

- Dual-process theories are the most recent approach to encompassing the high and low levels of rationality that characterize human behaviors and, often, the same individual; but predictive theories are required in order to develop effective strategies for prevention and intervention that reduce unhealthy risk taking

EXPLANATORY MODELS OF ADOLESCENT RISK TAKING

Reasoned, Reactive, and Intuitive Decision Making

Most models of adolescent risk taking assume the traditional kind of rational decision process that we have discussed: one that is goal oriented (i.e., directed at reaching personal goals) and logically coherent. According to the behavioral decision-making perspective, for example, options are considered, consequences are evaluated, and a decision is made. People are assumed to evaluate options by assessing probabilities, weighting values, and integrating them in order to make a choice—all quintessentially cognitive activities. An expanded version of this perspective adds emotional, social, and developmental factors to explain decision making (Fischhoff, 2005). If decision makers care about how other people evaluate their choices, for example, that consideration then becomes another factor in the calculation of costs and benefits.

Other rational models include the health-belief model, protection-motivation theory, the theory of reasoned action, the theory of planned behavior, and problem-solving approaches (e.g., Greenberg, Kusche, Cook, & Quamma, 1995; Shure, 2003). Each of these models incorporates mechanisms to explain how people actually make decisions (a descriptive focus) and, to varying degrees, implications of these mechanisms for improving decision making (a prescriptive focus). The aim of the problem-solving approaches, for example, is to develop emotional and social competence, and they encompass such skills as means-end thinking, resistance to peer pressure, seeking help, and generating alternative solutions to problems. Although not all of these problem-solving models have been evaluated with respect to outcomes in adolescence, they constitute instructive attempts to convert reactive and impulsive decision makers into rational, deliberative, and socially competent ones (see also Furby & Beyth-Marom, 1992). A review of problem-solving approaches is beyond the scope of the present article, but evidence of effects in reducing aggressive behavior, as well as other risk-reduction outcomes, has been obtained (see, for example, Greenberg, Domitrovich, & Bumbarger, 2000; Romer, 2003; U.S. Department of Health and Human Services, 2001). As noted earlier, results demonstrating effectiveness suggest that assumed explanatory mechanisms have merit.

The health-belief model can be roughly understood as an instantiation of a behavioral decision-making perspective in a health context (Becker, 1990; Byrnes, 1998). The model's

components are used to explain why people engage in health-promoting (or destructive) behavior and, thus, has implications for interventions. The model's components are (a) a person's assumed goal of achieving health (e.g., avoiding or curing illness), (b) perceived vulnerability to health threats, (c) perceived severity of health threats, (d) beliefs that specific behaviors will promote health or cure illness (e.g., beliefs about benefits and barriers to engaging in behaviors to achieve health) and (e) environmental cues to the actions or behaviors that are believed to be effective in achieving health. Broadly construed, the purview of the model includes smoking, dieting and eating disorders, drug and alcohol consumption, and other health-related risky behaviors. For example, according to this model, adolescents would be expected to stop smoking if they perceive that the health threats posed by smoking are great (e.g., inability to compete athletically if they continue smoking), that those threats apply to them (e.g., they have asthma and so will be more likely to experience shortness of breath), that the benefits to quitting are significant (e.g., they are on the track team), and that the barriers to quitting (e.g., addiction) are surmountable.

Protection-motivation theory is a variant of the health-belief model (e.g., Rogers, 1983). Protection motivation refers to the motivation to protect oneself against a health threat and is usually measured as the intention to adopt some recommended action. Its constructs include perceived vulnerability and severity, response efficacy (the belief that the recommended action is effective in reducing the threat), and perceived self-efficacy (the belief that one can successfully perform the recommended action). That is, people will have a stronger intention to adopt the recommended action to the extent that they believe the threat is likely, that the consequences will be serious if the threat occurs, that the recommended action is effective in reducing the severity of the threat, and that they are able to carry out the recommended action (Sutton, 2001). Two meta-analyses of protection-motivation-theory studies have been conducted and both supported the constructs as predictors of intentions or behaviors (Floyd, Prentice-Dunn, & Rogers, 2000; Milne, Sheeran, & Orbell, 2000).

Factors such as perceived vulnerability to and severity of health threats, as well as perceived barriers and benefits to engaging in health behaviors, have been found to be correlated with health behaviors (for a review, see Janz & Becker, 1984). Thus, there is empirical support for the health-belief model (and its variants, including protection-motivation theory). However, many other factors affect health behaviors (i.e., the variance accounted for by the health-belief model is fairly low), and such factors as perceived vulnerability and severity are only weakly correlated with health behaviors (Byrnes, 1998). Although health models are criticized for being narrow, per our discussion of rationality and adaptive decision making, the models can be extended to other behaviors that are only metaphorically adaptive in the sense that they promote physical and mental well-being (e.g., applying to colleges, which involves risk).

Moreover, all human behavior is multiply determined, and it is no mean feat to obtain statistically significant effects that predict important health behaviors (although prediction is often limited to statistical association rather than active manipulation of factors).

Also, the health-belief model provides obvious entry points for attitude change; if vulnerability is perceived as low (but is objectively high), adolescents should be taught how vulnerable they are—and so on with each of the factors. Because decision making is assumed to be conscious and deliberative, explicit instruction ought to make a difference, according to this model, and knowledge ought to be related to behavior (e.g., knowledge of HIV/AIDS risk factors has been found to be negatively associated with adolescent sexual risk-taking, although null effects have also been reported, and knowledge is often insufficient to change behavior; Crisp & Barber, 1995; Kotchick, Shaffer, Forehand, & Miller, 2001; cf. Dudley, O'Sullivan, & Moreau, 2002). In our zeal to acknowledge unconscious or nondeliberative effects on behavior, we should not ignore the fact that explicit instruction about vulnerability, severity, benefits, and barriers is sometimes effective in changing behavior.⁵

The main difficulties with these models are, first, that they are primarily supported by correlational evidence; they do not really predict outcomes in the sense that underlying mechanisms are understood and have been actively manipulated in experimentation to establish cause-effect relations (Kershaw, Niccolai, Ethier, Lewis, & Ickovics, 2003). (Protection-motivation theory has been tested extensively using experimental designs, but these experiments generally do not explore the mechanisms that underlie the constructs.) By “correlational,” we mean any study that does not involve experimental manipulation of factors, including studies using complex multivariate analyses and statistical controls. Unfortunately, having large sample sizes with many variables that are correlated with one another does not compensate for the absence of a predictive process model of risky decision making. Statistical controls or quasi-experiments are not sufficient to demonstrate causality (Reyna, 2004b). From a practical perspective, this means that, without experiments that support conclusions about causation, programs predicated on correlational studies may nevertheless be ineffective.

