adults displayed risk preferences in framing problems that were similar to those of risk-taking adolescents, the extent of brain activation in these areas correlated with the extent of their risk-taking activities. More noncriminal risk-taking was associated with more activation in reward and emotion areas ("hot" cognition), and more criminal risk-taking was also associated with activation in cognitive areas including numerical processing areas ("cold" cognition; Dehaene, Piazza, Pinel, & Cohen, 2003). These results suggest that risk-taking in adults, a non-normative behavior for this age group, may reflect developmentally delayed cognitive representational, as well as emotional/motivational, processing.

FTT indicates that both the hot and cold routes to risk-taking characterize adolescence. In particular, the second type of risk-taking, the cold route, involves verbatim analytical thinking about risk-reward trade-offs; when reward sensitivity and reward magnitudes are high, this produces reverse-framing decisional patterns. Individuals with autism also appear to process information in a more verbatim or literal way than neurotypical adults do (e.g., De Martino et al., 2008; Wojcik et al., 2018). We would characterize their information-processing style as high verbatim but low gist, which contributes to less comprehension of metaphors, lower levels of false memory (falsely remembering information that is gist-consistent but verbatim-inconsistent—that is, never presented), and lower likelihood of inferring implicit semantic connections in narratives (e.g., inferring that the bird is under the table from reading that the bird was in the cage and the cage was under the table), as predicted by FTT (Reyna & Brainerd, 2011). (See also the FTT research on mental representation of metaphor, false memory, and inference; Reyna, 2012.)

However, people with autism do not necessarily exhibit higher levels of sensation seeking. Therefore, to the degree that people have autism, FTT

predicts that they should be less likely to show standard framing effects. Given a high-verbatim, low-gist cognitive style, they would treat gains and losses more similarly than neurotypical adults and generally be less subject to other gist-based cognitive biases, as has been observed (see Reyna & Brainerd, 2011).

However, FTT would not expect that those with autism would show reverse framing. That is, people with autism appear to be more technically rational but not reward-sensitive (e.g., not drawn to higher rewards in the gamble). In addition, although people with autism have some difficulty inferring the feelings of others (cognitive empathy), they are not less likely to experience empathic caring. Thus, the affective valence of their social and moral values should not necessarily differ from those of neurotypical individuals (cf. Shah, Catmur, & Bird, 2016). FTT would therefore predict attenuation of framing among autistic individuals for both the money and lives dilemmas shown in table 20.1.

In contrast to people with autism, psychopaths are higher in sensation seeking or reward sensitivity and lower in empathic caring, compared with neurotypical individuals (Buckholtz et al., 2010; Glenn & Raine, 2014). Adult risk-takers in the study by Reyna and colleagues (2018) were also higher in sensation seeking (as well as being less likely to show standard framing). Psychopathy is also distinct from conduct disorder in adolescence (risk-taking and aggression) or impulsive antisocial behavior in adulthood. Traits of adult psychopathy, especially callous-unemotional traits, are detectable in childhood, and such traits during childhood predict adult psychopathy (Frick & Viding, 2009; Lynam, Caspi, Moffitt, Loeber, & Stouthamer-Loeber, 2007). *Criminal* risk-taking (e.g., drunk driving) in adulthood represents a more extreme form of antisocial behavior compared with *noncriminal* risk-taking (e.g., getting drunk). However, it could be argued that psychopathy represents the most extreme form of adult antisocial behavior because it involves intentional manipulation of others to obtain rewards (e.g., money) without empathic caring (Decety, Skelly, & Kiehl, 2013), as opposed to acting on impulse because of tempting rewards.

Based on behavioral and brain evidence, it appears that psychopathy represents a severe form of developmental delay in both reward sensitivity and cognitive processing (Buckholtz et al., 2010; Shannon et al., 2011). Crucially, Bartels and Pizarro (2011) showed that psychopathy is characterized by utilitarian thinking—which is, by definition, trading off risk and

reward to determine the rationally superior option, what FTT calls verbatim thinking. Thus, psychopaths would be expected to show reverse framing for monetary dilemmas, because they involve valued rewards (see table 20.1), but merely attenuated framing for lives problems. To the degree that psychopaths fail to endorse the moral value that saving lives is good, the lives dilemmas become just math problems governed by the verbatim numbers (cf. Bloom, 2017). Hence, risky choices of psychopaths would be a product of reward sensitivity (i.e., maximizing personal gains), cognitive representations that favor verbatim thinking, and lower levels of endorsement of moral principles such as saving lives is good.

For similar reasons, psychopaths would be expected to process the trolley problem analytically (five people killed is more than one person killed), although they would be less affectively or emotionally responsive to this dilemma (see Glenn & Raine, 2014, for evidence about lower levels of affective responsiveness; Patil, 2015). Like children, they should donate less in the singularity tasks than neurotypical adults to both one and six victims (because they experience lower affective valence or empathic caring), but again they would be more likely to consider these to be math problems because of verbatim thinking (Kogut & Slovic, 2016). Thus, if they donated, it would be more to six victims than one.

