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Risk Taking Under the Influence: A Fuzzy-Trace Theory of Emotion in Adolescence

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Abstract

Fuzzy-trace theory explains risky decision making in children, adolescents, and adults, incorporating social and cultural factors as well as differences in impulsivity. Here, we provide an overview of the theory, including support for counterintuitive predictions (e.g., when adolescents "rationally" weigh costs and benefits, risk taking increases, but it decreases when the core gist of a decision is processed). Then, we delineate how emotion shapes adolescent risk taking—from encoding of representations of options, to retrieval of values/principles, to application of those values/principles to representations of options. Our review indicates that: (i) Gist representations often incorporate emotion including valence, arousal, feeling states, and discrete emotions; and (ii) Emotion determines whether gist or verbatim representations are processed. We recommend interventions to reduce unhealthy risk-taking that inculcate stable gist representations, enabling adolescents to identify quickly and automatically danger even when experiencing emotion, which differs sharply from traditional approaches emphasizing deliberation and precise analysis.

Keywords

adolescence; risk taking; fuzzy-trace theory; decision making; emotion; affect; mood; memory

It seems oxymoronic to apply the term "decision making" to describe adolescent risk taking. After all, if adolescents were making decisions, perhaps they would not be getting into so much trouble. Adolescents appear to react rather than decide. But this view of decision making betrays an assumption that mature decision making is cold and deliberative, that it is the result of an intentional, analytical thinking process that eschews emotion (Nisbett & Ross, 1980). We argue just the opposite. Instead of assuming that development progresses from hot intuitive thinking to cold calculation bypassing emotion, we present research showing that intuition is developmentally advanced and that emotion is integral to intuition.

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In this article, we outline a theory of risk taking in adolescence—fuzzy-trace theory—that is grounded in research on how people represent, retrieve, and process information when they make decisions, and how decision making changes with development (Reyna, 2004; Reyna, Lloyd, & Brainerd, 2003). The principles of fuzzy-trace theory that we discuss are supported by empirical evidence, as opposed to being suppositions. Because these principles have been subjected to empirical scrutiny at each step of theory development, we have been open to counterintuitive findings. When those findings have been replicated and have pointed consistently to a new interpretation of risk-taking behavior, we have followed their lead. Therefore, we have arrived at a theory of risk taking in adolescence that violates some aspects of conventional wisdom, but, nevertheless, predicts behavior and provides guidance for interventions designed to reduce unhealthy risk taking. Here, we integrate fuzzy-trace theory with the latest research on emotion to show how emotion shapes which representations are encoded, how knowledge is retrieved, and, finally, how retrieved knowledge is applied to decision representations to produce risk-taking behavior.

Overview

Engagement in risky behaviors during adolescence is related to a variety of negative short- and long-term physical and psychological consequences. Excessive drinking can disrupt the ability to concentrate on school work resulting in poor academic performance. Unprotected sexual intercourse can lead to feelings of regret, pregnancy, and sexual transmitted infections (STIs). STIs that were once treatable—and therefore likely perceived as not significantly harmful—are now becoming resistant to antibiotic treatments (Centers for Disease Control and Prevention [CDC], 2007a). The long-term consequences of behaviors initiated during adolescence may be detrimental to the quality and length of life in adulthood. The establishment of many health-related behavior patterns such as smoking cigarettes, drinking, exercise, and eating fruits and vegetables begins in adolescence (CDC, 2004). For example, two diseases that have strong links to behavioral influences and lifestyle – cancer and cardiovascular disease – kill the greatest percentage of adults in the United States across all racial and ethnic categories (CDC 2007b; 2007c).

Hall (1904) describes adolescence as “the age…of rapid fluctuation of moods” – both positive moods such as elation and negative ones such as depression. The impact of negative moods characterizing this period on behavior and well-being has received much attention. For example, depression is a well-known correlate of substance abuse and premature pregnancy in adolescence (e.g., Brent & Birmaher, 2002; Leith & Baumeister, 1996; Rao et al., 1999). Emerging evidence indicates that positive moods and emotions also have a significant effect (e.g., Fredrickson, 1998; Isen, 2001). Although not all adolescents experience the storm and stress that is said to characterize this developmental period (e.g., Hall, 1904), adolescence is a time when the experience of extreme moods and emotions are more likely to occur, in contrast to other periods such as childhood and adulthood (Buchanan, Eccles, & Becker, 1992). It is within the context of these “emotional” changes that engagement in risky behavior increases substantially. Thus, to ignore the impact of mood and emotion on risk taking is to disregard significant events of the adolescent period. Indeed, Arnett (1999) characterizes adolescence as a time of both mood disruptions and risky behavior.

The purpose of this article is to examine the proposition that emotion and risky behavior are not independent in adolescence, rather they interact in meaningful ways. We review the literature describing the role emotions play in risky behavior to demonstrate that decisions made under its influence differ from those made in its absence. (We use the term “emotion” here in a broad sense, to incorporate mood, affect, valence, and other emotion-related terms. Later in the paper we distinguish these concepts and describe their relationship to risky behavior.) Drawing on fuzzy-trace theory—a comprehensive, evidence-based theory of

memory, decision making, and development—we attempt to identify the moments in the unfolding of the decision to engage in risky behavior wherein emotion can facilitate or impede risk taking, and how, in some cases, adolescent risk taking may not involve a decision at all, at least in terms of how decision making is defined traditionally (e.g., Steinberg, 2003).

We begin by describing an explanatory framework for adolescent risk behavior derived from fuzzy-trace theory. This theory differs from traditional decision-making theories by providing a process model that emphasizes reliance on the bottom-line gist of decision information, as opposed to analysis of verbatim details of that information. The theory also differs from other theories of adolescent risk taking by suggesting that when adolescents engage in what is traditionally considered "rational" decision making (weighing costs and benefits), risk taking increases. Instead, fuzzy-trace theory proposes that processing less information – the core gist – generally reduces risk taking. Then, we survey the literature describing the relationship between emotion and risk taking. We link fuzzy-trace theory to these findings in order to delineate a process model for understanding how and when emotion influences risk taking, either facilitating or impeding its occurrence. Finally, we describe an intervention approach derived from this analysis that incorporates the specific tenets of fuzzy-trace theory and our analysis of emotion in adolescent risky behavior.

Fuzzy-Trace Theory

Fuzzy-trace theory posits that advanced judgment and decision making is based on simple, gist mental representations of choices ("fuzzy" memory traces) as opposed to more detailed, quantitative representations (verbatim memory traces). Gist refers to the meaning an individual extracts from information (i.e., the semantic representation), which reflects the individual's knowledge, understanding, culture, and developmental level (e.g., Reyna, 1996, 2004; Reyna & Brainerd, 1998; Reyna & Farley, 2006). As individuals develop and acquire greater expertise in a domain, their decisions tend to be based on the *meaning* of the information in contrast to its verbatim details (e.g., Reyna & Lloyd, 2006).

Fuzzy-trace theory emerged by linking basic concepts in psycholinguistic research and Gestalt theory with several curious empirical findings. Specifically, the intuitively plausible assumption that memory capacity limitations explained performance in a wide variety of cognitive tasks was refuted (cf. Bjorklund, 1989; Cowan, 2001; Simon, 1956). In a series of experiments spanning many of the major paradigms in developmental and judgment-and-decision-making psychology, memory capacity for verbatim background facts (e.g., precise numerical information or the exact wording of premises) was found consistently to be unrelated to reasoning accuracy. Evidence instead supported predictions made by fuzzy-trace theory: When people performed reasoning, judgment, or decision-making tasks, they relied on gist rather than verbatim representations of information (see Reyna, 1992; Reyna & Brainerd, 1995a for reviews). In addition to explaining known effects, a number of novel findings especially relevant to topics at the focus of this special issue have emerged from work grounded in fuzzy-trace theory, including evidence that a reliance on intuitive, gist-based processing increases with development (e.g., Brainerd & Reyna, 2007; Reyna & Ellis, 1994) and reduces unhealthy risk taking (e.g., Reyna, 1996; Reyna & Farley, 2006). In this section we first provide an overview of the foundational principles of fuzzy-trace theory and then delineate their links to risk taking.

Foundational Principles of Fuzzy-Trace Theory

Fuzzy-trace theory is based on four, empirically-derived foundational principles: (1) multiple representations of information are encoded at varying levels of precision which form a hierarchy of gist; (2) verbatim and gist representations are encoded in parallel, stored separately, and retrieved independently; (3) task completion occurs using the simplest

representation as a default, i.e., a fuzzy-processing preference; and (4) greater experience with a particular task (e.g., a particular decision) increases the fuzzy-processing preference (producing greater reliance on gist-based processing with age because age covaries with experience; Brainerd & Reyna, 1990a; Reyna & Brainerd, 1990, 1995a). We describe each principle and its supporting evidence in turn. Table 1 provides illustrative supporting evidence.

Hierarchy of gist—The first principle posits that people encode multiple representations of information at varying levels of precision. At one end of the continuum, verbatim representations preserve low-level details of information, including surface form (e.g., the font in which a written word appeared, the voice that articulated a sentence), exact numerical information, or the precise wording of a sentence. At the other end of the continuum, gist representations preserve essential meaning and patterns (e.g., Clark & Clark, 1977; Kintsch, 1974). This representational principle applies to meanings for words and sentences, inferences connecting multiple sentences, and themes linking related words together, according to standard psycholinguistic approaches.

In fuzzy-trace theory, we have taken these psycholinguistic concepts and extended them to forms of information that are not solely verbal, such as numbers, graphs, pictures, and events. Therefore, gist representations also apply to numerical information, encompassing simple qualitative gists such as whether or not a quantity is present (categorical distinctions) and relative numerosity (ordinal distinctions). These representations form hierarchies of gist (Kintsch, 1974). With regard to verbal information, for example, hierarchies span from verbatim representation of letters in words to abstract inferences derived from sets of sentences and, for numerical information, hierarchies range from exact representations of numerical quantity to ordinal and categorical relations, roughly analogous to scales of measurement (see Reyna & Brainerd, 1995a). Hierarchies of gist include the gist of a single item (e.g., a single word, sentence, number, or picture) and the gist relations among these single items (e.g., the theme of a list of related words, the inferences that integrate sentences, the semantic relations that integrate numbers such as transitivity or relative magnitude, the gist of a series of pictures that tell a story, and so on; e.g., Reyna & Brainerd, 1995a).

Alongside the principle of task calibration—which posits that the level of precision required in a response constrains the level of representation recruited (see Reyna & Brainerd, 1989, 1995b) – the availability of several representations at varying degrees of precision explains paradoxical inconsistencies between choice and judgment (e.g., Fischer & Hawkins, 1993; Hogarth, 1980; Payne, Bettman, & Johnson, 1992; Tversky, 1969). Specifically, choice typically requires only categorical or ordinal representations (e.g., Win some money by choosing A vs. possibly win no money by choosing B, so choose A; Win less money by choosing A vs. possibly win more money by choosing B, so choose B), but judgment typically requires finer grained distinctions in responses (e.g., judging the numerical probability that a specified event, such as winning $100 or getting an STD, will happen). Therefore, preference reversals result from shifts in the underlying representations used to make choices or judgments, explaining at least in part why decisions are inconsistent from situation to situation (Reyna & Brainerd, 1995a).