⁵According to traditional deliberative models of risky decision making, explicit instruction about vulnerability, severity, benefits, and barriers should be effective in changing behavior. One might question, however, whether unconscious antecedents of behavior can be influenced by interventions, which would seem to require conscious reflection. However, this assumption highlights a core difference between deliberative (or computational) and fuzzy-trace models of reasoning and decision making. In the latter model, advanced gist-based reasoning and decision making is often (although not necessarily) unconscious. Indeed, according to that model, the aim of interventions should be to make such thinking unconscious and automatic through practice at intuitively grasping the bottom-line gist (or meaning) of risky situations, and then rapidly retrieving and implementing risk-avoidant values from long-term memory, without conscious deliberation about pros and cons (e.g., Adam & Reyna, 2005; Reyna, Adam, Poirier, LeCroy, & Brainerd, 2005).

Second, health-belief models do not account for the unconscious or irrational decision making that seems to be the source of much trouble in adolescence (i.e., impulsive or reactive decision making). As we discuss in connection with the entire class of models that assume rationality as deliberative and analytical, it seems doubtful (relevant data are presented below) that most factors that affect risky decision making are ones that adolescents are consciously aware of (and can report) and that adolescents combine those factors logically and objectively. In other words, it is questionable whether problem behavior in adolescence is exclusively the result of a rational cost-benefit analysis (but see Reyna, Adam, Poirier, LeCroy, & Brainerd, 2005).

The “rational agent” hypothesis is a prominent feature of Fishbein and Ajzen's (1975) theory of reasoned action—linking beliefs, attitudes, norms, intentions, and behaviors—which was later followed by the theory of planned behavior (e.g., Ajzen, 1991; Ajzen & Fishbein, 1980). In both theories, behavioral intention is the immediate antecedent to action (Gibbons, Gerrard, Blanton, & Russell, 1998). Attitudes are the overall affective and instrumental evaluations of performing the behavior. Subjective norms refer to social pressures to perform or not to perform a behavior (e.g., beliefs that parents disapprove or that peers approve of a behavior such as adolescents having sex). The main added construct in the theory of planned behavior is the idea of perceived behavioral control, conceived as a combination of self-efficacy (confidence or sense of ease in performing a task) and controllability (i.e., a sense that the behavior is “up to me”; see Rhodes & Courneya, 2004). Perceived behavioral control encompasses perceived resources, skills, and opportunities (Ajzen, 1991). Because behaviors are assumed to be intentional, they involve some degree of premeditation or planning. Behaviors that are not completely volitional are predicted by incorporating perceptions of control as an additional predictor of intention (Ajzen, 1991).

These theories have been supported empirically, having effectively predicted health-promoting behaviors such as condom use (Fisher, Fisher, & Rye, 1995) and health screening (McCaul, Sandgren, O'Neill, & Hinsz, 1993; see Conner & Sparks, 1996; Sheppard, Hartwick, & Warshaw, 1988, for reviews). A meta-analysis of the theory of reasoned behavior indicated that behavioral intentions accounted for 38% of the variance on average in studies of health behavior (van den Putte, 1993). A meta-analysis of the theory of planned behavior produced a similar estimate of 31% (Armitage & Conner, 2001). As Gibbons et al. (1998) pointed out, however, “Not all behaviors are logical or rational . . . It would be hard to argue that behaviors that impair one's health or well being, such as having sex without contraception when pregnancy is not desired or drunk driving, are either goal-directed or rational. . . . Nonetheless, these behaviors are common, especially among young persons” (p. 1164). Thus, as might be expected, health-impairing behaviors such as substance use, drunk driving, and smoking, as opposed to behavioral intentions, are sometimes not as well predicted by these theories (Morojele & Stephenson, 1994; Stacy, Bentler, &

Flay, 1994). Nevertheless, statistically significant associations between intended and actual frequency of substance use among adolescents have been obtained, supporting some degree of intentionality in these behaviors (Ajzen, 1989; Downey & O'Rourke, 1976; Huba, Wingard, & Bentler, 1979; Swisher & Hu, 1983; Wolford & Swisher, 1986).

Taken as a whole, these results suggest that risk-taking behaviors in adolescence can originate either intentionally or unintentionally, with each type of risk taking calling for a different kind of intervention. For example, intentional risk taking might be better modified by explicitly addressing such factors as perceived risks, benefits, and norms (e.g., that fewer peers are sexually active than believed). Unintentional risk taking, however, has been described as reactive, or as behavioral willingness, in contrast to behavioral expectations or intentions (Gibbons et al., 1998; Gibbons, Gerrard, & Lane, 2003). Behavioral expectation (the perceived likelihood of engaging in a behavior) is a modified measure of behavioral intention (planning to engage in a behavior) that is more inclusive and, thus, captures more variance in behavior. Behavioral willingness is an even more sensitive measure of susceptibility to risk taking—and one that explains unique variance—because adolescents are willing to do riskier things than they either intend or expect to do (Gibbons et al., 2003). Thus, there is a group of adolescents who indicate that they would be willing to engage in specific risk-taking behaviors but deny that they are expecting or intending to engage in those behaviors, and studies show that they go on to engage in those behaviors more often than do those who deny willingness. Adolescents who fall into the latter group (willing but without conscious intentions) are likely to be especially at risk because they do not take precautionary measures (e.g., carry condoms or arrange for a designated driver).