Note that, like autism, psychopathy is a matter of degree and varies across individuals. Presumably *pure* psychopaths would not donate anything if they could avoid social sanctions for doing so. Those with psychopathic *tendencies* would give less than other adults without such tendencies but would give more to six than one. Although we can piece together theoretical expectations based on prior work (e.g., showing reverse framing associated with adult risk-taking, including self-reported criminal behavior), there is as yet no published evidence that supports the latter predictions for psychopaths.

Summary and Conclusions

FTT attributes decision-making to three kinds of causes: how people think (focusing on literal details or simple gist), how responsive they are to rewards (sensation seeking), and their experienced affective valences associated with social and moral values (their internalization of social and moral norms). Thus, typical adults will choose to have some money for sure rather than take a risk and possibly have no money, even when they

probably could get more money by gambling (e.g., in the Allais problem in which a sure option of lower numerical value is preferred to a gamble of higher numerical value; see Reyna & Brainerd, 2011). Scientific tests show that simple gist representations of information (get some money versus get none) determine risk preferences, in concert with values such as "money is good," as illustrated in table 20.1. These simple gist representations also create cognitive biases such as framing effects in which the same person wants to avoid risks for gains but seek risks for objectively equivalent losses.

Counter to other theories of development, FTT predicts that children should be more objective than adults because reliance on verbatim analysis of surface details goes down and gist-based intuition grows from childhood to adulthood. Ironically, this means that children are less likely than adults to show a variety of gist-based biases, such as the framing effect, singularity effect (donating more money to one victim than eight), gist-based false memory, and other cognitive illusions. However, for the same developmental reasons, younger people are more likely to think about risk and reward analytically, which encourages risk-taking when rewards are high and probabilities of bad consequences are low. This vulnerability to risk-taking is worse in adolescence because reward sensitivity or motivation also increases and inhibition is not yet fully developed. Adolescent risk-takers are more likely to show a pattern of risk preferences that is rare in adults—reverse framing—preferring sure losses but seeking risky gains. Thus, with respect to their cognitive representations, adolescent risk-takers are often developmentally delayed. Reward motivation, less inhibition, and the thinking characterized by reverse framing all combine to predict greater real-life risk-taking (Reyna, Estrada et al., 2011).

Drawing on behavioral and brain evidence, FTT predicts that adult risk-takers are also more likely to show reverse framing. The degree to which they engage in criminal and noncriminal risk-taking is correlated with both reward motivation (i.e., they are higher in sensation seeking) and reverse framing (Reyna, Helm et al., 2018). Brain differences emerge for both types of risk-takers that further support a hot (related to reward and emotion areas, such as the amygdala) and a cold (related to the temporal and parietal cortex) route to risk-taking. These differences are detectable when the adults make choices consistent with reverse framing; when adults choose sure losses and risky gains, their brain activation covaries with the level of

self-reported unhealthy risk-taking. Adult risk-takers, especially those who engage in criminal risk-taking, appear to be developmentally delayed with respect to both motivation and cognition.

Building on other research, FTT suggests that disorders such as autism and psychopathy are characterized by reliance on verbatim analysis of risks and rewards rather than gist—again, with respect to their cognitive representations, exhibiting developmental delay. Psychopathy differs from autism, however, in also showing more responsiveness to rewards and less affective (emotional) responsiveness to social and moral values. Consistent with this framework, those with autism are less likely to demonstrate cognitive biases—they are *technically* more rational than typical adults in a variety of laboratory tasks because they base their responses on verbatim reality, such as objective outcomes and their probabilities, rather than being biased by subjective gist. Psychopaths would be expected to be similar to adolescent risk-takers and adult criminal risk-takers (who may include psychopaths or those with psychopathic tendencies) in showing reverse framing and differences in other cognitive biases, too.

FTT suggests that effects of impulsive reward seeking can be distinguished from such cognitive effects in accounting for developmental disorders such as psychopathy. The utilitarian approach of psychopaths is non-normative for adults, who typically respond more to intuitive gist than to precise numbers, undergirding social and moral development. In other words, morally, saving human life or sharing resources is a categorical good, as opposed to being a math problem involving distinguishing the number of lives saved or dollars shared. Thinking about moral choices in simple gist terms highlights categorical values, which helps most people make moral choices.

In summary, developmentally advanced gist intuitions are central to social and moral development. People who rely more on their gist intuitions when making decisions tend to make healthier socially adaptive choices and avoid unnecessary risks by thinking simply and categorically. Conversely, adolescents—and adults with developmentally immature cognition—think in a more literal, verbatim way, and this can manifest in atypical social development, including utilitarian approaches to moral dilemmas, unhealthy risk-taking, antisocial behavior, and even criminal activity. Ironically, irrational biases that promote healthy and moral choices seem to be a hallmark of the adaptive social brain.

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