Framing effects demonstrate how differences in representational precision between the two systems lead to predictable shifts in preferences (Kahneman & Tversky, 1979). More generally, these effects can be used to illustrate how people make risky decisions (Reyna, 2004). In the classic Asian disease problem, for example, participants are told that an unusual disease is expected to kill 600 people (Tversky & Kahneman, 1981). In the gain frame, one option would save 200 people for sure (of the 600 expected to die), whereas the alternative offers a 1/3 chance of saving 600 people and a 2/3 chance of saving no one. The loss frame simply restates these outcomes in terms of lives lost (400 would die for sure versus a 1/3 chance of no deaths and a

2/3 chance of 600 deaths). Preference for risk has been found to vary as a function of the frame; participants in the gain-frame condition are more likely to choose the sure thing but those in the loss frame condition are more likely to choose the gamble, despite no quantitative difference in expected value between the choices or across the two framing conditions (i.e., 1/3 X 600 saved = 200 saved; 2/3 X 600 die = 400 die of 600 expected to die, leaving 200 saved).

Extensions of this paradigm tested the necessity of the quantitative information (e.g., specific numbers of lives lost) in obtaining framing effects. Participants responded to framing problems in which numerical information was removed entirely and was replaced with vague phrases, such as “some people” or “some probability” (Fulginiti & Reyna, 1993; Reyna & Brainerd, 1991b, 1995a; Reyna & Fulginiti, 1992). For example, consider the gain frame version of the Asian disease problem in which subjects must choose between two programs to combat a disease, one saving 200 people for sure and another offering a 1/3 chance that 600 will be saved and a 2/3 chance that none will be saved. In one gain frame presentation, the word “some” replaced the number 200 in the sure option and the number 600 in the gamble. This manipulation consistently failed to eliminate framing effects (and, in fact, exacerbated them), supporting the hypothesis that precise quantitative information is not necessary for those effects. Although most theories assume that perceptions of the magnitudes of numbers create framing effects (e.g., small probabilities are over-weighted; larger numbers of lives saved or dollars won are subject to greater discounting), these findings show that numbers are not necessary to create the effects.

Instead, these non-numerical framing effects support fuzzy-trace theory's notion of a continuum of representations that begins with the simplest qualitative distinctions that could be made with respect to quantity (i.e., that there is *some* quantity or *no* quantity), which predicts framing effects (e.g., Reyna & Brainerd, 1991b; Reyna & Brainerd, 1995a). As shown in Table 2 for the Asian disease problem, the simplest representation of the options in the gain frame is *save some* for sure versus *possibly save some or save none*. Values in long-term memory, such as “saving some people is better than saving none,” are cued by the gist representation of the problem. When these values are applied to the gist representation, decision makers conclude that saving some people for sure is better than the possibility of saving none; thus the sure option will be chosen and the risk will be avoided. Similarly, in the context of losses, the options are most simply represented as *some die* versus *possibly some die or none die*. The possibility of none dying is better than some dying for sure; thus the risky option will be chosen.

In an additional manipulation in which the zero complement of the gamble (e.g., the 2/3 probability that no one will be saved; the 1/3 probability that no one will die) was removed, framing effects were eliminated – a finding inconsistent with traditional explanations positing some sort of subjective combination of outcome values (e.g., 600 saved) and subjective probabilities (e.g., 1/3 probability; Reyna & Brainerd, 1991b, 1995a). According to those theories, since the zero complement does not contribute to the calculation of the gamble's value or utility, its presence should not moderate the standard framing effect. Fuzzy-trace theory makes the opposite prediction; removing the zero complement, and leaving the non-zero complement (e.g., 1/3 probability 600 saved; 2/3 probability 600 die), decreases the salience of the qualitative some-none contrast which is central to the effect. This finding shows that numerical information of the sort identified as essential by expected utility and prospect theories (e.g., the non-zero complement) is not sufficient to create framing effects.

Conversely, as also predicted by fuzzy-trace theory, removing the non-zero complements of the gambles that expected utility or prospect theories identify as essential and leaving only the zero complement increased framing effects. Thus, with any standard gamble, offering a choice between a sure option and a risky option that has a zero complement, a categorical representation that contrasts some and none (e.g., some saved versus none saved) is relied on

in making a decision. Relevant to risk taking, the various findings on framing together suggest that explaining risky decision making in terms of the psychophysics of numerical magnitudes (as in expected utility or prospect theories) is not likely to be a fruitful approach because decisions are typically based on qualitative gist, such as the categorical contrast between some and none, rather than on numerical magnitudes. Fuzzy-trace theory subsumes earlier explanations of heuristics and biases, such as framing, and goes beyond them in making specific process commitments from which a range of new predictions have been derived (e.g., Reyna, 1991; Reyna, 2005; Reyna & Brainerd, in press; Reyna, Lloyd, & Brainerd, 2003; see also Table 3 in Reyna & Farley, 2006).

Parallel encoding, separate storage, and independent retrieval—The second foundational principle of fuzzy-trace theory, supported by many studies, is that verbatim and gist representations are encoded in parallel, stored separately (rather than integrated) and retrieved independently (e.g., Reyna & Brainerd, 1991a, 1992; Reyna & Kiernan, 1994, 1995). This principle explains how a person can have distinct, even contradictory representations (i.e., verbatim and gist representations) of the same situation. Evidence supporting parallel encoding of different levels of representation includes findings that the meanings of words are recognized both before their constituent letters (Ankrum & Palmer, 1989) and in the absence of constituent letters (Moravcski & Healy, 1995)—i.e., semantic storage of words precedes complete processing of instantiating targets (Brainerd & Reyna, 1993). The same compartmentalization is observed for representations of complex stimuli and real-life events (Brainerd & Reyna, 2005). Transitive inference, for example, often is involved in understanding stories or ordinary events (e.g., If Paul is older than Fred, and Fred is older than Bill, then Paul is older than Bill). Verbatim memory for presented statements (e.g., Paul is older than Fred) has been shown to be independent of memory for semantic gist (i.e., inferences; Paul is older than Bill, when that inference never was presented directly; Reyna & Kiernan, 1994). In transitive inference tasks in the laboratory, reasoners have been found to leap ahead once the transitive pattern is recognized and generalize a linear pattern of steadily increasing or decreasing magnitudes (e.g., of age) to premises that have yet to be introduced (Reyna & Brainerd, 1992). Moreover, gist representations are not derived from verbatim traces as some have argued (e.g., Glucksberg & Danks, 1975); indeed this notion has been disconfirmed under a variety of task conditions (Alba & Hasher, 1983; Brainerd & Gordon, 1994; Reyna & Brainerd, 1992; Reyna & Kiernan, 1995).

The proposition of independent storage and retrieval from two distinct types of representations is supported by a variety of single and double dissociations (crossovers) between measures of verbatim and gist representations. For example, increasing the accessibility of memory for accurate numerical information in the premises of class inclusion problems (e.g., 10 animals, 7 cows and 3 horses) actually increased the likelihood of committing errors on inclusion judgments (e.g., Are there more cows or animals?; Reyna, 1991; Reyna & Brainerd, 1993). Similar to explanations of why memory and reasoning performance are independent (because memory tasks typically tap verbatim representations, but reasoning tasks typically tap gist), correct solutions to these types of problems rely not on precise memory for problem premises but on the identification of an abstract pattern (e.g., a linear pattern of increasing magnitude; an inclusion hierarchy of taxonomic membership).

Fuzzy-processing preference: Reliance on the simplest representation emerges with development and experience—Although people can rely on either verbatim or gist representations, they have a tendency to rely on the simplest representation necessary to complete the task at hand. This preference for fuzzy processing plays an important role in several of the effects described previously (e.g., framing effects; probability judgment), and it also figures centrally in fuzzy-trace theory's account of rationality (e.g., Reyna et al., 2003). According to traditional perspectives, development involves a progression from intuitive to

increasingly analytical modes of processing (Reyna & Brainerd, 1991a). Some recent dual-process theories that acknowledge the prevalence of intuitive (or heuristic) processing in adulthood nevertheless designate such processing as primitive and evolutionarily ancient, requiring active inhibition from an analytical system whose operations more closely match traditional conceptions of rationality (Kahneman, 2003; Sloman, 1996). Notably absent from these approaches is any systematic attempt to integrate theoretically a plethora of developmental findings that contradict the hypothesized trajectory from intuitive to analytical thought (e.g., Jacobs & Potenza, 1991; Markovitz & Dumas, 1999; Reyna & Ellis, 1994; see Table 3 in Reyna & Farley, 2006). Recognizing that developmental data should inform theories of rationality, fuzzy-trace theory inverts the traditional perspective. Based on these data, fuzzy-trace theory holds that development involves an increasing tendency to rely on simplified representations of information, that is, a shift *towards* qualitative, intuitive processing, and *away* from quantitative, analytical processing that relies on the verbatim facts of experience. (See Brainerd & Reyna [1990b] for analogies to Brouwer's [1952] and Heyting's [1959] conceptions of intuition in mathematics.)

Evidence supporting this alternative picture comes from the general finding that as children's quantitative competence increases, they simultaneously exhibit a decreasing tendency to use such skills in reasoning and decision-making tasks (Brainerd & Reyna, 1993; Reyna, 1992). Across a wide range of perceptual and inferential tasks, older age groups are more likely to focus on global patterns in judgment and decision making, whereas younger groups are more likely to focus on superficial details (e.g., Brainerd & Reyna, 1993; Carey & Diamond, 1977; Liben & Posnansky, 1977; Perner & Mansbridge, 1983). Younger children, for example, are less likely to exhibit standard framing effects, choosing the gamble in comparable proportions across the gain and loss frame conditions in accord with multiplying numerical outcomes by their probabilities (Reyna & Ellis, 1994). Younger children also are sensitive to inequalities in these expected values (Reyna, 1996). Thus, at times, children appear more “rational” than adults because they are more likely to weigh the odds of winning against the magnitude of reward to arrive at a choice (Reyna, 1996). In addition, transfer effects, which require recognizing that an abstract principle or gist applies in a novel circumstance as well as the simultaneous inhibition of irrelevant problem details, are a particularly useful method of identifying reliance on gist-based processing. Indeed, older children are more likely than younger children, and adults are more likely than children, to transfer abstract knowledge, reflecting a greater reliance on gist-based processing (Reyna & Brainerd, 1992; Wolfe, Reyna, & Brainerd, 2005).

This developmental trend from verbatim/analytical processing toward gist-based intuition also appears during the acquisition of expertise in adulthood (e.g., Reyna & Lloyd, 2006). For example, in a study examining triage decisions for patients presenting to emergency rooms with chest pain, expert cardiologists processed information in a cruder all-or-none fashion (patients were either at risk or not at risk of an imminent heart attack) and they processed fewer dimensions of information than less expert physicians or students did (see also Reyna et al., 2003). Consistent with fuzzy-trace theory, the evidence suggests a shift to increasingly qualitative, simplified processing with increasing expertise in a domain (Reyna, Lloyd, & Whalen, 2001; Reyna, Lloyd, & Woodward, 1997; Shanteau, 1992).