Unintentional risk taking would be expected to be reduced by such measures as adult supervision or monitoring, because these remove opportunities to react to temptations. Indeed, amount of unsupervised time has been found to predict adolescent risk taking in a variety of domains (e.g., Chassin, Pillow, Curran, Molina, & Barrera, 1993; Crosby et al., 2001; Lahey, Gordon, Loeber, Stouthamer-Loeber, & Farrington, 1999; Lynch, Coles, Corley, & Falek, 2003; Millstein & Igra, 1995; Vitaro, Brendgen, Ladouceur, & Tremblay, 2001). Approaches such as supervision address the criticism that helping young people avoid traps such as trying smoking (and becoming addicted) requires more than inculcating rational decision skills. It is not sufficient to encourage sound thinking and problem solving; the environments in which adolescents develop must also be modified to remove opportunities for unhealthy risk taking when adolescents are not ready to handle them.

Note that supervision protects young people from experiencing negative feedback (because they are not put in a position to take risks and, thus, experience bad consequences). Because of this lack of opportunity to learn self-regulation and other self-control strategies, some theorists (e.g., Byrnes, 1998) have

suggested that “sheltered, inexperienced” (p. 153) children would be at higher risk (Byrnes' self-regulation model). This hypothesis would be supported by a curvilinear relationship between amount of monitoring and unhealthy risk taking—very low and very high monitoring both producing greater unhealthy risk taking but moderate amounts of monitoring producing adaptive behavior. However, within the ranges of amount of monitoring that have been studied, there is little evidence for such a relationship (cf. Shedler & Block, 1990). The reason for the effectiveness of supervision seems clear: Adolescents who either intend or are willing to engage in unhealthy risk taking are thwarted by thorough monitoring.

The prototype/willingness model, which incorporates the behavioral-willingness construct, has been supported by studies showing that much adolescent risk behavior is not planned and that willingness and intention are related but independent constructs that separately predict risk behavior (Gibbons et al., 1998; Gibbons et al., 2004). The prototype/willingness model can be thought of as an extension of the theory of reasoned action, retaining such elements as social norms and behavioral intentions but broadening the theoretical purview to unintentional behavior by using new constructs such as willingness. The model suggests that intentions and expectations become better predictors of behavior as maturity increases, whereas with maturity the predictive power of willingness decreases.

In the prototype/willingness model, prototypes are images of risk takers and non-risk takers, as well as images of self, that have been found to motivate behavior. Interestingly, overall favorability of images (e.g., of substance users) predicts risky behavior better than do specific attributes described by subsets of adjectives. (For example, when asked to describe a typical teenage smoker, only the overall positivity or negativity of the described image matters; the details do not predict risk-taking behavior.) These data are also predicted by fuzzy-trace theory, which holds that risky behavior is governed by fuzzy gist representations of categories of people, objects, and events (or by values and principles that are cued in context) rather than by verbatim details (Reyna 2004a; Reyna & Adam, 2003; Reyna et al., 2005). 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). Thus, dual-process models, such as the prototype/willingness model and fuzzy-trace theory, identify two divergent paths to risk taking: a reasoned route and a reactive route.

Although fuzzy-trace theory shares characteristics of the prototype/willingness model, it differs from that model in important ways. Both models explain risk taking that is not “reasoned” in the usual sense of that term, as well as explaining the declining tendency with age to react without thinking (Steinberg, 2003; for discussions of the role of inhibition in fuzzy-trace theory, see Reyna, 1991, 1995; Reyna & Mills, in press). However, fuzzy-trace theory assigns a central role in advanced

decision making to intuition—in contrast to the prototype/willingness model as well as to traditional developmental and decision theories, in which advanced decision making is precise, analytical, and deliberative.

The core assumptions of fuzzy-trace theory are based on research in memory, judgment, and decision making, taking into account social, cognitive, affective, and developmental factors (for overviews, see e.g., Reyna & Brainerd, 1995; Reyna et al., 2003). According to the theory, people encode multiple mental representations of their experience, ranging from precise verbatim representations that incorporate surface detail (e.g., exact wording of a risk communication, such as a product label; Reyna & Adam, 2003) to fuzzy gist representations that incorporate the essential meaning of an experience, gleaned through the filter of affect, culture, worldview, education, developmental level, and other factors known to affect semantic interpretation and inference (e.g., Reyna & Kiernan, 1994, 1995). Evidence from experiments with children, adolescents, and adults has shown that such verbatim and gist representations are encoded, stored, and retrieved independently (see Reyna, 2005; Reyna & Brainerd, 1995, for reviews).

Decision makers recognize the gist of a risky situation (often multiple gists of that situation) based on prior experience, and simultaneously encode its verbatim representation. Verbatim representations rapidly fade, and judgment and decision making are instead governed by a fuzzy processing preference (i.e., decision making preferentially operates on the gist representations, not on the verbatim ones). This tendency to base decisions on simple qualitative gist increases with age, experience, and expertise, as demonstrated by research with children and adults. As decision making becomes cognitively simpler (but not simpleminded) and gist-based, the tendency to take risks—for example, in tasks involving choosing between sure things and gambles—generally declines (Levin & Hart, 2003; Reyna, 1996; Reyna & Mattson, 1994; Rice, 1995). Figures 6 and 7 display developmental differences in risk taking, especially for higher levels of risk, for decisions involving both gains and losses (Levin & Hart, 2003, extended the research to adults and showed a child-to-adult decline in risk taking). Experimental evidence indicates that young children roughly multiply probabilities by magnitudes of outcomes (e.g., the number of prizes associated with each possible outcome) in decision tasks, quantitatively combining two dimensions (e.g., Schlotzmann, 2000, 2001; Schlotzmann & Anderson, 1994). On the same tasks, this quantitative focus slips to one dimension (outcomes) as children get older; adult performance has been shown to not be based on the quantities at all but rather on their qualitative gist (e.g., winning some prizes versus maybe winning some prizes or maybe winning none; Reyna & Brainerd, 1991b, 1994, 1995). (These conclusions are based on actively manipulating factors in experimental tests, presenting many decisions per child and using ratings and other preference measures, as opposed to being based on behavior on a few choice trials.) Thus, it

