

Risk and Rationality in Adolescent Decision Making

Implications for Theory, Practice, and Public Policy

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SUMMARY—*Crime, smoking, drug use, alcoholism, reckless driving, and many other unhealthy patterns of behavior that play out over a lifetime often debut during adolescence. Avoiding risks or buying time can set a different lifetime pattern. Changing unhealthy behaviors in adolescence would have a broad impact on society, reducing the burdens of disease, injury, human suffering, and associated economic costs. Any program designed to prevent or change such risky behaviors should be founded on a clear idea of what is normative (what behaviors, ideally, should the program foster?), descriptive (how are adolescents making decisions in the absence of the program?), and prescriptive (which practices can realistically move adolescent decisions closer to the normative ideal?). Normatively, decision processes should be evaluated for coherence (is the thinking process nonsensical, illogical, or self-contradictory?) and correspondence (are the outcomes of the decisions positive?). Behaviors that promote positive physical and mental health outcomes in modern society can be at odds with those selected for by evolution (e.g., early procreation). Healthy behaviors may also conflict with a decision maker's goals. Adolescents' goals are more likely to maximize immediate pleasure, and strict decision analysis implies that many kinds of unhealthy behavior, such as drinking and drug use, could be deemed rational. However, based on data showing developmental changes in goals, it is important for policy to promote positive long-term outcomes rather than adolescents' short-term goals. Developmental data also suggest that greater risk aversion is generally adaptive, and that decision processes that support this aversion are more advanced than those that support risk taking.*

A key question is whether adolescents are developmentally competent to make decisions about risks. In principle, barring temptations with high rewards and individual differences that reduce self-control (i.e., under ideal conditions), adolescents are capable of rational decision making to achieve their goals. In practice, much depends on the particular situation in which a decision is made. In the heat of passion, in the presence of peers, on the spur of the moment, in unfamiliar situations, when trading off risks and benefits favors bad long-term outcomes, and when behavioral inhibition is required for good outcomes, adolescents are likely to reason more poorly than adults do. Brain maturation in adolescence is incomplete. Impulsivity, sensation seeking, thrill seeking, depression, and other individual differences also contribute to risk taking that resists standard risk-reduction interventions, although some conditions such as depression can be effectively treated with other approaches.

Major explanatory models of risky decision making can be roughly divided into (a) those, including health-belief models and the theory of planned behavior, that adhere to a "rational" behavioral decision-making framework that stresses deliberate, quantitative trading off of risks and benefits; and (b) those that emphasize nondeliberative reaction to the perceived gists or prototypes in the immediate decision environment. (A gist is a fuzzy mental representation of the general meaning of information or experience; a prototype is a mental representation of a standard or typical example of a category.) Although perceived risks and especially benefits predict behavioral intentions and risk-taking behavior, behavioral willingness is an even better predictor of susceptibility to risk taking—and has unique explanatory power—because adolescents are willing to do riskier things than they either intend or expect to do. Dual-process models, such as the prototype/willingness model and fuzzy-trace theory, identify two divergent paths to risk taking: a reasoned and a reactive route. Such

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models explain apparent contradictions in the literature, including different causes of risk taking for different individuals. Interventions to reduce risk taking must take into account the different causes of such behavior if they are to be effective. Longitudinal and experimental research are needed to disentangle opposing causal processes—particularly, those that produce positive versus negative relations between risk perceptions and behaviors.

Counterintuitive findings that must be accommodated by any adequate theory of risk taking include the following: (a) Despite conventional wisdom, adolescents do not perceive themselves to be invulnerable, and perceived vulnerability declines with increasing age; (b) although the object of many interventions is to enhance the accuracy of risk perceptions, adolescents typically overestimate important risks, such as HIV and lung cancer; (c) despite increasing competence in reasoning, some biases in judgment and decision making grow with age, producing more “irrational” violations of coherence among adults than among adolescents and younger children. The latter occurs because of a known developmental increase in gist processing with age. One implication of these findings is that traditional interventions stressing accurate risk perceptions are apt to be ineffective or backfire because young people already feel vulnerable and overestimate their risk. In addition, research shows that experience is not a good teacher for children and younger adolescents, because they tend to learn little from negative outcomes (favoring the use of effective deterrents, such as monitoring and supervision), although learning from experience improves considerably with age. Experience in the absence of negative consequences may increase feelings of invulnerability and thus explain the decrease in risk perceptions from early to late adolescence, as exploration increases. Finally, novel interventions that discourage deliberate weighing of risks and benefits by adolescents may ultimately prove more effective and enduring. Mature adults apparently resist taking risks not out of any conscious deliberation or choice, but because they intuitively grasp the gists of risky situations, retrieve appropriate risk-avoidant values, and never proceed down the slippery slope of actually contemplating tradeoffs between risks and benefits.

