HHS Public Access

Author manuscript

Curr Dir Psychol Sci. Author manuscript; available in PMC 2016 October 01.

Published in final edited form as:

Curr Dir Psychol Sci. 2015 October ; 24(5): 392–398. doi:10.1177/0963721415588081.

Educating Intuition: Reducing Risky Decisions Using Fuzzy-Trace Theory

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Abstract

Risky decision-making, especially in adolescence, is a major public health problem. However, fuzzy-trace theory suggests that bad outcomes are preventable by changing thinking, and, therefore, feelings, about risks. The theory aligns with new findings and has been shown to be effective in experiments on sexual risk-taking, medication adherence, and genetic testing. Despite the vulnerabilities of the adolescent brain, decision processes can be modified by applying evidence-based theory.

Keywords

health; adolescence; decision-making; behavior change; fuzzy-trace theory

Why do teenagers--and some adults--take risks? Many kinds of psychologists care about the answer to this question, as do professionals in behavioral economics and public health. Although taking risks can be beneficial in certain situations (romance would have little hope if people did not risk rejection), risk takers create economic, psychological, and physical damage to themselves and others by having unprotected sex, committing crimes, driving recklessly, and abusing drugs and alcohol. Is this damage an unavoidable consequence of an immature brain? Recent research suggests that the answer is no; there is hope, as a new report of a randomized experiment to reduce adolescent risk-taking shows (Reyna & Mills, 2014). However, we have to discard some old stereotypes about adolescents and expand our theoretical ideas.

Background

According to Tymula et al. (2012), there are two main theories of the development of risky decision-making: imbalance theory (Casey & Caudle, 2013) and fuzzy-trace theory (FTT; Reyna, 2012). Imbalance theory is a developmental version of dual-process theory, which

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pits lower- against higher-order processes in the tradition of Descartes. The theory builds on research in developmental neuroscience, contrasting early maturation of subcortical reward areas of the brain with late maturation of prefrontal areas responsible for behavioral inhibition and delay of gratification. Social interaction with peers is a powerful reward for adolescents, and the mere presence of peers increases risk-taking in simulated driving (Steinberg, 2008). Thus, the imbalance model posits that sensitivity to rewards does not just increase linearly from childhood to adulthood, as inhibition does; it peaks during adolescence, a curvilinear pattern (Reyna et al., 2011; Romer & Hennessy, 2007). However, these ideas are not sufficient to explain—and change—risk-taking.

What is Fuzzy Trace Theory and How is it Different?

FTT incorporates the traditional ideas about reward and inhibition that we have discussed, but it introduces the core concept of mental representation to explain risk-taking. Mental representations range in precision from verbatim (literal) to fuzziest gist (simplest cognitive and affective meaning). Unlike speculative notions, the tenets of FTT have been formalized in mathematical models and tested in experiments on memory, language, reasoning, and decision-making across the lifespan (for an integrative overview, see Reyna & Brainerd, 2011).

According to this theory, people record independent tracks, like stereophonic sound, of their experience in verbatim and gist representations, even in the moment as they make decisions. As people mature and gain experience, they rely more on gist rather than verbatim representations, called a *fuzzy-processing preference*. People can ratchet up the precision of their representations if the task requires it (task calibration). However, a major developmental principle of the theory is that advanced cognition (i.e., adults vs. children; experts vs. novices) typically operates on gist representations (e.g., Reyna et al., 2014; Reyna & Lloyd, 2006). No other developmental or dual-process theory makes this prediction, namely, that processing fewer dimensions of information in a simpler all-or-none fashion is more likely to guide decision-making as a function of greater experience or expertise in a domain.

Indeed, traditional theories of decision-making are rooted in the concept of expected value (magnitude of probability × magnitude of payoff = expected value of a decision option). Thus, people should take risks if those risks are offset by the sizes of expected payoffs. Some developmental approaches contrast “cold” deliberation of such risk-reward tradeoffs with “hot” heightened emotional arousal, consistent with imbalance theory (see Figner & Weber, 2009).