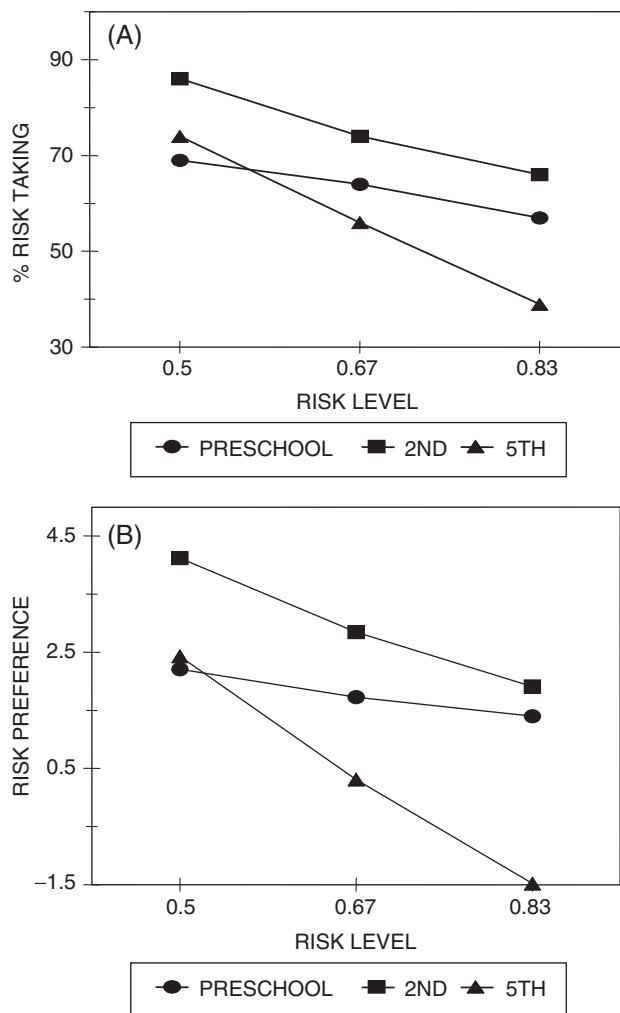


Fig. 6. Choice proportions for the risky, as opposed to sure, option (panel A) and risk-preference ratings on a 7-point happy-face scale (i.e., children pointed to smiley faces that varied from neutral to very happy; panel B) for 3 risk levels across gain and loss decisions for 44 preschoolers, 33 second graders, and 47 fifth graders; ratings for sure choices were multiplied by -1 so that ratings could vary from strongest preference for the gamble ($+7$) to strongest preference for the sure option (-7 ; based on Reyna & Mattson, 1994).

is young children who demonstrate sophisticated quantitative competence, trading off the magnitude of rewards against the magnitude of risks, modulating their preference for risk according to the overall quantitative value of the options (obtaining these findings requires highly sensitive methodologies, but the results have now been replicated in several laboratories). Adults, in contrast, engage in simpler (but not simplistic) decision processes (see also Table 3). The empirical evidence from laboratory studies supports the conclusion that gist-based intuition produces risk avoidance, but deliberation—weighing of alternatives—encourages risk taking, and gist-based intuition is associated with maturity (e.g., Reyna et al., 2005).

Representations alone do not determine decision making; retrieval of values and their implementation in context are also

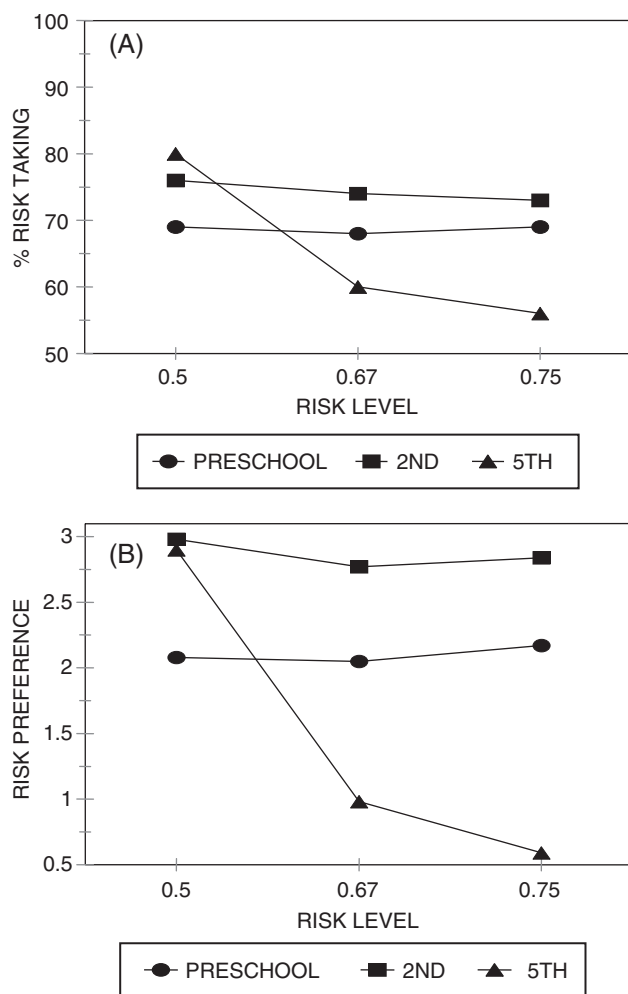


Fig. 7. Choice proportions for the risky, as opposed to sure, option (panel A) and risk-preference ratings on a 7-point happy-face scale (i.e., children pointed to smiley faces that varied from neutral to very happy; panel B) for 3 risk levels across gain and loss decisions for 44 preschoolers, 51 second graders, and 51 fifth graders; ratings for sure choices were multiplied by -1 so that ratings could vary from strongest preference for the gamble ($+7$) to strongest preference for the sure option (-7 ; based on Rice, 1995; see also Reyna, 1996).

critical. As a result of acculturation, children acquire values that they endorse and store in a vague form in long-term memory (e.g., life is better than death; it is better to have a relationship than to be alone). Depending on the cues in the situation, people retrieve their values from long-term memory and apply them to the gist representation of the situation (fuzzy-trace theory has a detailed retrieval model, which has been formalized using mathematical models whose parameters have been tested individually and collectively for goodness of fit to actual data; e.g., Brainerd, Reyna, & Mojardin, 1999). Affect is one important contextual cue, among others, that prompts retrieval of values. In the example of a choice of a sure thing or a gamble with varying prizes, people generally retrieve such values as “more prizes are better than fewer prizes” and therefore choose the sure

option. Variability in situational cues, in part, explains task variability and apparent instability of preferences and decisions. Compared to adults, adolescents have less experience with situational cues concerning risk, and thus they are less likely to recognize danger or to immediately think of consequences.