Fuzzy-Trace Theory and Risk Taking

According to fuzzy-trace theory, decision making becomes less computational and more intuitive as development proceeds. Laboratory experiments with children, adolescents, and adults have confirmed this prediction (e.g., Reyna, 1996; Reyna & Brainerd, 1991b; Reyna & Brainerd, 1993, 1994, 1995a; Reyna & Ellis, 1994; Reyna et al., 2003) as have studies of real-life decision making (e.g., Mills, Reyna, & Estrada, in press; Reyna & Farley, 2006). Adults

are typically risk averse for gains when a sure thing and a gamble are equal in expected value, as demonstrated in the Asian disease problem. The same risk aversion holds for money. That is, when faced with a choice, most adults prefer a sure win involving money (e.g., $1,000) over a risky option (e.g., winning $2,000 or nothing depending on the outcome of a coin-flip). We have discussed how this preference is predicted by the principles of fuzzy-trace theory, specifically, by assuming that simple gist representations are encoded (e.g., win some money for sure vs. win some money or win nothing in the gamble) and that simple values are then applied to these representations. Thus, choosing the sure option is favored if the decision maker adopts the simple gist representation noted above, which ignores magnitudes of possible winnings in the gamble. Similarly, most adults would not play Russian roulette regardless of the amount of the potential winnings and despite favorable odds of survival (five out of six). School-age children, in contrast, prefer to gamble with gains or losses (although they are sensitive to the magnitudes of risk and outcomes; e.g., Boyer, 2006; Levin & Hart, 2003; Reyna, 1996; Reyna & Ellis, 1994; Reyna & Farley, 2006; Reyna & Mattson, 1994; Rice, 1995). A general conclusion of this stream of work is that risk aversion steadily increases through adolescence, even when the odds of winning for the gamble are favorable, which reflects the tendency to base decisions on simple gist representations.

Studies examining the development of expertise provide an illustration of a similar developmental trajectory. For example, physicians who make decisions within their area of expertise do so in ways consistent with gist-based processing, processing fewer dimensions of information and processing that information qualitatively (Reyna & Lloyd, 2006). Specifically, when making decisions about cardiac cases, cardiologists form an overall impression of myocardial infarction risk, categorizing patients as at *risk* or *not at risk* in contrast to physicians who have less cardiology training. Expert physicians who processed information using a qualitative approach more accurately diagnosed patients as being at low vs. high risk of myocardial infarction, judged against evidence-based practice guidelines, than did nonexperts (e.g., noncardiac physicians, medical students) who used many more details about the patient to make their decisions (see also Reyna et al., 2003).

In contrast to traditional theories, fuzzy-trace theory posits that advanced reasoning, such as that of experts, reflects the fuzzy processes of intuition. In particular, decision making about risk progresses developmentally from a focus on precise quantitative differences in outcomes (i.e., the exact amount of fun, money, or other desirable outcome outweighs the degree of risk in getting that outcome), to an ordinal focus (i.e., an option gives me more fun, more money, or more of some other desirable outcome, along with more risk, compared to another option involving less fun with less risk) to an all-or-none focus on categorical differences (i.e., an option gives me something good for sure as opposed to taking a risk and not getting anything). Traditional theories of cognitive development posit that decision-makers progress from intuitive (gist-based) to computational (verbatim) thinking when processing decision information (e.g., weighing the costs and benefits of decision options; e.g., Bjorklund, 1989; Siegler, 1991). If reasoning operated this way, favorable odds would lead to risk-taking (i.e., benefits outweigh costs). However, mature decision makers often avoid risk even in the face of favorable odds. Thus, although fuzzy-trace theory shares important features with other developmental theories, it differs in assuming that advanced reasoning is intuitive (cf. Sloman, 1996). In this way, fuzzy-trace theory is counterintuitive; it implies that mature thinking may be considered technically “irrational” because it does not necessarily reflect quantitative, compensatory trade-offs between risks and rewards. In fact, consistent with fuzzy-trace theory, inconsistencies and biases in decision making that are based on *semantic* processing of gist, such as framing effects, emerge with development and become greater with age, which are side effects of a generally robust form of rationality that is gist-based (see Reyna et al., 2003).

Adolescents are at the developmental moment where they typically encode multiple, independent representations along a hierarchy of gist ranging from fine-grained quantitative distinctions (e.g., 10% more risk) to categorical distinctions (e.g., some fun vs. no fun; risky vs. not risky). Given their developmental level, adolescents operate at multiple levels in-between precise quantities and crude categories. They tend to use ordinal distinctions in choosing between two options which are "more vs. less" risky (see Reyna & Brainerd, 1995a). For example, two options that adolescents would perceive as more versus less risky are confessing to skipping school and risking parental punishment versus skipping school but keeping quiet and risking being found out. The more mature decision maker would consider the two options as categorically risky, and avoid them both (i.e., not skip school); the less mature thinker would weigh the relative odds and choose the option for which the rewards were "worth" the risks. Adolescents are teetering on the brink developmentally between mainly weighing pros and cons (verbatim analysis) versus mainly relying on gist-based intuition (and avoiding unhealthy risks).

Figure 1 provides examples of a hierarchy of risk representations ranging from verbatim to categorical gist (see box labeled, "Hierarchy of Representations"). Studies have shown that younger adolescents tend to base decisions on verbatim representations of details, trading off the amount of risk against the amount of rewards, and thus take more risks, compared to older adolescents and adults (Reyna & Farley, 2006). Mature decision makers, in contrast, tend to rely on the bottom-line gist that potentially catastrophic risks should be avoided under ordinary circumstances (Reyna, Adam, Poirier, LeCroy, & Brainerd, 2005). Table 3 provides an example of a categorical gist thinking scale; high levels of endorsement of such thinking have been linked to reductions in sexual risk taking in adolescence (Mills et al., in press). Additional evidence for a developmental shift toward categorical thinking about risk is provided by results of Cohn et al. (1995). They showed that the largest difference between adolescents and adults in perceived harm was for taking risks "once or twice" as opposed to occasionally or frequently; adolescents were more likely to make distinctions among levels of risk taking, whereas adults perceived the gist of these options more categorically (lumping levels of risk taking together in contrast to not taking a risk at all). The point here is not whether adolescents perceive more or less risk than adults (although sometimes they perceive more risk; Millstein and Halpern-Felsher, 2002), but, rather, that adolescents make fine-grained distinctions among *degrees* of risk that adults lump together (i.e., "once or twice" together with "frequently") in contrast to not taking a risk at all, a reversal of the usual developmental prediction. Specifically, fuzzy-trace theory predicts that both adults and adolescents encode the fine-grained (verbatim) distinctions, but adults are more likely to rely on gist representations of risk as being categorically present or absent.

Although representations are central to fuzzy-trace theory, they are not sufficient to explain behavior. Decision makers must do more than understand the gist of their options; they must also retrieve values and principles in order to act on those representations. Retrieved values and principles are applied to representations of options to make judgments and decisions. According to fuzzy-trace theory, people have values and principles stored in long-term memory that they retrieve in response to situational cues. Because retrieval is cue-dependent, a person may hold multiple relevant and deeply felt values that are not necessarily retrieved at the point of a decision (e.g., Reyna & Brainerd, 1992, 1994). Much has been made of the fact that choices and preferences seem to be highly variable because they are influenced by superficial cues, such as question wording. Some researchers have even questioned whether people have stable values. However, such variability is explained in fuzzy-trace theory by assuming that values are represented in long-term memory as vague gist representations (also making it possible to apply them more compatibly to gist representations of decision options). As Figure 1 shows, values and principles such as "No risk is better than some risk" and "Some fun is better than no fun" can be applied to a decision representation such as choosing between *having some fun*

with no risk versus *taking a risk and having some fun or having no fun* (if something bad happens, like getting caught). Table 4 presents a list of gist-based values and principles; endorsement of these simple values and principles has also been associated with reductions in sexual risk taking in adolescence (Mills et al., in press).

In addition to representation and retrieval, processing in the sense of applying retrieved values or principles to representations is the source of independent difficulties in decision making (Brainerd & Reyna, 1990b, 1995; Reyna, 1991; Reyna & Mills, in press). Probability judgment is particularly difficult because it involves overlapping sets or classes: the class of targets in the numerator (e.g., the number of women who become pregnant after unprotected sex) and the class of total instances in the denominator (e.g., the number of women who become pregnant plus the number who do not become pregnant after unprotected sex). Because of confusion about overlapping sets, people often focus on classes in numerators (or targets) and neglect denominators, a kind of foreground-background salience effect (e.g., Reyna, 1991, in press; Reyna & Mills, in press; Stone et al., 2003). Although large errors in probability judgment can occur because of denominator neglect, especially for doubly embedded conditional probabilities, the errors concern the mechanics of processing rather than fundamental conceptual difficulties. Therefore, it is easy to underestimate adolescents' ability to understand quantitative probabilities. In one study, for instance, 256 high school students solved the same conditional probability judgment problem as 82 physicians, as well as other groups of adult professionals (e.g., Reyna, 2004; Reyna & Adam, 2003). The high-school students' performance was virtually identical to that of experienced physicians solving a familiar post-test diagnostic judgment problem. Unfortunately, both groups performed poorly due to processing interference from overlapping classes. A simple formatting manipulation that disentangles overlapping classes significantly reduces errors in all age groups, ranging from children to adults (e.g., Lloyd & Reyna, 2001; Reyna, 1991). The underlying ability to process probabilistic information is manifested clearly when the classes are made transparent.

The aforementioned factors of representation, retrieval, and implementation are sufficient to account for many developmental differences in risk taking that are reliably produced in the laboratory for hypothetical gambles and observed for real-world risk taking (for a review see Reyna & Farley, 2006). However, emotional factors modulate real-world risk taking in adolescence, as they do in adulthood (e.g., Boyer, 2006; Reyna, 1996; Reyna & Farley, 2006; Steinberg, 2003). Therefore, a full account of risk taking must encompass the role of emotion, in particular, the mechanisms through which it affects decision making. As the section below illustrates, emotion interacts with decision making at every stage from encoding representations of options, to retrieval of values or principles, to processing (or implementation) of those values or principles by applying them to the representations of the options.

Emotion and Decision Making

> "With all its cleverness…decision theory is somewhat crippled emotionally, and thus detached from the emotional and visceral richness of life" (Loewenstein, 1996, p. 289).

Explanatory theories of *reasoned* action, *planned* behavior, and decision *analysis* dominate the literature on adolescent risk taking (see Reyna & Farley, 2006, for a review). Many models are consistent with an economic utility approach that treats perceived risks and benefits as cognitive variables which predict, when combined multiplicatively, risky behavior (e.g., Fischhoff, 2005; Fishbein & Ajzen, 1975). However, as the quote opening this section suggests, decision theories have failed historically to account for the influence of emotional factors on risk taking, instead focusing on cognitive factors. Among the exceptions to the "cold" and "dispassionate" theoretical perspectives are positions put forth by Loewenstein and colleagues (e.g., Loewenstein, 1996; Loewenstein, Weber, Ksee, & Welch, 2001). From their perspective,

knowledge about the consequences of a risky behavior (e.g., taking drugs, unprotected sex) is often inconsequential under the influence of strong emotions. Like decision theorists who adhere to economic utility models of decision making, people do not prepare for the influence of emotions on their behaviors, nor do they explain behavior that is contrary to their values and goals as resulting from the emotional state experienced at the time the behavior was initiated. Thus, discrepancies between self-interest (what is good for the self and, perhaps, for others) and behavior often results from the influence of emotion and other visceral factors (Loewenstein, 1996). Accordingly, it is necessary to understand how emotions influence risk taking in order to develop interventions that effectively reduce adolescent risky behavior.

In this section we outline how fuzzy-trace theory accounts for emotion's influence on risk taking. Specifically, we provide an analysis of emotion's influence within the context of fuzzy-trace theory enabling researchers to make predictions about how emotion influences the encoding of stimuli (i.e., how the choice is represented), the retrieval of values and principles, and the implementation of values and principles (i.e., their application to option representations). Such predictions are necessary to develop interventions to reduce risk taking during adolescence.