Thus, a sharp distinction between FTT and traditional theories of decision-making is that, according to the former, more mature decisions often hinge on mental representations of simple *categorical* contrasts, for example, between saving some lives and saving none, as opposed to trading off *degrees* of risk and reward. In fact, young adolescents who see initiating sex as “No risk is better than some risk” rather than the almost synonymous but more hair-splitting “Less risk is better than more risk” were about half as likely to have

initiated sex (Mills, Reyna, & Estrada, 2008), a surprising finding that has been replicated (Reyna et al., 2011).

Improving Decisions

According to FTT, it is possible to improve decisions by manipulating level of construal so that people use more gisty or abstract representations (e.g., Fukukura, Ferguson, & Fujita, 2013). Rather than being only a question of motivation or incentives, adolescents can be educated to process information differently, changing choices (Reyna & Mills, 2014). We call this process "educating intuition" because teens are taught to appreciate the gist of decision options, rather than to deliberate or analyze their options (cf. Hogarth & Soyer, 2015). When people focus on the simple gist of their choices, they are also better able to retrieve their social and moral values and, thus, successfully apply them to decisions (Fujita & Han, 2009; Mills et al., 2008). Applying FTT to promote gist processing has been shown to increase value-concordant medication decisions from 35% to 64% and to decrease interest in inappropriate genetic testing from about 50% to less than 25%, among other outcomes (e.g., Fraenkel et al., 2012; Wolfe et al., 2015).

Conversely, thinking precisely in terms of degrees of risk and reward (toward the verbatim end of the representational continuum) can promote unhealthy risk-taking, as a review of real-life risk-taking showed (Reyna & Farley, 2006). For example, adolescents are more likely than adults to trade off risks and rewards, reasoning that the objective risks of contracting HIV are very small, but the benefits of sex are large, which promotes sexual risk-taking. Adults who are aware of low levels of HIV risk, nevertheless, rely on the categorical gist that "it only takes once to get HIV" (Reyna, 2008; Reyna et al., 2011). Therefore, Reyna and Mills (2014) endeavored to instill this kind of categorical gist thinking in adolescents, while informing them about the precise (i.e., verbatim-level) facts of sexual risk-taking.

Applying Fuzzy-trace Theory to Reduce Risk-Taking

Reyna and Mills (2014) randomized 734 adolescents from three states (Arizona, Texas and New York) into one of three groups: Reducing the Risk (RTR), gist-enhanced RTR+, or unrelated control. All curricula were comparable in length and number of interactive activities. The gist-enhanced program was designed to improve on an already effective intervention (RTR) to reduce premature pregnancy and sexually transmitted infections (STIs), including HIV. RTR+ had virtually identical content and social components (e.g., role-playing), so that it was closely aligned with RTR. The difference between the programs was that RTR+ emphasized the bottom-line meaning of the information by providing simple summaries (rather than detailed lists) and explaining that some risks should be viewed categorically despite low objective risk.

Specifically, precise information about risks was provided in both intervention groups, for example, that there is about a 1/12 chance of pregnancy from unprotected sex that results in a more than 90% chance of pregnancy after a year (if sex occurs once a month). Both groups were taught that risk accumulates with repeated encounters, illustrated with classroom exercises. The gist intervention acknowledged that the risk from a single encounter was low,

but noted that it only takes once, risks add up fast, and pregnancy was pretty much going to happen in about a year. The message was that pregnancy risk is essentially categorical—it will happen—in a year, if people keep having sex.

Similarly, although both groups were taught the facts about treatment for STIs, the gist intervention emphasized that viruses (e.g., herpes or HIV) differ categorically from bacteria (e.g., gonorrhea or syphilis): Unlike bacterial infections, viral infections cannot be cured with treatment. Both groups also learned about low, medium, and high risk situations for having sex. But adolescents in the gist intervention learned to quickly and intuitively categorize risk, as opposed to reflectively analyze the details of such situations. RTR and the gist-enhanced RTR+ were aimed at changing psychosocial mediators of behavior change (e.g., gist knowledge, attitudes, self-efficacy, beliefs about social norms, and categorical risk perceptions), as well as behaviors and behavioral intentions.

Outcomes data were collected at pre-intervention, immediately post-intervention, three months, six months, and twelve months. Reviews of the literature show that only about one third of high-quality interventions to reduce sexual risk-taking improved two or more outcomes (Kirby, 2011). Interventions are rarely evaluated beyond short-term outcomes and are notoriously subject to fade-out effects when evaluated longer term. However, gist memories of essential meaning are preserved over long periods, in contrast to verbatim memories of learnt facts that quickly fade. Consistent with FTT, by emphasizing gist representations, which are key memories used in decision-making, the enhanced intervention should produce larger and more sustained effects on behavioral outcomes and psychosocial mediators of adolescent risk-taking.