Fuzzy-trace theory, therefore, emphasizes reactions to cues in the environment, although the mental processes of advanced decision makers have been distinguished from merely acting on impulse (e.g., Reyna, 1991, 1995). Advanced decision makers rapidly home in on the essential gist, ignoring verbatim detail and irrelevant cues. For example, studies of physicians making risky decisions in emergency rooms have demonstrated that, when they make decisions in their domain of expertise, more knowledgeable individuals (e.g., cardiologists) process fewer dimensions of information and do so more qualitatively (consistent with using gist representations) than do those with less knowledge and training (and yet, more knowledgeable physicians’ medical decisions are more accurate; Reyna & Lloyd, in press; Reyna et al., 2003; see also Dijksterhuis, Bos, Nordgren, & van Baaren, 2006). Evidence from these and other studies suggests that more advanced decision makers (adults compared to children or experts compared to novices) automatically encode the gists of risky situations, retrieve risk-avoidant values that are appropriate to those situations, and smoothly apply those generic values to the specific situations. The difference between advanced decision makers and impulsive reactors lies in the ability of the former to quickly react to a small number of relevant cues, as opposed to reacting to misleading or irrelevant lures and other sources of temptation.

Integrating Individual Differences in Affect and Experience With Explanatory Theory

Although the reactive route to risk taking highlights environmental factors, such as negative peer influences and other sources of temptation, reactions depend in part on the characteristics of the individual (Breiner, Stritzke, Lang, 1999). Cafra and Schneider (2000), for example, identify affective or emotional motivators that (a) promote risky behaviors by enhancing pleasant affective states, as in sensation seeking; (b) promote risky behaviors by reducing negative affective states, such as tension or depression; or (c) deter risky behaviors by avoiding anticipated regret. Consistent with these predictions, they found that adolescents who had had more experience with risky behaviors believed that those behaviors enhanced positive affect and reduced negative affect. Adolescents with less experience taking risks were more motivated to avoid negative future consequences. Cooper, Agocha, and Sheldon (2000) similarly found that adolescents with negative affect and avoidant personalities were more likely to engage in substance use and other risky behaviors, presumably to assuage their negative affect (see also Chassin, Pillow, Curran, Molina, &

TABLE 3
Developmental Studies Showing an Increase in Cognitive Illusions With Age

Study	Cognitive illusion(s)	Age/grade range	Results
Davidson (1991)	Noncompensatory decision making: failing to trade off, not taking all information (pro and con) into account	40 2nd-grade, 40 5th-grade, and 40 8th-grade children and adolescents	In searching for predecisional information, 2nd graders were exhaustive in their search for information, whereas older subjects' decision making involved the use of less demanding, noncompensatory strategies.
Davidson (1995)	Conjunction fallacy and the representativeness heuristic (see below): Probability judgments about conjunctive descriptions (elderly person <i>and</i> playing soccer) are biased by perceptions of representativeness	20 2nd-grade, 20 4th-grade, and 20 6th-grade children and adolescents	Older subjects were more likely to use information consistent with stereotypes about the story characters. Conjunction problems, concerning how likely elderly or young adults would be to engage in certain occupations or activities, showed subjects to be susceptible to the conjunction fallacy and the representativeness heuristic.
Jacobs & Potenza (1991)	Representativeness heuristic: Judgments of probability are based on stereotypes (biased beliefs applied to individuals seen as fitting the stereotype) rather than actual base rates or frequencies	66 1st-grade, 86 3rd-grade, and 82 6th-grade children and adolescents, and a comparison sample of 95 college students	Older subjects were more likely than younger ones to use stereotypes to make probability judgments rather than numerical information about base rates. When both stereotypical individuating and base-rate information was given, in the social domain, base-rate responses were chosen significantly less often with increasing age. Explanations based on perceived representativeness also increased in the social domain (but not in the object domain).
Klaczynski & Narasimham (1998)	Biconditional reasoning error: assuming "if A then B" implies "if B then A"	Study 1: 40 preadolescents (mean age = 10 years, 11 months), 40 middle adolescents (mean age = 14 years, 1 month), and 40 older adolescents (mean age = 17 years, 1 month). Study 2A: 56 college students (mean age = 22 years, 10 months). Study 2B: 64 college students (mean age = 19 years, 2 months)	Reasoning fallacies increased with age on problems containing causal conditional relations; the generation of plausible alternative antecedents is more difficult on causal than on permission conditional rules. Conditional (if-then) reasoning was used to solve permission problems, and biconditional reasoning was more typically used on causal problems. If the truth rules of conditional reasoning are imposed to evaluate performance, deductive-reasoning competence simultaneously increases (on permission problems) and declines (on causal problems) with age.
Markovits & Dumas (1999)	Transitivity error: treating relations such as "is a friend of" as though they were transitive like length	Study 1: 360 6- to 9-year-old children. Study 2: 114 7-, 9-, and 11-year-old children and adolescents	Transitive inferences using both a linear dimension (A is longer than B) and a nonlinear dimension (A and B are friends) were examined. Older subjects wrongly inferred that if A is a friend of B and B is a friend of C, then A is a friend of C. Younger children did not make that error.
Reyna & Ellis (1994)	Framing effect: choosing a sure option when outcomes are described as gains and a gamble option when the objectively identical outcomes are described as losses	28 preschoolers (mean age = 4 years, 8 months), 40 2nd-grade (mean age = 8 years, 0 months), and 43 5th-grade (mean age = 11 years, 1 month) children and adolescents	Older subjects were more likely to assimilate quantitative differences and show framing effects. Younger subjects responded to quantitative differences (i.e., in objective probabilities and magnitudes of outcomes), and did not exhibit framing effects (risk avoidance for gains, risk seeking for losses).