To organize our survey of emotion and risk taking, we work from fuzzy-trace theory's process model of decision making, depicted graphically in Figure 1. The model posits that for a decision to engage in a risky behavior to be made, the risk stimulus must be encoded using existing knowledge as well as knowledge newly available in the decision context. (Recall that encoding occurs at multiple levels in a hierarchy of verbatim-to-gist representations.) The encoding process involves attaching meaning to the choice—meaning that may be affected by the salience of valenced cues (positive/negative, good/bad) in the stimulus as well as by current feeling states (both incidental and integral to the choice). Gist values and principles then are retrieved from memory and implemented to direct behavior. Decisions, subsequent behaviors, and their associated outcomes, in turn, affect the encoding of subsequent risk stimuli. At each stage of this process, decision making may be affected by the presence (or absence) of emotion. The accumulating empirical evidence reviewed in this section does not indicate that risk taking is simply more or less likely under emotion's influence, but rather that decisions about risk made in the presence of emotion are made differently than those made in its absence.

To clearly delineate how emotion interacts with decision making, we distinguish valence (i.e., the simple evaluation of a stimulus as good/bad, positive/negative, or approach/avoid; e.g., Slovic, Peters, Finucane, & MacGregor, 2005), feeling or mood states (which may be incidental or integral to the decision), arousal (physiological arousal, drive, and/or temptation), and discrete emotional states (such as fear, anger, and sadness which encompass relatively distinct patterns of feeling states, arousal, cognitive appraisal tendencies, and other factors). The literature examining the impact of emotion on decision making adopts multiple and often broad definitions of the construct (e.g., the terms “affect,” “feeling,” and “mood,” among other terms, often are used interchangeably with emotion and with each other). Indeed, controversies permeate the literature about how to define emotion centering on, for example, whether emotions are discrete entities (e.g., anger, sadness, fear) or dimensional in nature (e.g., ranging along an affect-arousal continuum in various combinations of positive to negative affect and high to low arousal; e.g., Barrett, 2006; Ekman & Davidson, 1994; Russell, 1980; Russell, 2003; Watson & Tellegen, 1985). Consequently, the “necessary and sufficient components” of emotion are debated widely, affecting the measurement and manipulation of emotion, as well as empirical and theoretical descriptions of its impact on risk taking. Although we do not resolve this debate, we find it useful to organize the research according to specific components of emotion (valence, feeling states, arousal, and discrete emotional states) in order to integrate the influence of emotion on adolescent risk taking into theory and the development of interventions.

Valence

The risky decision making literature has much to say about the influence of "emotion" (or "affect") on judgments in particular, and on behavior, to some extent (e.g., Finucane, Alhakami, Slovic, & Johnson, 2000; Loewenstein et al., 2001; Rottenstreich & Hsee, 2001; Slovic et al., 2005). Much of this work focuses on the influence of valence. Valence refers to the simple evaluation of a stimulus (e.g., as good/bad, positive/negative, or approach/avoid) and is one of the most pervasive and fundamental gist representations that guide risky decisions, a conclusion bolstered by neuropsychological findings implicating the amygdala in memory for gist (Adolphs, Tranel, & Buchanan, 2005). Although the particulars of the somatic marker hypothesis have been challenged, evidence remains that valence, derived from experience, supplies unconscious intuitions (i.e., gist) that protect us from harm (Naqvi, Shiv, & Bechara, 2006). For example, as Gibbons, Gerrard, and Lane (2003) write, "it is not specific characteristics of the images that motivate behavior (as goals), but rather the general impression of the type of person who engages that is influential" (p. 127). Consistent with fuzzy-trace theory, it is the valence alone rather than details of an image of "smokers" that predicts whether adolescents will smoke (see also Finucane, Peters, & Slovic, 2003; Gerrard, Gibbons, Stock, Vande Lune, & Cleveland, 2005).

When presented with a choice, fuzzy-trace theory proposes that, during encoding, representations of the choice depend, in part, on valenced knowledge (i.e., that the choice object is good or bad, positive or negative), as illustrated in Figure 1. (Valenced knowledge is referred to by some as the "affective impressions" of a stimulus [e.g., Slovic et al., 2005] or as attitudes [e.g., Alhakami & Slovic, 1994].) The activation of valenced knowledge, which may be conscious or unconscious, contributes to judgment formation about the stimulus, including whether that stimulus is perceived as risky or beneficial. Slovic and colleagues (2005) call this process "consulting the affect pool." In the most basic sense, if a stimulus is associated with a positive valence it will be approached (chosen) and if associated with a negative valence it will be avoided (Chen & Bargh, 1999). (Of course individuals may engage in more extensive cost-benefit analysis in evaluating choices, but recall that evidence supporting fuzzy-trace theory shows a *preference* for fuzzy processing, that is, a reliance on gist-based processing in decision making, especially among mature decision makers; Reyna & Brainerd, 1992.)

The valence component of gist is a central component of meaning associated with a stimulus. As one illustration, the valence of a stimulus drives other judgments about the stimulus. Stimuli marked with a positive valence are perceived as being more beneficial and less risky; but stimuli marked with a negative valence are perceived as being more risky and less beneficial (Alhakami & Slovic, 1994). Although not always true in reality, in people's minds, the benefits and risks of a stimulus can be inversely interdependent (Alhakami & Slovic, 1994; Slovic et al., 2005), reflecting consistency in the meaning attributed to the stimulus. Indeed, by manipulating the salience of a stimulus's benefits (or risks), Finuncane and colleagues (2000) showed that people adjust their perceptions of that stimulus's risks (or benefits).

According to fuzzy-trace theory, gist-based processing yields a categorical evaluation of a stimulus as good/bad or an ordinal evaluation as better/worse. This evaluation drives judgment and decision making (although processing is not exclusively gist-based, as discussed earlier.) The valence of a stimulus, its bottom-line gist as good/bad or better/worse, can make other information about the stimulus irrelevant in judgment and decision making. Loewenstein and colleagues (2001), for example, showed that individuals are likely to choose a positively valenced stimulus (winning money) regardless of its probability of occurring. Similarly, judgments made by participants in studies by Rottenstreich and Hsee (2001) were relatively insensitive to significant changes in probability for stimuli in which valence was more salient (e.g., kissing a movie star, getting an electric shot) compared to judgments made by participants about stimuli with less salient valence (e.g., winning $50, losing $20). Other research shows

that risk judgments vary as a function of valence associated with the stimulus even in cases in which the risk is objectively low. In one example, risk judgments made by expert toxicologists were related to the valence they associated with a chemical even when exposure levels to that chemical were quite negligible (e.g., toxicologists rated risk highest for chemicals they viewed as negative and lowest for those viewed as positive; see Finucane et al., 2003).

Valence can drive judgment and decision making even in the face of conflicting information; new information that conflicts with firmly established valenced knowledge may be ignored or discarded (Slovic et al., 2005). Farrell and colleagues (2002), for example, showed that the valence men associated with prostate cancer and screening tests directed men's intentions to obtain a test even after receiving one-on-one counseling about the costs and benefits of screening (wherein costs often outweighed benefits, i.e., screening leads to detection of cancers that may never become clinically significant, resulting in exposure to unnecessary treatment and its side effects). Thus, strongly held valenced beliefs (gist representations) were relatively impervious to influence by factual information (verbatim details). Similar to valence strength, the mix of positive and negative valences (the extent to which the stimulus is associated with mostly positive or mostly negative valence, as opposed to more mixed associations) also is likely to moderate the influence of valence in judgment and decision making (see Finucane et al., 2003). Each of the findings reviewed in this section illustrates the fuzzy-trace theory principle that gist-based thinking ignores details (e.g., degrees of probability, presence of less relevant contradictory details) to get to the functionally significant bottom line of information —and that bottom line often involves valence.

Experience with stimuli is important in creating a valenced knowledge store— A characteristic of valenced knowledge that is especially important to consider in adolescent risk taking is that experience with a stimulus contributes to the creation of a valenced knowledge store that is cued automatically when presented with a choice. Children cannot recognize immediately the significance of cues such as an unsupervised party for teenagers, renting a hotel room on prom night, or a middle-aged man inviting a 12-year-old girl to lunch, but adults quickly attach a negative valence to each of these scenarios. Recognizing the bottom-line gist of such situations appears to develop during adolescence and young adulthood (see Reyna & Farley, 2006). This rapid and unconscious recognition of a “bad” situation is part of what is meant by intuition in fuzzy-trace theory.

Let us consider the sleepover versus unsupervised party example that is depicted in Figure 1. Adults, with their more extensive knowledge, may perceive readily the unsupervised party to be risky as negatively valenced knowledge is conjured up automatically, quickly likening the behavior to other obvious risks (such as driving drunk or having unprotected sex). In general, children have limited experience with the types of situations that include risk (unsupervised parties); these often nuanced situations are new to the emerging adolescent. For example, during childhood, the stimulus “enjoying time with friends” may cue positively valenced knowledge with accompanying evaluations that the benefits of the behavior are high and the risks are sufficiently low so that they do not overcome benefits, leading to engagement in the behavior (Reyna & Farley, 2006). There are few adolescents who respond positively to the inquiry–if all your friends jumped off a bridge, would you do it too? The risk of one's body plunging over the side of a bridge is linked with negatively valenced knowledge in the adolescent (as it probably is in the child as well), but a behavior not previously experienced or confronted (such as unsupervised parties) may not be. In other words, during early adolescence, risk stimuli may not yet be associated with negatively valenced knowledge as the knowledge store from which to draw images of risks newly confronted during this time period is quite limited. Children and younger adolescents, therefore, are analogous to participants who are in the early trials of the Iowa Gambling Task (in which cards are drawn from multiple decks with various payoffs to determine which decks are “good” or “bad”), before they have experienced

many negative outcomes (e.g., Bechara, Damasio, Tranel, & Damasio, 2005). The perceived benefits of behaviors, such as hanging out with friends, may also depress perceptions of its risks (Slovic et al., 2005). In light of this interpretation, the common adolescent rationale “all my friends are doing it” is understandable because negative outcomes are usually rare, especially if one's experience is limited.

Evidence from Slovic (2001) on youth perceptions of smoking supports this analysis. The meaning of smoking to young smokers is positive; smoking is interpreted as fun, exciting, and something to do with friends. The negative consequences of smoking are not yet attached to their gist of the behavior. In addition, as their positive evaluations of the behavior increase, negative evaluations diminish (e.g., Slovic, Finucane, Peters, & MacGregor, 2004). Older smokers, with their accumulated experience of the behavior as addictive and detrimental to health (i.e., the salience of the negative aspects of smoking constitutes the gist), report that smoking should be avoided. There also is some empirical evidence that, at least for adults, risk aversion becomes greater with increased experience with a particular risk (Shiv, Loewenstein, & Bechara, 2005). The latter effect of experience increasing risk aversion may explain the finding that most adolescent risk taking is limited in duration (although a small subgroup seems inured to the negative consequences of risk taking, labeled life-course persistent, as opposed to adolescence-limited risk takers; Moffitt, 1993, 2003). However, experience with stimuli need not be extensive to create a valence knowledge store. Research on conditioning and the mere exposure effect are two examples of how brief exposure to positive or negative experiences with a stimulus contributes to encoding its valence (e.g., Zajonc, 2001). Some of the most exciting and promising research on adolescence concerns how experience affects the encoding of the valence of risks as good or bad (e.g., Halpern-Felsher, Biehl, Kropp, & Rubinstein, 2004; Halpern-Felsher et al., 2001).