Overall, the gist-enhanced RTR+ intervention was superior to the control group for 17 of 26 outcomes, and to the regular RTR for 9 outcomes. RTR+ effects were still statistically significant for 12 outcomes more than a year after the intervention (RTR effects were significant for 10). Figure 1 shows some effects of interventions. Analyses controlled for age, gender, race/ethnicity, state, and baseline score on the outcome; so results were not dependent on such factors. Adolescents in the RTR+ intervention reported such outcomes as delayed initiation of sex (reduction in risk was 84%) and fewer sexual partners, as well as changes in attitudes, norms, self-efficacy, perceived control, and motivations to have sex.

Thus, regarding psychosocial mediators (e.g., attitudes, social norms) identified in many studies, RTR+ influenced reliable and valid measures of mechanisms of behavior change, according to traditional theories (Reyna & Farley, 2006). Furthermore, RTR+ influenced theoretically novel mechanisms identified in FTT. For example, adolescents in the gist-enhanced RTR+ group were more likely than adolescents in the RTR or control groups to agree with statements about the categorical gist of the decisions, such as categorical risk perception (e.g., “It only takes once to get HIV”; see Figure 1F). Additionally, adolescents in the RTR+ group were more accurate than those in the RTR and control groups in their categorizations of the gist of risky situations as low or high in danger (e.g., of unprotected or forced sex; see Figure 1D). In other words, they learned to discriminate risky vs. not risky situations, to recognize “warning signals” that suggest unsafe sex may be imminent (e.g., being alone with someone, lights low and soft music playing, the presence of alcohol).

In contrast, verbatim measures of risk-taking (e.g., rating the likelihood of contracting an STI in the next six months on a 0–100% quantitative scale) did not vary by group. Endorsement of gist principles that capture social and moral norms also did not vary by group, but it was high in all groups. That is, adolescents could choose to check off as few or as many principles as they thought described their personal core values, expressed as simple gist statements (e.g., “I have a responsibility to my partner to not put him/her at risk”; “Better safe than sorry.”). The average number of endorsements hovered between 10 to 11 out of 15 norms for each of the three groups (for other results regarding risk reduction and social norms or values in FTT, see Broniatowski et al., 2015; Fraenkel et al., 2012; Reyna, et al., 2013; Wolfe et al., 2015).

Importantly, by reporting effects on psychosocial mediators separately--mediators shown to have distinct effects in prior work--it is possible to understand why the gist-enhanced curriculum was successful. This transparency about mechanisms allows interventions to be applied more effectively because practitioners know the psychological targets that they are trying to hit.

The research we have reviewed shows that adolescents are not held hostage by an overactive reward system and an immature prefrontal cortex, with little recourse other than to outgrow their propensity for risk-taking. The way adolescents think can be changed by instilling gist-based intuitions about risk.

Laboratory Research that Motivated Effective Interventions

The interventions we discussed were grounded in laboratory research, which controls for factors that are mixed together in real life. For example, a laboratory task might involve a choice between winning $5 for sure versus a gamble offering a 50% chance to win $10 and a 50% chance to win nothing. Risks and rewards are displayed visually (e.g., using game-like spinners and piles of money to suggest amounts). Children, and adolescents who take real-life risks, are more likely to choose the risky gamble over the sure thing; adults prefer the sure thing (Reyna & Farley, 2006; Reyna et al., 2011).

When all of the winnings are increased proportionately (say, $150 for sure vs. a 50% chance of $300, which controls for perceived similarity of numbers; Roitman, Brannon, & Platt, 2012), adolescents are even more likely to prefer the gamble, but adults are even more likely to prefer the sure thing. All the studied age groups roughly multiply risks and rewards, a verbatim-based analysis, although the ability to execute these analyses improves in childhood (Levin et al., 2007). However, adolescents are attracted to larger rewards and also compare the amount to be won in the sure thing to the amount in the gamble, whereas adults rely on the gist of winning something compared to nothing (Kühberger & Tanner, 2010; Reyna, 2012; Reyna et al., 2014; Venkatraman et al., 2009). In Venkatraman et al.'s study, for example, most adults chose to add money to options in a gamble to eliminate the categorical *possibility* of winning nothing rather than adding money to maximize the *amount* of the payoff.