Barrera, 1993). Consistent with this view of affective motivators, low self-esteem, depression, sensation seeking, and thrill seeking are also correlated with adolescent risk taking, such as inconsistent condom use and reckless driving (e.g., Caffray & Schneider, 2000; Farley, 2001; Kotchick et al., 2001; Rolison &

Scherman, 2003; Smith, Gerrard, & Gibbons, 1997; Zuckerman, 1979).

Among these individual differences, sensation seeking has been one of the more extensively studied and strongly linked to risk taking (Brown, DiClemente, & Park, 1992; Crawford, Pentz,

Chou, Li, & Dwyer, 2003; Horvath & Zuckerman, 1993; Zuckerman, 1994). Sensation seeking is “a need for varied, novel, and complex sensations and experiences and the willingness to take physical and social risks for the sake of such experiences” (Zuckerman, 1979, p. 11). Although perceived risks and benefits account for significant variance in behavioral intentions for a range of risky behaviors (e.g., Parsons, Siegel, & Cousins, 1997), sensation seeking accounts for more variance in some studies than either of those predictors. For example, Rolison and Scherman (2002) administered the Risk Involvement and Perception Scales (RIPS), consisting of 19 risk behaviors—ranging from everyday behaviors to high-risk ones (e.g., smoking cigarettes, having sex without a condom, drinking alcohol, and use of illegal drugs)—to 171 adolescents. They found that sensation seeking was more strongly correlated with frequency of participation in risky behaviors than perceived risks or benefits were. Impulsivity, which we have discussed, can be distinguished from sensation seeking and explains additional variance in risk taking (Ainslie, 1992; Chambers & Potenza, 2003; Loewenstein & Elster, 1992; Zuckerman, 1994; Fig. 2).

Affective or emotional motivation has begun to receive increased attention in theories of risky decision making (Isen & Labroo, 2003; Loewenstein, 1996; Loewenstein, Weber, Hsee, & Welch, 2001; Mellers, 2000; Peters & Slovic, 2000; for an excellent overview, see Finucane, Peters, & Slovic, 2003). Loewenstein, Weber, Hsee, and Welch (2001), for example, distinguish between anticipated and anticipatory emotions. The former refers to how one is expected to feel as a result of a choice (similar to anticipated regret, discussed earlier). As we have noted, feelings can be treated as just another input to a cognitive equation—and Loewenstein et al. maintain that anticipated emotion is a cognitive exercise in trading off anticipated costs and benefits. Anticipatory emotions, by contrast, are “immediate, visceral reactions (e.g., fear, anxiety, dread) to risks and uncertainties” (p. 267), the experience of which is unlike computing costs and benefits. Anticipatory emotions, then, provoke what we have described as reactive (prototype/willingness model) or intuitive (fuzzy-trace theory) decision making, as opposed to reasoned decision making.

Loewenstein and colleagues’ work on the hot-cold empathy gap further illuminates how adults and adolescents make reactive, impulsive decisions in response to temporary drive states (Loewenstein, 1996). Loewenstein demonstrated that inducing a mild drive state, such as hunger, cold, or sexual arousal, causes dramatic shifts in risk-taking preferences and in moral compunctions (e.g., being more willing to agree that one would lie to obtain sex). Because decisions made in a hot state cannot be empathized with when in a cold state, and vice versa, reasoned instruction about costs and benefits is unlikely to affect subsequent decisions made in an emotionally aroused state. Furthermore, decision makers should have little insight into the factors that cause them to react impulsively, making it difficult to plan effective risk-reduction strategies.

Rather than engage in rational reflection, such risk taking can be reduced by self-binding—that is, by making decisions in a cold state that prevent the selection of unhealthy options in an aroused state. For example, adolescents might decide to never be alone with a member of the opposite sex, to never eat in a fast-food restaurant, to never attend unsupervised parties, or to never drink alcohol (because of its inhibition-lowering properties). In contemporary Western societies, these particular self-binding choices are rare but not unheard of. Self-binding involves preventing choices rather than learning to make good choices. Although there is no reason why adolescents might not attempt to do both—self-bind and make good choices—the research by Loewenstein et al. and others about affective motivators suggests that rational plans are unlikely to be followed under conditions common to adolescent risk taking (Gibbons et al., 1998). As minors, adolescents are also subject to other-binding, such as parental supervision and prohibition, but, short of incarceration, older adolescents may find ways around such strictures. Self-binding has the advantage of adolescent “buy-in” and thus self-monitoring.

So far, we have discussed affective motivation as an unhealthy influence on adolescent risky decision making. Based on the seminal work of Bechara, Damasio, Damasio, and Anderson (1994), many theorists are beginning to stress the healthy influences of affect (Finucane et al., 2003; Kahneman, 2003; Peters & Slovic, 2000; see also Isen & Labroo, 2003). Bechara et al. reported a series of striking experiments with patients who had damage to the prefrontal cortex and who maintained normal intellectual functioning but whose decision making was impaired (i.e., risky or imprudent) in their personal lives. In laboratory tasks, these patients demonstrated diminished emotional reactions and poor emotional regulation: When allowed to sample from four decks of cards with each draw producing wins and occasional losses (Fig. 8), they persisted in sampling from high-gain, high-risk decks with a negative overall expected value (i.e., overall, they would have net losses).