INTRODUCTION

In this monograph, we review scientific evidence concerning the causes and remediation of unhealthy risk taking in adolescence. Adolescent risk taking has economic, psychological, and health implications (e.g., Maynard, 1997). Smoking, drug use, unprotected sex, and unsafe driving take demonstrable tolls in healthcare costs and property damage, as well as less readily

measured costs in human misery and lost potential. Habits begun at this age can last a lifetime. Table 1 shows one set of prevalence measures for adolescents. Opinions about proper solutions to the problem of unhealthy adolescent risk taking are plentiful, ranging from abstinence education to higher legal drinking ages. However, the public and policymakers rarely make use of the scientific literature on risky decision making in adolescence, and, as in many areas of human behavior, prevention and intervention programs are generally not based on such evidence.

Those seeking a comprehensive view of the evidence (and not just the bits supporting one’s own favored position) need to cast a wide net. One of the barriers to more comprehensive use of the scientific literature is the fragmentation of research. Relevant studies are scattered across disciplines (e.g., psychology, sociology, pediatrics, public health) and problem-specific professional communities (e.g., smoking, AIDS prevention, alcohol and substance abuse) whose members attend specialized conferences and read specialized journals, and who are sometimes isolated further by adherence to specific research paradigms or treatment modalities. To be sure, specialization is necessary if scholars are to apprehend the vast amount of research within particular problem domains. For example, the biochemistry of smoking and alcohol are each complex enough to justify separate expertise. The effects of alcohol on brain development and on psychomotor skills (e.g., driving) are themselves different enough to direct scholars and practitioners to separate conferences and publications.

However, fragmentation exacts a price. Relevant work is published that escapes notice in closely related domains (e.g., smoking versus alcohol use) and explanatory models found useful in one domain are not necessarily considered in other domains. There is also the problem of reinventing the wheel. For example, Dawes and Corrigan (1974; Dawes, 1979) found that many competing models of decision-making processes were inherently indistinguishable because of their shared statistical properties.¹ Additionally, the commonalities among laboratory and “real world” tasks argued to reflect risk taking need to be identified and limits of commonality or generalizability established. Risk taking in a laboratory task involving minor symbolic risks may have little to do with the risk taking of a carload of drunk adolescents on the interstate on a Friday night (Farley, 1996). Hence, a cross-cutting analysis is urgently needed to identify the findings and explanatory models that generalize across domains, as well as the domain-specific limits to generalization.

To address this need, we examine one topic that generalizes across domains: the optimality of adolescents’ decisions about

¹ Attempts to reconcile the weights afforded to various factors in different studies were doomed to failure, because they reflected uninteresting measurement issues. In fact, Dawes’s conclusion was an inductive rediscovery of principles derived deductively by Wilks (1937), in an even more general look at the properties of linear models.

TABLE 1

Percentages of Youth in 9th Through 12th Grades Engaging in Various Risk and Risk-Preventive Behaviors, From National Youth Risk Behavior Survey (1991–2003)