Summary—The evidence reviewed in this section provides support that the gist (i.e., meaning) attached to a stimulus drives preferences. Specifically, the valence associated with a stimulus is integral to judgment and decision making. This valence may exist already in the form of gist representations through cultural transmission or a valenced gist may become associated with the presentation of the stimulus (e.g., making its negative or positive features more salient) through experience. Slovic and colleagues argue that it is the feeling state that drives preference (e.g., Finucane et al., 2003; Slovic et al., 2005), however the studies presented here do not assess the influence of feeling states (e.g., subjective reports of mood or affect) during judgment and decision making tasks, nor were feeling states manipulated (but see Monahan, Murphy, & Zajonc, 2000; Zajonc, 2001). When such reports are elicited, they do not necessarily map consistently onto observed differences that are attributed to feeling states (e.g., Peters, Lipkus, & Diefenbach, 2006). It is very likely that feeling states contribute to (but are not necessary for) preference formation, such that positive feeling states associated with stimuli contribute to the creation of positive gist and negative feeling states contribute to the creation of negative gist (e.g., Schwarz & Clore, 2003, see below). For example, graphic cigarette warning labels used in Canada were most effective in reducing smoking among individuals who reported greater fear and disgust in response to the warnings (Hammond, Fong, McDonald, Brown, & Cameron, 2005; see also Peters et al., 2007). As summarized in the next section, there is evidence that feeling states, both integral and incidental to a stimulus, determine judgment and decision making.

Feeling States

Feeling states can infuse the interpretation or gist of a stimulus, especially when the stimulus is ambiguous (Forgas, 2000; Schwarz & Clore, 1983, 1988, 1996). When a stimulus is perceived, consulting one's current feelings can efficiently guide decision making and behavior (Zajonc, 1980), helping individuals “navigate quickly and efficiently through a complex,

uncertain, and sometimes dangerous world" (Slovic et al., 2004, p. 313). In general, positive (pleasant) feelings motivate behaviors that enhance or maintain the experience or that reproduce those feelings (i.e., approach behaviors), and negative (unpleasant) feelings drive behavior to reduce or avoid those feelings (i.e., avoidant behavior). Consulting one's feelings during decision making may be adaptive in situations wherein the feeling state occurs in response to the stimulus, that is when the feeling state is *integral* to the decision (i.e., the response is linked to the object itself and therefore reflective of preference). Decision making guided by feeling states may prove ill-advised when states are not associated directly with responses to a stimulus. *Incidental* feeling states, such as moods, are diffuse and often experienced regardless of stimulus presentation. When feelings are incidental to the stimulus, interpreting the meaning of a stimulus using one's feeling state as information may lead the decision maker astray.

Research on mood congruency shows the impact of incidental feeling states in judging ambiguous stimuli. To illustrate, reports of physical aches and pains were significantly higher among participants induced to experience a negative mood compared to those induced to experience a positive mood, and more intense moods were correlated with increased reports of aches and pains (Salovey & Birnbaum, 1989). Participants in a negative mood also rated that they were less able to engage in behaviors to alleviate symptoms (Study 1) and they had higher probability estimates of negative health-related events (e.g., How likely is it that you will develop high blood pressure?; Study 3). Other data support these findings, including the now classic empirical examples of feeling states influencing self-reports of well-being, with higher well-being reported among participants induced to positive feeling states compared to those induced to negative feeling states (e.g., Strack, Schwarz, & Gschneidinger, 1985). Instead of being informative, incidental affect may distort judgments, decisions, and, thus, behavior. These studies demonstrate that feeling states, to the extent that they color interpretations of information and experience, shape gist.

In addition to influencing gist, feeling states also may influence the information attended to during encoding and how that information is represented in the gist hierarchy (e.g., categorical, ordinal, or verbatim, see Figure 1). For example, positive feeling states direct attention to global information, such as the overall impression of an image (i.e., the "forest"), whereas negative feeling states direct attention to localized information, such as the lines and details that constitute an image (i.e., the "trees"; Gasper & Clore, 2002). Experiencing a positive feeling state has been shown to reduce the own-race bias in face recognition, presumably because faces of other races were processed more holistically (which is how individuals typically process same-race faces) than when in a neutral or negative feeling state (Johnson & Fredrickson, 2005). Emotional traits or dispositions influence attention in comparable ways. Individuals with negative emotional traits (like anxiety) are more likely to have a localized focus and individuals with positive emotional traits (like optimism) are more likely to have a global focus (Basso, Schefft, Ris, & Dember, 1996). In other words, this research shows that positive feeling states and traits are more conducive to gist representations of choice, compared to negative feeling states and traits which are more conducive to verbatim representations of choice and less conducive to relational processing (Bless et al., 1996;Storbeck & Clore, 2005).

In summary, decision making under the influence of positive feeling states occurs more quickly and efficiently, often relying on stereotypes and other heuristics, than decision making under neutral or negative feeling states (e.g., Bodenhausen, Sheppard, & Kramer, 1994; Isen, 2001), which do not involve necessarily a lowered motivation to process information (Storbeck & Clore, 2005). Instead, positive feeling states may increase reliance on and application of general knowledge structures, as opposed to the processing of new information regarding the specifics or details of the stimulus (Bless et al., 1996). Under the influence of positive affect, cognitive processing is more likely to be relational, holistic, inclusive, flexible, and efficient

(e.g., Fredrickson & Branigan, 2005; Isen, 2001; Johnson & Fredrickson, 2005), each of which has been empirically associated with gist processing (e.g., Reyna & Brainerd, 1995a). When experiencing negative affect, the specifics of the stimulus are more likely to be encoded, and processing is more likely to be effortful, analytical, and vigilant (e.g., Bless et al., 1996; Bodenhausen et al., 1994), which has been associated with verbatim processing. In other words, positive feeling states are more conducive to gist processing than are negative feeling states.

Arousal

Arousal has been interpreted as another dimension of feeling states (or moods) and is defined as a level of activation varying along a continuum from soothed or calm to excited or agitated (e.g., Corson & Verrier, 2007; LaBar & Cabeza, 2006). In this section, we discuss effects of arousal on gist representations of events, on perceived benefits of risk taking and other motivational effects, and on resistance to the influence of arousal (e.g., affective and behavioral inhibition). Although often confounded with the valence of feeling states in research, emotional arousal is thought to focus attention on central gist information at the expense of peripheral details (e.g., Kensinger, 2004; LaBar & Cabeza, 2006). Valence appears to affect *what* information is encoded (e.g., people encode the fundamental gist that an event was emotionally positive or negative; see (Stein, Rohenkohl, & Brainerd, 2007) for evidence of false memories purely for the valence of presented stimuli). Arousal, however, seems to affect *how* information is processed; emotionally arousing stimuli are attended to selectively, processed preferentially, and retained over long time periods relative to neutral stimuli.

For example, Adolphs and colleagues showed that arousing, negative emotion enhanced memory for the “gist” of presented information (e.g., scenes of a car accident), but reduced memory for neutral details (Adolphs, Denburg, & Tranel, 2001; Denburg, Buchanan, Tranel, & Adolphs, 2003). These effects were mediated by the amygdala: Patients with amygdala damage did not show the gist-enhancing and detail-impairing effects of emotion on memory (Adolphs et al., 2005). However, negative emotional arousal also has been shown to enhance the specificity with which information is remembered. For example, individuals were better at distinguishing “same” from “similar” object exemplars when those exemplars were negatively emotionally arousing than when they were neutral (Kensinger, Garoff-Eaton, & Schacter, 2006, 2007; see Reyna & Kiernan, 1994, for similar comparisons of test items to isolate memory for verbatim representations). In young adults, negative emotional arousal appears to enhance gist memory for emotional stimuli, to enhance memory for verbatim details that are central to those stimuli, and to interfere with or leave unaffected verbatim memory for peripheral details (Burke, Heuer, & Reisberg, 1992; Kensinger et al., 2006; Kensinger, Garoff-Eaton, & Schacter, in press). By focusing information processing on central, functionally relevant aspects of events, arousal helps the information processor extract and retain the important elements of experience. Emotional arousal in adolescence, therefore, may facilitate the recognition of central gist themes of risk-taking experiences (e.g., getting drunk always makes things worse) that adults readily recognize in the absence of emotional arousal.

Although arousal has the potential to be a protective factor over the long term because it focuses information processing, it is a risk-promoting factor in the short term. Emotional arousal is associated with the motivational effects of rewards (e.g., Metcalfe & Mischel, 1999). Indeed, there is evidence for heightened responsiveness to rewards in adolescence (e.g., Casey, Getz, & Galvan, this issue; Spear, 2000; Steinberg, this issue). As Reyna and Farley (2006) noted, survey studies of adolescents' perceived benefits have shown that such benefits are significant predictors of risk-taking behaviors, and their beta weights in regression equations can dwarf those of perceived risks (which of course does not imply that risks do not also predict behavior; Michels, Kropp, Eyre, & Halpern-Felsher, 2005). Consistent with fuzzy-trace theory, these studies support a “reasoned route” to risky decision making in adolescence, which is

characterized by analytical processing of risks and rewards (i.e., what we have called verbatim processing).

The reasoned route, in which high arousal reflects the high reward value of engaging in a behavior, contrasts with the reactive route that reflects impulsivity or failure to inhibit behavior (Reyna & Farley, 2006). According to fuzzy-trace theory, impulsivity declines from childhood to adulthood (Reyna, 1995; Reyna & Mills, 2007). Each of these routes is assumed to be adolescence-limited in the sense that there are developmental changes that impel youth to progress from verbatim-analytical processing to gist-based intuition and, in a distinct developmental trajectory, from impulsivity to greater self-regulation (although individual differences may persist in impulsivity (Eigsti et al., 2006).

A key difference between the reasoned and reactive routes is the potential for regret with the latter, perhaps moments after the impulsive behavior has occurred. The reasoned route, however, is one that is ratified by deliberate reflection (Reyna & Farley, 2006). For example, Baird and Fugelsang (2004) showed that adolescents took longer than adults to respond “no” to arousing questions such as “Is it a good idea to swim with sharks?”; neuroimaging data showed that response times for adolescents correlated with the amount of activation in brain areas associated with reasoning and deliberation, and such areas were much more active in adolescents than adults. Adults, however, showed activation in areas associated with images and gut responses. Each of the routes to adolescent risk taking, reasoned and reactive, calls for different kinds of risk-reduction interventions (see Table 4, Reyna & Farley, 2006).

Regardless of the kind of processing engaged in, research on fuzzy-trace theory has shown that behavioral inhibition contributes independently to behavior (e.g., Reyna, 1995; Reyna & Brainerd, 1998; Reyna & Mills, 2007). High arousal or temptation can deplete reserves of willpower that are used to inhibit inappropriate responses, masking underlying cognitive competence (Gailliot & Baumeister, 2007). For example, Kralik (2007) showed that monkeys could learn to discriminate between a connected cloth that could be used to pull a reward toward them versus a disconnected cloth that could not. When the rewards were small, they reliably pulled the correct cloth toward them to gain the reward. When a large reward was placed on a disconnected cloth, however, they vigorously pulled the cloth, giving up the sure small reward, despite demonstrating their knowledge of the futility of that choice in interpolated trials pitting the two small rewards against each other. Reason apparently flew out the window in the face of sufficient temptation. Lest we think that such behaviors apply only to monkeys, Ariely and Loewenstein (2006) have demonstrated similar behaviors in humans (see also Loewenstein, 1996). Similarly, Agocha and Cooper (1999) randomly assigned college students to conditions in which physical attractiveness of a potential sexual partner was either low or high; risk perceptions and intentions to engage in safer sex practices were reduced in the high condition, especially for men. Arousal has such a powerful effect on behavior that when people are not aroused, they lack empathy or insight into their own behavior in aroused states; in a cold state, they cannot imagine, predict, understand or justify their own behavior when aroused.