Bechara et al. (1994) argued that prefrontal damage produced insensitivity to future consequences (relative to people without this damage; see Fig. 2) because of an absence of anticipatory emotional responses (the somatic-marker hypothesis), despite awareness of which decks are better overall bets. The latter characterization resembles the behavior of adolescents (as confirmed by Crone & van der Molen, 2004; Hooper et al., 2004); and indeed, in a modification of the Bechara et al. task, children also did not easily learn to choose from the good decks (Garon & Moore, 2004; Kerr & Zelazo, 2004). Figure 9 illustrates such developmental changes in learning from experience from childhood through young adulthood. The younger the subjects, the more slowly bad-deck choice dropped as a function of amount of prior experience.

Other recent work has shown opposite risk preferences in experiential learning versus learning about outcomes and probabilities via verbal descriptions (Hertwig et al., 2004; We-

WIN	\$100	\$100	\$100	\$100	\$100	NET
LOSE	\$0	\$150	\$350	\$0	\$200	-\$200
WIN	\$100	\$100	\$100	\$100	\$100	NET
LOSE	\$0	\$0	\$700	\$0	\$0	-\$200
WIN	\$50	\$50	\$50	\$50	\$50	NET
LOSE	\$0	\$0	\$200	\$0	\$0	+\$50
WIN	\$50	\$50	\$50	\$50	\$50	NET
LOSE	\$25	\$0	\$50	\$75	\$50	+\$50

Fig. 8. Illustration of outcomes (i.e., wins and losses) for five cards from four decks in the Iowa Gambling Task (based on Bechara, Damasio, Damasio, & Anderson, 1994).

ber et al., 2004). The Bechara et al. card task (Fig. 8) is an experiential-learning task in which risks emerge as a result of card choices (outcomes are experienced as the cards are selected from one of four decks). A corresponding verbal description of the Bechara et al. card task, supposing for the sake of simplicity that one had only the middle two decks of cards to choose between, would be that one could, on each draw, choose between winning \$100 for sure and a one-in-five chance of losing \$700 (i.e., second row) and winning \$50 for sure and a one-in-five chance of losing \$200 (i.e., third row). (In experiential tasks, people learn about the magnitudes of outcomes and their probabilities by making choices and experiencing outcomes, whereas in verbal tasks, the probabilities and outcomes are simply described to them.) Specifically, people are much more willing to take risks in experiential tasks than in verbal tasks (choosing a risky option, such as taking a one-in-four chance of winning \$100, rather than choosing a sure thing, such as winning \$25 with certainty), apparently becoming inured to the possibility of bad outcomes when such outcomes have not happened recently. People are more discomfited by the possibility of loss or of winning nothing when a gamble is described verbally, but tolerate a possibility of loss or of winning nothing when outcomes of the same gamble are experienced. Failures to experience bad outcomes may instill similar complacency in real life. Note that, in Bechara et al.’s study, an artificial card task administered in the laboratory predicted which people were more likely to engage in unhealthy risk taking in real life; this predictive validity holds for many other so-called artificial tasks that tap real psychological factors (see Yechiam et al., 2005).⁶ The work of Slovic, Peters, Finucane, and colleagues also illustrates how models of emotion and risk taking can be tested under both laboratory and applied circumstances, with converging results (e.g., Slovic, Finucane, Peters, & MacGregor, 2004).

⁶The Bechara task, also known as the Iowa Gambling Task, is far from a perfect predictor of real-life difficulty with decision making, although people with problem behaviors (e.g., addiction, gambling) have been shown to differ from controls. In addition, risk taking and impairment in decision making are not synonymous (Bechara, Damasio, & Damasio, 2000).

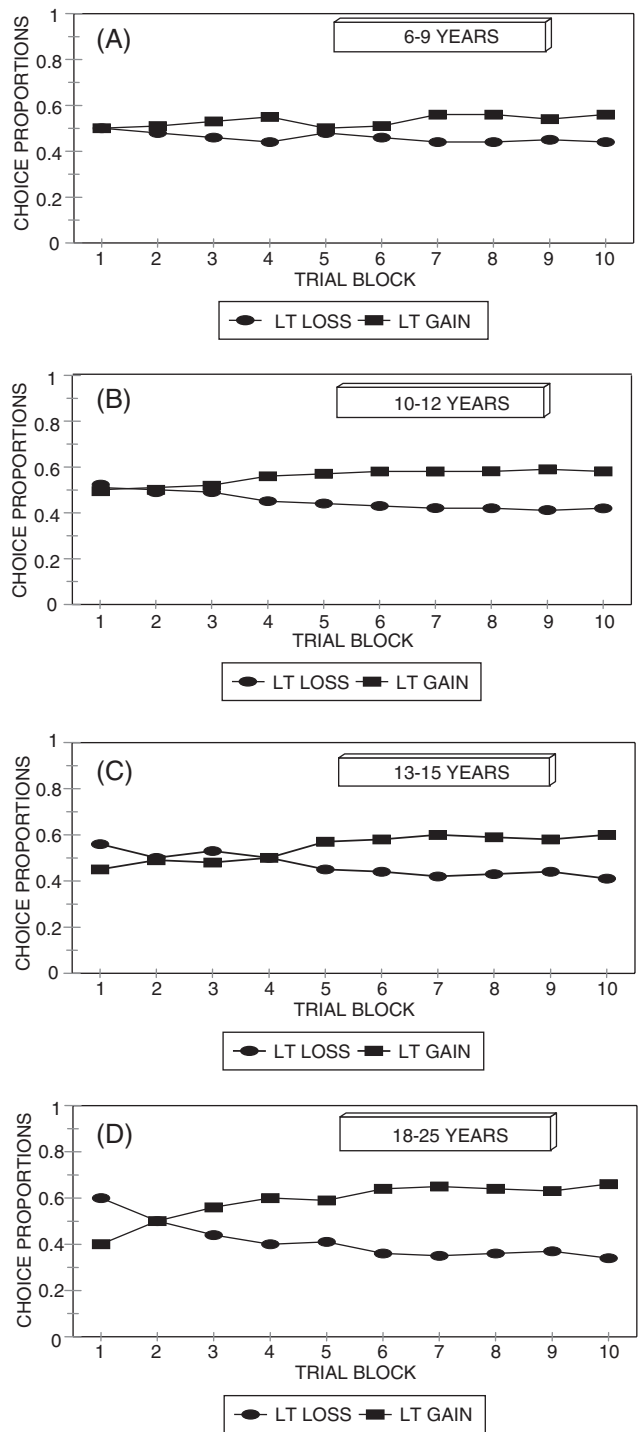


Fig. 9. Proportion of participants choosing decks that yield long-term (LT) gains versus those yielding LT losses, across ten blocks of learning trials in the Iowa Gambling Task for 6- to 9-year-olds (panel A), 10- to 12-year-olds (panel B), 13- to 15-year-olds (panel C), and 18- to 25-year-olds (panel D; based on Crone & van der Molen, 2004).