FTT predicts these risk strategies, their developmental trends, and critical effects (e.g., of increasing magnitudes of rewards), by positing parallel ways of thinking—one more precise

and literal and another more simple and meaningful. Thinking interacts with motivational factors such as reward, but explains additional variance (Reyna et al., 2011). Thus, a combination of cognitive and motivational factors, plus greater freedom and opportunity to take risks relative to childhood, produces the observed spike in real-world risk-taking in adolescence.

Future Directions: Bringing Together Brain and Behavior

Reyna and Huettel (2014) provided a preliminary framework for the neuroscience of risky decision-making, drawing on brain research on decision-making and on false memories—memories consistent with gist rather than literal reality (Brainerd & Reyna, 2005; Dennis et al., 2012). A promising direction for future research is to integrate this framework with research on developmental and individual differences (Casey & Caudle, 2013; Levin et al., 2014; Reyna et al., 2011; Steinberg, 2008). To capture such differences, Reyna and Brainerd (2011) introduced a fourfold distinction between low-versus-high verbatim and gist processing. They classified autism as high-verbatim/low-gist, literal processing with lower susceptibility to gist effects (De Martino, et al., 2008; Miller et al., 2014; see also “weak central coherence” Frith, 2012). Adults' risk aversion becomes risk-seeking when outcomes are losses (gain-loss framing), as explained by gist: losing some money for sure is worse than gambling and possibly losing nothing. FTT predicts less framing and other gist-based biases in autism, as observed. Recent reviews suggest that cortical underconnectivity distinguishes autism from neurotypical development, a potential brain mechanism for gist development (Anderson, 2014; Just et al., 2013).

Conversely, old age is characterized by high-gist/low-verbatim processing, as research on FTT and the brain has shown (Brainerd et al., 2014). Gist processing is relatively preserved in normal aging, perhaps because of the distributed nature of memory traces in the brain, parts of which can be lost and yet the gist can still be reconstructed (Brainerd, Reyna, & Howe, 2009; Reyna & Mills, 2007). Using gist, risky decision-making--when detailed memory about options is not required by the task--is intact in normal aging and is similar to that of young adults (Samanez-Larkin & Knutson, 2014).

Conclusions

Our discussion highlights how the developing mind is malleable, and how theoretical mechanisms identified in basic research on risky decision-making can be translated into effective health programs. FTT integrates these mechanisms—mental representations, motivation, and inhibition—to explain, predict, and change risky behaviors.

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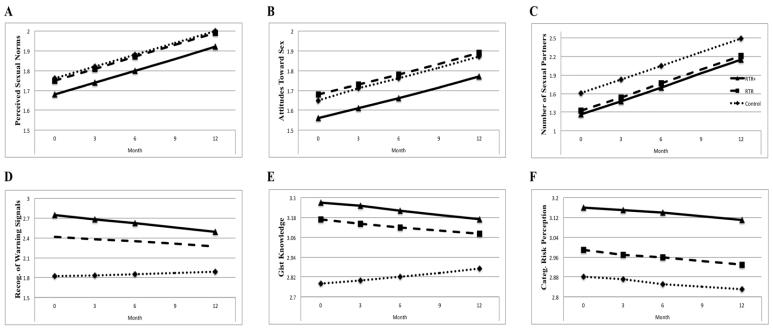

Fig. 1.

Adjusted means of outcome variables by intervention and time of assessment (see Reyna & Mills, 2014): ***A***, Perceived sexual norms were lower for RTR+ than either RTR or control; lower numbers indicate lower perceived frequency of peer sexual behavior. ***B***, Attitudes toward sex were lower for RTR+ than either RTR or control; lower numbers indicate less favorable attitudes towards sex. ***C***, Number of sexual partners was lower for RTR+ relative to control. ***D***, Recognition of warning signals was highest for RTR+, lower for RTR and lowest for control. ***E***, Gist knowledge was highest for RTR+, lower for RTR and lowest for control. ***F***, Categorical risk perceptions were highest for RTR+, lower for RTR and lowest for control.