In summary, studies have shown that emotional arousal focuses information processing on the functionally significant core gist of experience, as well as on central details, so that important information is selectively encoded and retained over long periods. Arousal is also associated with perceived benefits, which are heightened in adolescence and traded off against risks using verbatim, analytical processing. This reasoned route to risky decision making is distinguished from a reactive or impulsive route that reflects failures in behavioral inhibition (a separate construct in fuzzy-trace theory). High levels of arousal can overwhelm efforts to engage in self-regulation, although behavioral inhibition improves from childhood to adulthood. Finally, relying on gist representations and highly over-learned retrieval of values and principles, so

that risky decision making is an intuitive rather than deliberative process, should reduce susceptibility to high levels of arousal.

Discrete Emotional States

Discrete emotional states, such as anger, sadness, joy, and fear which encompass relatively distinct combinations of feeling states, arousal patterns, and cognitive appraisal tendencies (among other features), have a distinct impact on judgment and decision making (e.g., Abe & Izard, 1999; Frijda, 1986; Izard, 1977; Lazarus, 1991). Accordingly, the findings described in the previous sections need to be considered in light of emerging research examining the impact of discrete emotional states in which valence, arousal, and other factors interact (e.g., Lerner & Keltner, 2000). Here we review how discrete emotional states affect the decision process depicted in Figure 1.

Whereas research on feeling states largely compares the influence on judgment and decision making of a “negative” feeling state versus a neutral or “positive” feeling state and the arousal literature largely compares the influence of high versus low arousal, the studies reviewed in this section typically compare the influence of two different discrete emotional states (e.g., anger versus sadness) which may vary in some combination of valence (positive-negative), arousal (high-low), cognitive appraisal (such as certainty-uncertainty), among other characteristics. In a series of experiments, for example, DeSteno and colleagues (2000) showed that likelihood estimates of events classified as causing sadness (e.g., malnourishment of orphans due to food shortages) or as causing anger (e.g., violent criminals set free because of legal technicalities) varied as a function of the discrete emotional state experienced at the time the judgment was made. Participants induced to experience anger rated angering events as more probable than sad events; the opposite pattern occurred for participants induced to experience sadness. Tests of mediation yielded support for a feeling-as-information process (e.g., Schwarz & Clore, 1983), wherein participants consult their emotional state to extract meaning about the stimulus, here the likelihood of the event. (An alternative mediational model, which tested the claim that the effect resulted from a retrieval-based process wherein participants had greater access to memories of sad versus angering events, was not supported by the data.) Thus, as with feeling states, discrete emotional states infuse the interpretation of gist during the encoding process.

A subsequent series of studies provide further support that discrete emotional states affect the gist attributed to stimuli (DeSteno, Petty, Rucker, Wegener, & Braverman, 2004). Specifically, participants induced to experience sadness (or anger) attributed more positive valence to messages that matched their emotional state compared to messages that were either emotionally neutral or framed in a different emotion (i.e., an angering message presented to sad participants). Moreover, individuals reported an increase in approach behaviors, measured by behavioral intentions, for messages that matched their emotional state. In both sets of studies, the emotion induced was incidental to both the judgments and the persuasive messages (DeSteno et al., 2004; DeSteno et al., 2000). Even when irrelevant to a decision, discrete emotional states are likely to influence judgments and subsequent behavior (although only behavioral intentions were assessed in DeSteno et al., 2004). Thus, these studies show that gist is a function of both the valence associated with the stimulus and the discrete emotional state of the perceiver; discrete emotional states shape the gist (interpretation) of valence and shunt behavior in accord with that valence.

Taking discrete emotional states into consideration also modifies the previously described general effects of positive/negative feeling states on attention during encoding and on subsequent representation. Recall that when experiencing a negative feeling state, the specifics of the stimulus are more likely to be encoded and processing is more likely to be effortful, analytical, and vigilant (e.g., Bless et al., 1996; Bodenhausen et al., 1994). In a series of

experiments, Bodenhausen and colleagues (1994) showed that sadness yields the effortful information processing found in previous research examining effects of negative feeling states (which typically involves the induction of a sad or depressed mood), but anger, which also has a negative valence (but is associated with higher arousal), *reduces* extensive processing of information. When angry, processing is more gist-like, typically relying on stereotypic and heuristic cues (e.g., angry participants are more likely to make judgments of a person's guilt based on ethnic stereotypes or to be persuaded more by messages delivered by credible sources, which serve as a heuristic cue for message quality). Being in a sad emotional state does not render individuals invulnerable to judgment biases (indeed, much of the research reviewed in the previous section is based on inductions of sad feeling states). Bodenhausen and colleagues (2000), for example, showed that participants induced to experience sadness were more likely to make judgments that assimilated an anchor, identified explicitly to participants as *irrelevant* to the task, than were participants in a neutral emotional state who appropriately ignored the anchor in forming their judgments. By engaging in more effortful processing and attending to the available details, sad individuals may incorporate extraneous information that biases judgments. (These findings support predictions made by the Affect Infusion Model; Forgas & Vargas, 2000).

Discrete emotions that differ in positivity/negativity (such as hope and fear, happiness and disgust) yield comparable effects on processing when they share similar certainty appraisals. By way of example, consider four emotions typically associated with negative valence: Fear and sadness, in general, are associated with feelings of uncertainty (e.g., unknown consequences related to threat or loss, for fear and sadness, respectively), whereas disgust and anger are associated with feelings of certainty (e.g., a target is repulsive or blocking one's goal, for disgust and anger, respectively; e.g., Smith & Ellsworth, 1985; Tiedens & Linton, 2001). Evidence suggests that experiencing discrete emotional states associated with certainty appraisals (anger or contentment) encourages more gist-like processing, but experiencing discrete emotional states associated with uncertainty (worry or surprise) encourages processing that is less gist-like (Tiedens & Linton, 2001).

Explanations for emotion specificity effects in judgments and information processing follow from a functionalist perspective which posits that each emotion modifies cognitions and physiological responses to direct an immediate behavioral response (e.g., Frijda, 1986; Lazarus, 1991). Cognitive appraisal perspectives, such as those ascribing to an appraisal-tendency framework, make comparable arguments that new objects and events are evaluated in ways that are consistent with the cognitive-appraisal patterns of the current emotional state (e.g., Lerner & Keltner, 2000; Smith & Ellsworth, 1985). For example, anger signals that the self is in immediate danger and needs protection; rapid processing of information is necessary to drive behavior. In contrast, sadness signals a problem in need of solving. In this emotional state, information is processed systematically in order to identify an effective solution incorporating available information (Schwarz, 1990). Thus, some discrete emotional states (like anger) preload a gist interpretation of a situation before information about that situation has been processed thoroughly. A template for interpreting a situation is assumed based on a discrete emotional state, prior to a thorough assessment of the verbatim details of a situation.

In summary, integrating discrete emotional states into predictions about emotion's influence on decision making is important. Some emotions, like anger, facilitate gist-like processing (increasing susceptibility to heuristics, biases, and other forms of intuitive thinking), but other emotions, like sadness, reduce gist processing (increasing the integration of irrelevant details into judgments and decision making). Consequently, the reliance on gist-based processing varies across discrete emotional states even when those states may share some similar characteristics (e.g., valence, arousal).

Summary

Emotions can influence judgment and decision making during each stage of the decision making process that is depicted in Figure 1. Emotional or affective meaning (e.g., of options) in the form of valence (categorical or ordinal representations of positive/negative good/bad) is often at the core of gist representations; this gist influences preferences during encoding. Feeling states and discrete emotional states infuse the interpretation or gist of a stimulus also during encoding, especially when the stimulus is ambiguous. Moreover, emotional states can facilitate or interfere with the values or principles that are retrieved in context by acting as retrieval cues that guide decision making, and also influence whether processing is more gist-like (e.g., relational, holistic, efficient) or more characteristic of verbatim processing (e.g., effortful, analytical, vigilant). Emotional arousal may promote more gist-like processing; however it also may interfere with coherent reasoning by disrupting the smooth application of values to representations of options, especially among adolescents who show a heightened responsive to rewards which are linked to experiences of arousal. Distinguishing how risk taking may be affected by these different components of emotion (valence, feeling states, arousal, discrete emotional states) serves to guide the development of interventions that reduce adolescent risk taking, as we illustrate in the next and final section of this paper.

Intervention Approaches

Research reviews and synthesizing disparate literatures should be more than intellectual exercises. Indeed, the preceding review was motivated by the need to develop effective interventions to reduce adolescent risk taking. In this final section, we highlight three intervention approaches that are consistent with the principles of fuzzy-trace theory. The approaches, which are not necessarily independent, highlight components of interventions that are critical based on our review of how emotion influences risk taking, and are offered as guidelines. Empirical evidence to test their effectiveness currently is being collected by our laboratory.

Intervention Approach I: Manipulate Gist

The gist of new stimuli can be manipulated by varying the salience of positive or negative information. This type of preference formation was shown by Slovic, Monahan, and MacGregor (2000) who asked clinicians to make discharge decisions about a patient with a history of violent behavior. Clinicians who received risk information about the patient framed in terms of frequency (e.g., 1 out of 10 patients similar to this one commit a violent act after discharge) rated the patient at higher risk than clinicians who received the same information framed in terms of probability (e.g., 10% probability of patients similar to this one commit a violent act after discharge). Presenting statistics in terms of frequency makes their meaning more salient (here, the negative valence) because denominators tend to be underweighted (Reyna & Brainerd, 1993, 1994, in press). Providing indicators of goodness and badness in the form of categorical labels (e.g., fair versus good) instead of just numbers that lack meaning (e.g., a score of 56 versus 63) also makes meaning salient and serves to influence preference formation (Peters et al., 2006). As with frequencies and categorical labels, the gist of the valence associated with a stimulus is more salient when presented in terms of anecdotes or narratives (e.g., Slovic et al., 2005). In sum, the valence of a stimulus is not readily apparent and may be subject to interpretation when presented in terms of “cold” numbers or in the absence of context (such as when there is no comparison or alternative (e.g., Finucane et al., 2003). Narratives, verbal labels, and comparisons aid in evaluating the goodness or badness of a stimulus directing preferences (Reyna, in press). Context and comparisons selectively influence gist representations, which are interpretations of the meaning of numbers and other stimuli, as opposed to influencing literal, verbatim representations.

Because information can be presented in ways that form preferences, there are opportunities to influence the gist youth create for risky stimuli. Smoking campaigns, historically, manipulated preferences for cigarettes (i.e., smoking was associated with images that would automatically cue a positive valence so smoking would be encoded positively as well) so that youth would associate positive images with smoking and engage in the behavior. Current attempts to reduce youth smoking are doing the opposite by linking negative images to smoking (Hammond et al., 2005). These interventions are similar to those derived from fuzzy-trace theory to influence preferences concerning sexual risk, namely, by encouraging gist-based processing. By teaching adolescents how to quickly and automatically encode the negative valence of myriad situations that threaten sexual health, adolescents are more likely to avoid these situations (Reyna et al., 2005; Reyna & Farley, 2006). Note that such "intuitionist" approaches differ fundamentally from those that stress reflection, deliberation, and processing of details about probabilities and consequences (Reyna & Farley, 2006).