Behavior	Data							Change: '91–'03	Change: '01–'03
	1991	1993	1995	1997	1999	2001	2003		
Seatbelts ^a	25.9	19.1	21.7	19.3	16.4	14.1	18.2	Decrease	None
Drinking driver ^b	39.9	35.3	38.8	36.6	33.1	30.7	30.2	Decrease	None
Carried weapon ^c	26.1	22.1	20.0	18.3	17.3	17.4	17.1	Decrease	None
Fighting ^d	42.5	41.8	38.7	36.6	35.7	33.2	33.0	Decrease	None
Suicide attempt ^e	7.3	8.6	8.7	7.7	8.3	8.8	8.5	None	None
Cigarette use ^f	27.5	30.5	34.8	36.4	34.8	28.5	21.9	Decrease	Decrease
Smokeless tobacco ^g	NA	NA	11.4	9.3	7.8	8.3	6.7	Decrease	None
Alcohol use ^h	50.8	48.0	51.6	50.8	50.0	47.1	44.9	Decrease	None
Marijuana use ⁱ	14.7	17.7	25.3	26.2	26.7	23.9	22.4	Increase	None
Cocaine use ^j	1.7	1.9	3.1	3.3	4.0	4.2	4.1	Increase	None
Sexual intercourse ^k	54.1	53.0	53.1	48.4	49.9	45.6	46.7	Decrease	None
Condom use ^l	46.2	52.8	54.4	56.8	58.0	57.9	63.0	Increase	Increase
Exercise ^m	NA	65.8	63.7	63.8	64.7	64.6	62.6	None	None
Physical education ⁿ	41.6	34.3	25.4	27.4	29.1	32.2	28.4	Decrease	None
Overweight ^o	NA	NA	NA	NA	10.8	10.5	12.1	None	None

Note. The data are from Centers for Disease Control and Prevention (2004).

^aRarely wore seatbelts while riding in a car driven by someone else

^bRode in a car with a driver who has been drinking alcohol during the past 30 days

^cCarried a gun, knife, or club at least once during the past 30 days

^dWas in a physical fight at least once during the past 12 months

^eAttempted suicide at least once during the past 12 months

^fSmoked cigarettes on at least 1 day during the past 30 days

^gUsed chewing tobacco, snuff, or dip on at least 1 day during the past 30 days

^hDrank alcohol on at least 1 day during the past 30 days

ⁱUsed marijuana on at least 1 day during the past 30 days

^jUsed cocaine on at least 1 day during the past 30 days

^kHas had sexual intercourse at least once

^lUsed condoms during sexual intercourse

^mParticipated in vigorous physical exercise for at least 20 minutes on at least 3 of the past 7 days

ⁿAttends physical education class daily

^oIs above the 95th percentile for the body mass index, by age and sex norms

risky behaviors. We consider both the processes involved and the performance levels that adolescents achieve—and could achieve, with possible interventions. Knowing those levels is critical to creating sound policies concerning such issues as drinking age and adolescents' culpability for crimes, informed consent for medical procedures, and responsiveness to AIDS-prevention curricula. We recognize that adolescents' choices reflect the interaction of general skills and specific situational demands, which together determine the bounds of rationality in adolescence. Thus, in this article, we discuss the mounting evidence about adolescent rationality and the implications of this evidence for problem behaviors.

Owing to the voluminous and fragmented nature of the literature, our review is not the conventional sort in which every article fitting some set of inclusion criteria is examined, effect sizes are calculated, and a single question (say, about effectiveness of pregnancy-prevention curricula) is asked and answered. Although we undertook such a conventional review before writing this paper, to ensure that our judgments are firmly grounded in current work, space does not permit us to discuss or even to

mention every scientific article on adolescent risk taking. Instead, our aim is to provide a solid, empirically grounded framework for understanding adolescent risk taking and determining what it would take to reduce or eliminate unhealthy behaviors.

Many unanswered questions concerning the nature of adaptive behavior, healthy risk taking, and rational decision making in adolescence remain. Notwithstanding the limitations of current knowledge, however, scientists have learned a great deal that can be useful today. Extant data identify successful practices (e.g., effective curricula for reducing risk taking) and promising practices that have yet to be studied systematically. Existing data also demonstrate that some common beliefs, such as the belief that adolescents feel uniquely invulnerable, are myths. Questions that are addressed by current data include the following, which provide an outline for the remainder of this review:

- Why is adolescent risky decision making important?
- What is rational, adaptive, or good decision making for adolescents?
- What are the main explanatory models of adolescent risk taking?

- What are the key data—more particularly, the data that illuminate prediction, explanation, and intervention?
- What are some key implications of current findings for different approaches to risk reduction and avoidance?