Thus, there are two contemporary views of the effect of emotion on risky decision making: first, that emotion clouds judgment and increases susceptibility to temptation; and second, that it provides an adaptive cue that allows people to learn from the consequences—the rewards and punishments—that follow

their actions. Both of these perspectives on emotion differ from traditional decision-analysis approaches in emphasizing the importance of emotion—whether it is germane to resisting immediate pleasure or to anticipating future pain. The behavioral decision-making perspective has been expanded to encompass social and emotional evaluations of risk taking as legitimate precursors of rational choices. There is a growing consensus that the inability to connect consequent emotions to antecedent choices can produce debilitating social problems (such as those observed in Bechara et al.'s patients, substance abusers, and other groups), including self-destructive risk taking.

Explanatory models of individual differences in risk-taking propensity have long emphasized the importance of physiological (e.g., arousal) and genetic underpinnings, especially in such personality traits as sensation, thrill, or novelty seeking (e.g., Cloninger, Svrakic, & Przybeck, 1993; Eysenck, 1967; Farley, 2001; Zuckerman, 1979). The pace of research on physiological and genetic approaches has quickened, however, because of the development of new techniques and methodologies. The integration of behavioral genetics, neurophysiology, neuroimaging, and animal models is an exciting frontier in the effort to improve explanatory models of risk-taking propensity in adolescence (e.g., Cardinal & Howes, 2005; Moffitt, 2005; Steinberg & Morris, 2001; for an overview, see Dahl & Spear, 2004).

Because these areas are so new, particularly as applied to adolescence, empirical generalizations must be qualified and are subject to flux. For example, challenges to the association between dopamine receptor D4 (DRD4) gene polymorphism and novelty seeking were quickly followed by a study producing evidence for this association but showing that it was moderated by sociodemographic characteristics (Lahti et al., 2006). Although the debate about DRD4 is not over, the theme of gene–environment interaction has been echoed in other research on relations between genetics and temperament in risk taking (e.g., see Moffitt, 2005; Steinberg et al., 2004). These subtle, inter-

active effects underscore the importance of adapting environments (e.g., schools; Farley, 2001) to accommodate different temperaments. Although we have stressed the unhealthy side of risk taking in adolescence, there is, for sensation, thrill, or novelty seekers, a potential upside to risk—provided that environmental factors are conducive. A fortuitous combination of person and environment can yield creative artists, scientists, or entrepreneurs who eschew conventional approaches and relish risky challenges with large positive potential for society as well as for themselves (Farley, 2001). As we have discussed, a person–environment mismatch, however, can result in substance use, unsafe sex, reckless driving, and other attempts to increase stimulation.

Despite overall developmental trends toward lowered risk taking after adolescence, a minority of individuals continue to take unhealthy risks in adulthood, as in life-course-persistent (as opposed to adolescence-limited) antisocial behavior (Moffitt,

1993, 2003). Antisocial behavior that appears initially in adolescence has been linked to effects of the environment, whereas life-course-persistent criminality shows a moderate genetic influence (Zuckerman, 2002). These extreme and persistent risk takers contribute disproportionately to the societal burden of unhealthy risk taking. Comprehensive prevention and intervention programs that encompass the most extreme risk takers await novel integration of the explanatory approaches we have discussed. For extreme thrill seekers, the usual behavioral equation is confounded because the risks *are* the benefits (i.e., the thrill of taking risks is a reward in itself).

KEY FINDINGS: DESCRIPTION

Explanatory models predict that the perception of risks (e.g., vulnerability in the health-beliefs model), benefits (e.g., affective motivators in reactive models), or both (e.g., beliefs about the probabilities of outcomes and their subjective utilities or values in the behavioral decision-making framework) should determine adolescent risk-taking behaviors. It has generally been assumed—and we present pertinent data later—that adolescents' risk perceptions are distorted. If adolescents perceive risks to be sufficiently high, then, according to rational models, they should not take those risks. Thus, one remedy for risk taking is to assess risk perception and, if subjective risk is too low, provide information that brings perceptions into line with objective reality.

Distortions in risk perceptions can be examined in at least three ways: (a) Adolescents' perceptions of their own risks can be compared to their perceptions of peers' risks, (b) adolescents' perceptions of their own risks can be compared to adults' perceptions, and (c) adolescents' perceptions of risks can be compared to published estimates of objective risks. Specifically, with respect to the first type of comparison, adolescents can be asked to estimate their own risk relative to the risk of peers, acquaintances, or other adolescents. Across studies of this sort, the risk being estimated has ranged from the possibility of unspecified harm to the probability of dying from lung cancer if one smokes for 30 to 40 years. A common method in evaluating risk perceptions is to use a rating scale (e.g., -3 to $+3$) for which the midpoint (0) is labeled as “average” risk, negative numbers (e.g., -3) represent less risk than average, and positive numbers (e.g., $+3$) represent more risk than average. Adolescents who view themselves, on average, as at less risk than average exhibit a Lake Wobegon effect (i.e., “where all the children are above average”) or, more technically, an *optimistic bias*. This phenomenon of optimistic bias was originally found with adults, and has since been replicated across many health domains (e.g., Rothman, Klein, & Weinstein, 1996; Weinstein, 1980, 1982, 1989).

Although optimistic bias is not invariably found for adolescents, many studies have documented a tendency for them to see their own vulnerability as lower than that of comparable others