Intervention Approach II: Inculcate Stable Gist Representations of Risk

Recognizing the conditions under which emotion (including feeling states, arousal, and discrete emotional states) influences judgment and decision making can guide the development of interventions to reduce adolescent risk taking. Specifically, emotions are more likely to influence judgments in relatively ambiguous and complex situations which require constructive cognitive processing (Forgas, 2000). This substantive cognitive processing combines previous knowledge pulled from memory with the creation of new knowledge acquired in the present context. In such situations, emotion contributes to the knowledge base and can direct judgments and subsequent behavior. Abundant research supporting the feelings-as-information hypothesis corroborates this claim (Schwarz & Clore, 2003). Emotion also is more likely to influence judgments when a stimulus is not processed deeply, for example, when the stimulus is not personally relevant, when the individual is under cognitive load or has limited time, or when the individual lacks motivation to process the stimulus in a meaningful way (Forgas, 2000). Under these conditions, individuals are more likely to rely on their feelings as a cue for how to evaluate and respond to the stimulus.

In contrast, emotion is less likely to influence judgment when information processing is direct and motivated, i.e., when individuals actively search memory for specific relevant knowledge (Forgas, 2000). For example, individuals with a proclivity towards processing information deeply (high in need for cognition; e.g., Cacioppo, Petty, Kao, & Rodrigues, 1986) evaluate all relevant information–including their emotional state–to derive judgments and formulate behavioral intentions (DeSteno et al., 2004). Judgments and behavioral intentions are less susceptible to emotion's influence when they involve strongly held beliefs or values that are easily accessible (Forgas, 2000). The effects of emotion on judgments also are reduced when individuals are aware that feelings are irrelevant to the current task, especially when they are motivated (and able) to find an explanation for their feelings. For example, participants who experienced a negative mood induction and later asked to rate the quality of their lives were influenced by their present mood state (i.e., they rated the quality of their lives negatively), but participants provided with a possible explanation for their negative mood state were not (i.e., they rated the quality of their lives positively; Schwarz & Clore, 1983).

In applying these findings to risk taking, adolescents may be more vulnerable to emotion inappropriately coloring their interpretations of events because the gist of events is difficult for them to grasp. As we have discussed, gist is the product of knowledge and experience. Adolescents lack expertise at life the way medical students lack expertise at cardiology (e.g., Reyna & Lloyd, 2006). Thus, interventions should strive to inculcate stable gist representations of events that are well-practiced, and thus automatically recognized, even under negative feeling states. Again, this approach differs from one stressing reflection, deliberation, and

details at the time of the decision. If adolescents are unable to recognize the gist of a situation, they should be taught how to engage in a focused knowledge search when confronted with a potentially risky situation in order to reduce the impact of incidental feeling states on judgment and decision making. The mood disruptions that characterize adolescence make such interventions especially critical (e.g., Arnett, 1999; Hall, 1904). Teaching adolescents how to quickly and automatically identify a risk increases the likelihood that their search for specific relevant knowledge is direct and motivated, and decreases the likelihood that their incidental feeling states will influence judgment and decision making. Viewed through a different but complementary lens, intervention approaches could focus on inculcating stable gist representations of benefits as there is evidence that perceived benefits (in addition to perceived risks) predict risk taking (e.g., Goldberg, Halpern-Felsher, & Millstein, 2002; Halpern-Felsher et al., 2004; for a review see Reyna & Farley, 2006). Adolescents may be motivated to engage in a risky behavior because they focus on some benefit that will result (e.g., social acceptance, popularity). Accordingly, the aforementioned intervention approach could be modified to help adolescents quickly and automatically identify alternative benefits that likewise would reduce risk taking (e.g., safety, health).

Interventions also need to account for the phenomenon that reasoning which occurs in an aroused state is different than that which occurs in a non-aroused state. For example, in designing an intervention for gay men who have unprotected anal intercourse, Gold (2000) leveraged the observation that in the “cold light of day” men were cognizant that having unprotected anal intercourse was risky and not a good choice, but in the “heat of the moment” engaged in self-justifications to engage in unprotected anal sex (e.g., “I'll withdraw,” “He looks healthy” etc.). The arousal during the heat of the moment prompts these self-justifications and engagement in the risky behavior; for example the arousal of passion (a positive arousal state) is likely to make these men more confident in their self-justifications (i.e., that they are making reasonable judgments; see also Agocha & Cooper, 1999). When men who were motivated to not have unprotected anal intercourse were prompted in a non-aroused state to identify and reflect on the self-justifications they made in an aroused state, they were less likely to engage in subsequent incidences of unprotected anal intercourse (compared to those in a standard information provision intervention). This research shows that practicing the retrieval of values and principles facilitates their automaticity even under arousal's influence. The mental models approach used by Downs and colleagues (2004) and described by Fischhoff (this issue), although it focuses on analysis and reflection, may decrease sexually transmitted infections in adolescent girls by increasing automaticity.

Reliance on gist rather than verbatim representations has the advantage that gist is more resistant to all forms of interference, including the disruptive effects of emotional arousal (e.g., Brainerd & Reyna, 1993; Reyna, 1995; Reyna & Mills, 2007). Thus, reliance on gist should provide a bulwark against the arousal, mood swings, and emotional anguish that threaten clarity of reasoning in adolescence. According to fuzzy-trace theory, automatic processing of simple gist representations, rather than reflective deliberation, should provide greater protection against arousal-induced risk taking. Similarly, practice at retrieving values and principles to achieve automaticity can make decision making more resistant to interference effects from arousal. The principle is much like over-training soldiers to respond automatically in order to prepare them for combat so that they respond without thinking when they are under fire (and presumably highly aroused by fear).

Intervention Approach III: Recognize that Emotion Interferes with Applying Gist Representations

Although gist is more resistant to interference, adolescents are at the developmental moment where they typically encode multiple, independent representations of the same information

along a gist-to-verbatim continuum, which ranges from vague gist that preserves the core meaning of experience to verbatim surface details. Distracted by multiple representations, they are less likely to focus on the *central* information that promotes health, and discourages unhealthy risk taking. Their limited experience with nuanced risk stimuli (e.g., the unsupervised party) may also continue to make risk cues less salient. Moreover, the heightened responsiveness to rewards and the limited capacities of the brain's inhibitory control system in adolescence affects the adolescent's ability to avoid a risk (Casey et al., this issue; Spear, 2000; Steinberg, this issue). Recognizing that younger adolescents are especially lacking in inhibitory control, intervention approaches may take a preemptive approach with this group by limiting access to risk. Steinberg (this issue) offers myriad suggestions that align with this approach.

Summary

The approaches described in this section integrate fuzzy-trace theory and the literature on emotion's influence on risk taking. Some of the key points highlighted by these intervention approaches include:

- helping adolescents to recognize quickly the valence of a situation (especially negative valence) and to distinguish that valence from internal feeling states (i.e., determining when current feeling states are central versus incidental to evaluating one's situation);
- automatically and intuitively connecting the valence of a situation with risk-avoidant values that promote healthy behaviors (i.e., developing educated intuition);
- making the values that promote healthy behaviors easily accessible in specific situations that may involve risk, which requires practice with realistic examples;
- being aware of how feelings and arousal states interfere with thinking and decision making (and relying on more robust, interference-resistant gist representations and principles instead);
- anticipating emotional responses and choosing situations wisely (e.g., being aware that one might feel pressure to engage in risky behaviors in the presence of friends at unsupervised parties, and choosing to avoid those situations); and
- distinguishing younger adolescents, who are more subject to impulsivity and effects of arousal (because they engage in analytical reasoning about risks and rewards), from older adolescents, and limiting opportunities for younger adolescents to take risks until cognitive and emotional processing is more mature (e.g., encourage supervised behaviors).

These intervention approaches are aimed at changing how adolescents make decisions about risk. Intervention approaches that aim to effect change at different levels such as within a community, school district, or nationally also can be guided by these theoretical frameworks by, for example, creating strong negative associations with risk behaviors (e.g., public relations campaigns that associate negative images with risky behaviors) so that such cues to valence are salient to adolescents during decision making. Narratives that incorporate emotion, such as novels and television dramas, also can help adolescents recognize the gist of positive or negative valence and the relevance of core values, even when they are obscured by complex and distracting cues. Such narratives also have the power to induce emotions, allowing adolescents to simulate real-life decision making (and vicariously experience outcomes) without actually experiencing harmful consequences. These approaches are supported by fuzzy-trace theory because its aim is to encourage global intuition that reflects meaning, as stories do, rather than memorizing details or engaging in reflective deliberation at the crucial moment when adolescents face a risky choice.

Conclusions

Three overarching conclusions emerge from our review: First, emotion is gist, but gist is not necessarily emotion. Memories of emotion, including, valence, arousal, feeling state (or mood), and discrete emotion often linger long after the verbatim details of experience fade. Such endurance is a hallmark of gist memories. Furthermore, emotions mark significant life events, allowing individuals to focus on core information, which can then be recognized as gist in subsequent situations. However, beyond valence, which seems to be encoded automatically, emotion does not characterize all information that is mentally represented (e.g., Kintsch, 1974). Research has conflated meaning (often gist representations) with affective meaning, but it is clear that mental representations of categorical contrasts such as good/bad or no risk/some risk are not necessarily accompanied by differences in arousal, feeling states, or discrete emotions. By separating mental representations per se, especially of risky situations, from effects of emotion on different kinds of representations, on retrieval of values, and on application of values to those representations, we hope to have opened up avenues of new research that were obscured by conflating these factors.

Second, we have identified a number of specific ways in which emotion influences mental representations and information processing. For example, valence can color the overall gist of a decision option; feeling states can be inadvertently incorporated into the gist of a situation; and arousal can interfere with adolescent decision making, especially when it is focused on interference-sensitive analysis of verbatim details (e.g., weighing the pros and cons of a decision in terms of exact amounts of rewards and precise degrees of risk). Discrete emotional states, such as anger, preload a gist template for interpreting a situation before information about the verbatim details of that situation has been processed thoroughly. Arousal and specific, discrete emotional states influence whether processing is gist-based as opposed to verbatim-based, which, in turn, governs risky decision making, as results on framing illustrate. Emotional states can facilitate or interfere with the values or principles that are retrieved in context by acting as retrieval cues that guide decision making. Risk taking occurs as a result of reasoning, especially verbatim processing, in which benefits are seen as worth the risks. However, it also occurs as a result of reaction or impulse that is difficult for young people to inhibit, especially in response to highly arousing stimuli.

The third major conclusion is that research can be used to shape interventions to reduce unhealthy risk taking and to inform public policy. The volatility that characterizes adolescent risky decision making can be reduced, it is argued, by inculcating stable gist representations that encode danger (e.g., the risk associated with an unsupervised party or with a man approaching a young girl in a mall) and by practicing retrieval of simple values and principles until they are evoked automatically in relevant situations. Developing such educated intuitions should shield adolescent risky decision making somewhat from the strong emotions that infuse this time of life. These recommendations differ sharply from conventional wisdom in this area, which stresses reflection, deliberation, and accurate analysis of risks and benefits. In this connection, fuzzy-trace theory is the only developmental theory that identifies advanced reasoning with the gist-based processes of intuition. Although many of our recommendations focus on resisting inappropriate effects of emotion, we also expect that adolescents who are high in emotional intelligence can recognize and incorporate information about emotion to improve their decision making (Mayer & Salovey, 1997; Salovey & Mayer, 1990), but little research exists on this topic (but see Rivers, Brackett, & Salovey, in press). More generally, we emphasize the importance of applying evidence-based theoretical models to understand and change adolescent risk taking, which is the source of substantial morbidity and mortality.