BACKGROUND AND PERSPECTIVES

The intended audience for this monograph is anyone who wants to become acquainted with current scientific evidence concerning the causes and remediation of unhealthy risk taking in adolescence, including those for whom policy, practice, or prevention is the main motivation. A narrated list of findings, however, would be insufficient to address this topic. The first and most fundamental question is how to know what unhealthy risk taking is. The answer may seem obvious, but noted scholars have disagreed vehemently about this issue. So before we examine the issue in depth, we give the reader a sense of why the answer is not obvious and how the answer shapes thinking about unhealthy risk taking and its remedies. We then explain why evidence-based theories of risky decision making cannot be ignored if we wish to understand and apply the findings regarding adolescent risky decision making to improve lives. In short, if the goal is to change behavior in a positive direction, it is crucial to know more than a list of findings about risky adolescent decision making: It is crucial to know what the desired endpoint (“positive change”) is and how to measure it, and to know which explanations of behavior are likely to be true, based on the evidence. Thus, we review specific theories of behavior change and decision making because, in our view, these theories offer the best account of the evidence to date. “Theories,” in this usage of that term, are summaries and explanations of evidence, not speculations or philosophical arguments.

How can we know what unhealthy risk taking is? Although perspectives on how to tell if decision making is good or bad differ, each one captures important aspects of the data. Ultimately, we include both of the major schools of thought (coherence and correspondence) in our criteria for rational decision making, but others might justifiably side with one view rather than another (we present our arguments in depth later).

Traditional theories of rational decision making indicate that either risk taking or risk aversion can be rational, as long as the decision process is coherent (i.e., internally consistent). Traditional decision-making theorists do not make judgments about what people believe, and they would characterize many of the behaviors that society might wish to discourage among adolescents as “rational.” Although some might disagree with these conclusions about rationality, traditional theories point up factors that have been shown to influence risk-taking behavior in adolescence and, if the theories are true, they identify which policies and practices are likely to be effective in reducing risk taking (although new theories, discussed below, suggest that reducing unhealthy risk taking requires more than rational

reasoning skills). Traditional theories distinguish rational decision processes from good outcomes because outcomes are determined by many factors outside of the decision process. Someone cannot be described as engaging in unhealthy risk taking if there is no rational basis to predict that, for unforeseeable reasons, the outcome will turn out to be bad.

Critics of traditional theories disagree that outcomes are irrelevant to judging the quality of decision making and, on the contrary, disparage coherence of decision processes as a criterion of rationality. In this correspondence view, good outcomes signal good decision making. Correspondence refers to correspondence to reality, which outcomes reflect. Although this view has superficial appeal, there are numerous documented examples of decision makers who enjoyed good outcomes by accident (having made clear mistakes in judgment) and vice versa. The adolescent who has unprotected sex numerous times without getting pregnant could argue, in this view, that her behavior is perfectly rational because she has avoided an undesirable outcome. Clearly, the correspondence view has shortcomings that are not apparent at first blush.

Some evolutionary theorists have also criticized traditional coherence approaches to rationality, arguing that violations of logic or probability or other rules of coherence are apparent rather than real and that evolution gives human decision makers “simple heuristics that make us smart” (Gigerenzer, Todd, & the ABC Group, 1999). However, these simple gut-level decisions that are encouraged by evolution appear to make people stupid in the modern world under predictable circumstances, and they encourage unhealthy risk taking rather than discourage it. (Naturally, such behaviors may have been adaptive at an earlier point in evolutionary history.) The realm of adolescent decision making, therefore, provides a counterexample to the general claim made by some evolutionary theorists that the smart choices in one’s work or personal life are those selected for by evolution. It is useful for prevention and intervention efforts to acknowledge that adolescents may have to resist evolutionary pressures that promote consuming substances that offer immediate pleasure or having sex before they are prepared for its economic and psychological consequences.

We do not claim that evolutionary theories are irrelevant, and we cite several books for further reading in this area, such as those by Baumeister (2005); Geary (2005); and Gigerenzer, Todd, and the ABC Group (1999). Evolutionary theory, and the construct of adaptive behavior, is central to understanding rationality in the correspondence sense (i.e., which decision processes and behaviors promote positive long-term outcomes). However, evolutionary claims that are made on the basis of philosophical arguments, mathematical proofs not involving observables, and hypothetical computer simulations should be sharply distinguished from claims that have been tested empirically. If the policy recommendations of social scientists are to be taken seriously, it is necessary to retain scientific credibility by sticking to empirical evidence and to theories that

are grounded in empirical evidence. In order to be ready for consideration at the level of policy, promising evolutionary theories should be subjected to the same kinds of empirical tests as the core theories that we discuss below.