There are a number of limitations of the research we have reviewed. Evidence on the influence of *emotion* on decision making and behavior has been collected, almost exclusively, on adult

samples. Applying the findings to adolescents must be done with caution until evidence is collected that emotion operates similarly across these age groups. It is known that self-regulation (e.g., behavioral inhibition) develops appreciably during this period (e.g., Casey et al., this issue; Reyna & Mills, 2007; Steinberg, this issue). Developmental differences also are likely to be observed in the ability to recognize valence, identify its true origin, marshal it for use in risk avoidance, retrieve values and principles, and apply them efficiently across decision situations. Developmental differences in each of these components have been observed in research on laboratory tasks involving judgment and decision making, on other cognitive developmental tasks, and on surveys of real-life risk taking, but research that integrates these specific processes in adolescent risk taking and applies them broadly is lacking. The barriers to integrating cognition and emotion in developmental research are even greater, with some researchers arguing that one or the other domain is irrelevant to risk taking, a conclusion that we hope to have discouraged. Instead, the research reviewed here provides worked examples of how cognitive and emotional approaches can be interwoven, producing new insights into the causes and remediation of unhealthy risk taking.

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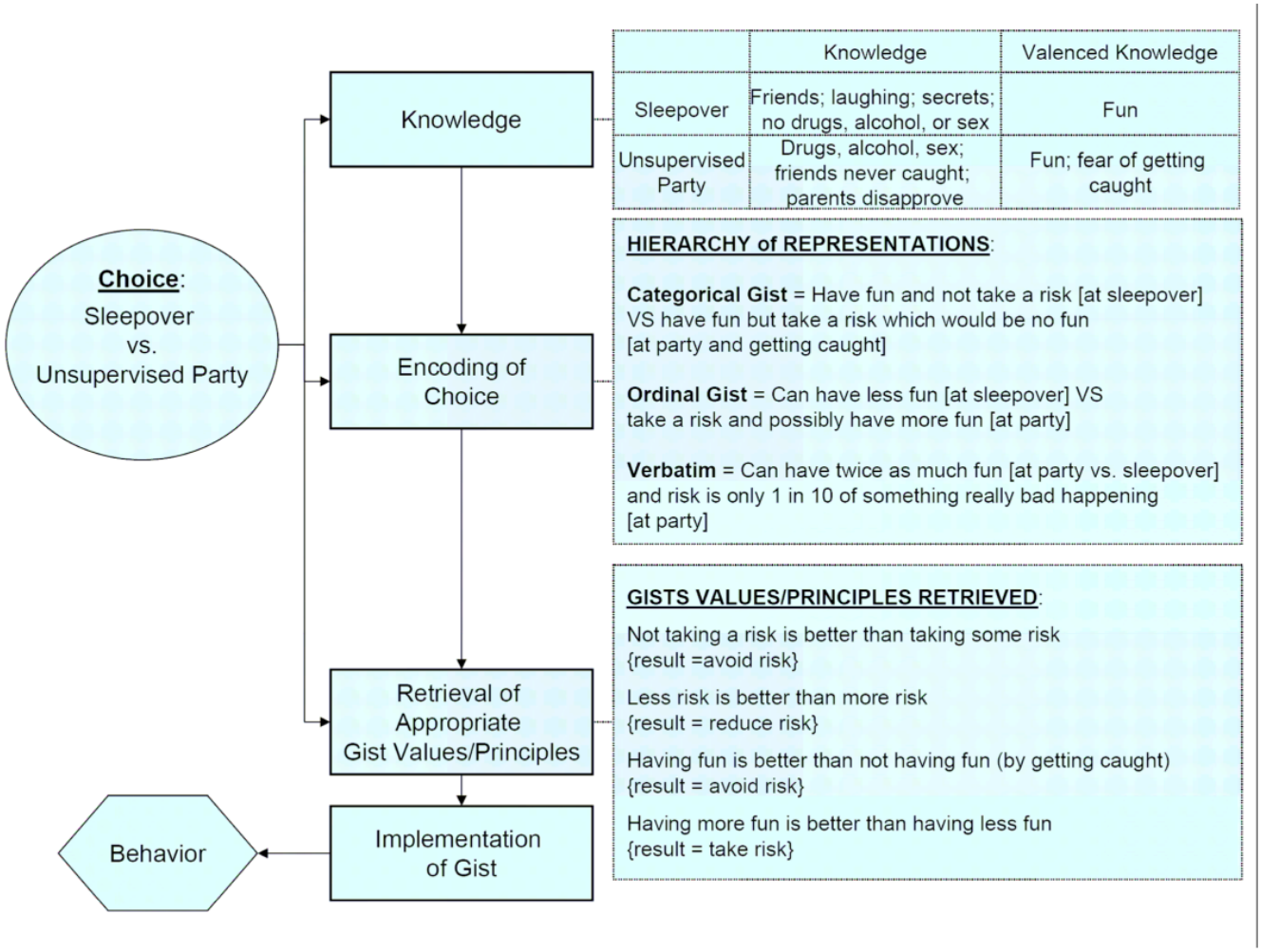

Figure 1. A process model for risky decision making based on fuzzy-trace theory

Table 1

Illustrative Findings Supporting Three Principles of Fuzzy-Trace Theory

Principle	Stimuli	Task	Finding	Sources
I. Hierarchy of gist representations	Numerical inputs, such as Farmer Brown has 8 cows, 7 sheep, 4 pigs and 2 horses.	Recall verbatim numbers of animals; make gist judgments of relative magnitude.	Subjects encoded verbatim as well as multiple gist representations (e.g., cows are most; more cows than horses).	Brainerd & Gordon, 1994
II. Independent encoding, storage, and retrieval of gist vs. verbatim representations of experience	Probability judgment tasks in which frequencies vary depicting the magnitudes of numerators (e.g., number of winning tokens in a jar) and denominators (e.g., total number of tokens in the jar).	Choosing which of two risky options (e.g., blue jar or red jar) offer the best chance of winning. Memory for frequencies (e.g., number of winning tokens in a jar) was tested before and after choices were made.	Memory for frequencies (i.e., for the numerical information that determined the probabilities) was stochastically independent of the accuracy of probability judgments; memory for frequencies was based on verbatim representations, whereas probability judgments were based on qualitative gist representations (e.g., "more winning tokens in the blue jar").	Reyna & Brainerd (1994, review of literature); see also Reyna & Kiernan (1994, 1995).
III. Fuzzy-processing preference (default reliance on gist-based processing, or intuition, in reasoning, judgment, and decision making)	Three decision experiments; in Experiment 1, numerical information was partially or completely deleted (replaced with vague verbal descriptions such as "Some people are saved."). Experiment 2 focused processing on numerical information (e.g., 200 saved vs. 1/3 600 saved) key in prospect and other utility theories.	Choosing between sure option and risky option of equal expected value (e.g., saving 200 people expected to die vs. 1/3 probability of saving 600, 2/3 probability saving no one).	Framing effects (choosing the sure option in the gain frame and gamble in the loss frame) became more pronounced as detailed numerical information was deleted; hence framing effects reflect reliance on simple, qualitative gist as the norm for adults' risky decisions. Experiment 2 showed that focusing on numerical information made framing effects disappear.	Reyna & Brainerd (1991, 1995); see also Reyna (2004).
IV. Greater experience produces greater reliance on gist-based processing (intuition)	18 decisions with 3 levels of risk X 3 levels of outcome X 2 levels of framing (gain/loss)	Choosing between sure option and risky option of equal expected value (e.g., winning 1 prize for sure vs. spinning a spinner with ½ chance to win 2 prizes and ½ chance to win no prizes); degree of preference also rated on 1-7 scale.	Preschoolers weigh both quantitative dimensions, the level of risk and the number of prizes (i.e., amount of reward); 2nd graders rely on one quantitative dimension, number of prizes; 5th graders show first evidence of adult framing pattern, sometimes relying on qualitative gist (not on quantitative distinctions about level of risk or number of prizes)	Reyna & Ellis (1994); see also Reyna & Lloyd (2006) indicating that experience not age/maturation is key to gist reliance.

Note: People routinely encode and store *hierarchies of gist*, rather than a single gist representation, that vary in their level of precision (e.g., "the blue jar has some winning tokens," "the blue jar has more winning tokens than the red jar," "the blue jar has more than 20 or 30 winning tokens, but I don't know exactly how many"). Hierarchies of gist vary, too, in their level of integration across meaningful units of experience (e.g., people encode the gist of single sentences and also the gist of inferences supported by multiple sentences; or, they encode the gist of individual words on a word list and also the gist or theme of the entire list, if it has one).

Table 2

Gist (qualitative) representations of framing conditions

	Representation	FRAME	
		LOSS	GAIN
Gamble (Risk)	Quantitative:	2/3 Chance that 600 People Die Or 1/3 Chance that None Die	1/3 Chance that 600 People are Saved or 2/3 Chance that None are Saved
	Qualitative:	Possibly Some Die or None Die	Possibly Some Saved or None Saved
Sure Thing	Quantitative:	400 People Die	Save 200 People
	Qualitative:	Some Die	Some Saved

Note. In some experiments, all numbers were replaced by the vague phrases shown here (e.g., some saved) to determine whether numbers were necessary; in other experiments, the standard, numerically specified zero complement was removed and placed with the preamble information to avoid ambiguity; in still other experiments, the standard, numerically specified non-zero complement was removed and placed with the preamble information to avoid ambiguity. When some numbers were removed, all other numerical information remained specific. Effects were demonstrated with problems that involved money and lives. (Examples of framing changes from Fulginiti & Reyna, 1993; Reyna & Brainerd, 1991b, 1995a; Reyna & Fulginiti, 1992)

Table 3

Categorical Thinking Scale (9 items)

1	If you keep having unprotected sex, risk adds up and you WILL get pregnant or get someone pregnant.
2	When in doubt about having sex, delay or avoid it.
3	If you keep having unprotected sex, risk adds up and you WILL get a sexually transmitted disease.
4	Even low risks add up to 100% if you keep doing it.
5	It only takes ONCE to get pregnant or get an STD.
6	Even low risks happen to someone.
7	Even if you use condoms, eventually you'll get an STD if you have sex enough.
8	Once you have HIV/AIDS, there is no second chance.
9	If you can't handle getting protection, you are not ready for sex.

Responses made using 5-point Likert-type scales (0 = strongly disagree; 4 = strongly agree). Greater agreement of items reflects categorical risk avoidance.

Table 4

Gist Principles Scale (15 items)

1	Better to not have sex than risk getting HIV/AIDS
2	Better to focus on school than have sex.
3	I have a responsibility to my partner to not put him/her at risk.
4	Avoid risk.
5	Better to be safe than sorry.
6	Better to not have sex than risk getting pregnant or getting someone pregnant.
7	Better to wait than to have sex when you are not ready.
8	I have a responsibility to my parents/family to not have sex.
9	Better to not have sex than hurt my parents/family.
10	I have a responsibility to God to wait to have sex.
11	I have a responsibility to myself to wait to have sex.
12	Better to have fun (sex) while you can. (reverse-scored)
13	Known partners are safe partners. (reverse-scored)
14	Having sex is better than losing a relationship. (reverse-scored)
15	Having sex is worth risking pregnancy. (reverse-scored)

Respondents check statements that apply to their decision to have or not have sex. More checked items reflects greater adherence to simple values regarding sexual activity.