Whichever view of rationality one takes (traditional coherence, correspondence, or, at some future point when more data are gathered, evolutionary), it is essential to consider the developmental differences between adolescents and adults when judging their behavior. The traditional coherence view emphasizes the centrality of making choices that allow the decision maker to reach his or her own goals. As we discuss, evidence on developmental differences raises the specter that goals change with age, and the issue is then which goals (adolescents' current goals or their inferred future goals) to consider in judging rationality. If rationality also demands (as it must in traditional views) that decision processes be logical, then it also makes sense to ask whether adolescents are capable of thinking logically. We briefly review the data on that issue as well. Other developmental differences relevant to judging rationality, including impulsivity, are also reviewed.

Laboratory data on developmental differences in probability judgment and in decision making—for example, involving choosing between sure things and gambles—are also relevant to the kinds of psychological competence that underlie risk-taking behavior. The developmental questions are: What do children (and, subsequently, adolescents) know and when do they know it? On the one hand, laboratory studies have shown that young children trade off the probability of winning a prize and the number of prizes to be won (essentially multiplying the odds of winning by the amount to be won, and choosing accordingly; e.g., Reyna & Ellis, 1994). On the other hand, analogous studies of probability judgment and choice in adults have been the source of numerous illustrations of cognitive illusions—namely, adults ignoring objective information about probabilities and outcomes and instead basing their responses on illusory stereotypes or superficial wording of decision scenarios (e.g., Gilovich, Griffin, & Kahneman, 2002). However, this seeming contradiction between early analytic competence and late-persisting cognitive illusions can be explained by modern developmental theories (e.g., fuzzy-trace theory) that predict exactly these kinds of paradoxical patterns.

The theories that we review are older ones that have amassed the most definitive evidence about causal factors in risky decision making, and newer ones that enjoy the advantage of building on the discoveries of the pre-existing models, thus being able to improve on their predictions. We should add that all of the models we review, including the older models, should be considered currently relevant and that, although the data favor newer models, those data are far from extensive at this point. Traditional models are those that essentially adhere to the behavioral decision framework, which would include such rational deliberative approaches as health-belief models, the theory of reasoned action, the theory of planned behavior,

problem-solving approaches, and other similar theories including some with less evidence (that we, therefore, do not discuss). Concepts that figure in such models include perceived risks and benefits, social norms (beliefs about other people, such as whether one's parents approve of underage drinking or whether peers are engaging in sex), self-efficacy (beliefs about being competent in a specific domain or skill, such as being capable of standing up to pressure to have sex), perceived control, and behavioral intention. Newer models of adolescent risky decision making include the prototype/willingness model and fuzzy-trace theory. In these models, risk taking is determined by mental representations of risk takers (e.g., smokers) or risky situations (e.g., a couple alone in a hotel room on prom night), along with other factors such as willingness (as opposed to intention, in the prototype/willingness model) and situation-dependent retrieval of risk-avoidant values (in fuzzy-trace theory). These traditional and newer models aim to describe and explain real behavior. However, they also typically incorporate assumptions about what constitutes ideal behavior, and thus provide a goal for prescriptive interventions to improve decision making.

In each of these models, perception of risks plays an important role (although how people think about risk is construed very differently across models). There are different ways to assess risk perception that seem to yield different conclusions, but those conclusions are actually compatible. A concrete example may be helpful: Imagine an adolescent who has sex without a condom and who *overestimates* the risk of contracting a sexually transmitted disease but *overestimates* his own risk *less* than he does that of comparable others (e.g., other adolescents who have sex without condoms)—an optimistic bias. Furthermore, imagine that this adolescent rates his own risk of getting a sexually transmitted disease as higher than adolescents who use a condom rate their own risk and as higher than adults rate their own risk (regardless of whether they use a condom or not). (Conditional assessments, such as estimating the risk of acquiring sexually transmitted diseases if one has sex without a condom, do not change the result that adolescents rate themselves as more vulnerable than adults rate themselves.) As is apparent from this example, these comparisons suggest different messages about perceived vulnerability if taken in isolation from one another, but they are not mutually exclusive. This adolescent overestimates the level of objective risk, displays an optimistic bias relative to others, and yet acknowledges that he is at higher risk than adults and adolescents not engaging in specific risk-taking behaviors. Based on the literature, we can say that this adolescent is typical, as these results tend to be found consistently (except with respect to comparisons between lower-risk and higher-risk adolescents, which have produced variable results).

To preview our later discussion, the key descriptive findings regarding adolescents' perception of risks are these: Much like adults, most adolescents exhibit an optimistic bias, in which

they view their own risks as less than those of comparable peers. However, objectively higher-risk groups sometimes estimate their risk as higher, and sometimes as lower, than lower-risk groups rate themselves. For example, Johnson, McCaul, and Klein (2002) found that adolescents who were daily smokers and those engaged in unprotected sex estimated their risk of getting lung cancer or a sexually transmitted disease, respectively, as significantly higher than others not engaging in those behaviors did. Some studies confirm this pattern; other studies report no difference or lower perceived risks among those engaging in risk-taking behavior. As we discuss, measures matter; how the question about risk is asked makes a difference (Fishbein, 2003). The role of experienced outcomes may also explain these variable findings (experiencing negative outcomes may increase risk estimates and failing to experience negative outcomes may do the opposite), but preliminary evidence on this point is meager.

A consistent finding that emerges from this literature, and one that has been replicated in different laboratories, is that the optimistic bias is no more prevalent in adolescents than it is in adults, and, indeed, adolescents perceive themselves as more vulnerable than adults perceive themselves to be. In addition, when subjective and objective estimates of risk can be compared, adolescents tend to overestimate important risks (e.g., of HIV infection or lung cancer), although they may underestimate harmful consequences and long-term effects, such as addiction. They think that the risk is high, but the consequences are not that bad. (Not all risks are overestimated; unfamiliar risks that are not covered in health curricula, such as the risk of food poisoning, might well be underestimated.) Another consistent finding is that, when they are directly compared, benefits loom larger than risks. That is, perceived benefits predict risk-taking behavior and often carry more weight than perceived risks do. Thus, despite overestimation of risks, perceived benefits may drive adolescents' reactive behaviors and behavioral intentions, explaining why adolescents who perceive risks to be high would still take those risks. Nevertheless, constructs such as perceived risks and benefits do not explain all risk taking for all adolescents; there is variance in risk-taking behaviors that is not accounted for by traditional models.

The bottom line of the data concerning extant models is that the older models of deliberative decision making (resulting in behavioral intentions and planned behaviors) fail to account for a substantial amount of adolescent risk taking, which is spontaneous, reactive, and impulsive. This conclusion about gaps in older models holds even when higher methodological standards, such as conditional risk assessments (e.g., estimating the risk of acquiring sexually transmitted diseases if one has sex without a condom) and prospective designs that control for initial perceptions and behavior, are used in research (see Brewer, Weinstein, Cuite, & Herrington, 2004; Gerrard, Gibbons, Benthin, & Hessling, 1996; Weinstein & Nicolich, 1993; and Weinstein, Rothman, & Nicolich, 1998, for details concerning

design and methodology). To be sure, methodological improvements have resulted in improved support for traditional models, yielding, for example, stronger and more consistent relations between perceived risk and behavior (e.g., Brewer et al., in press; Fishbein, 2003). However, almost all of the patterns of findings we discuss that pertain to adolescents remain robust despite these methodological modifications.

We do not conclude that traditional models are worthless. On the contrary, there is ample evidence favoring such models and, simultaneously, evidence indicating that they have important gaps. We resolve this dilemma by acknowledging, based on the data, that adolescents apparently make decisions in different ways—namely, deliberately, reactively, and intuitively. Deliberate decision making is explained by traditional models; reactive decision making is explained by the prototype/willingness model; and fuzzy-trace theory explains intuitive decision making, contrasting gist-based intuition to avoid risk with deliberation that encourages risk taking. (A gist is a fuzzy mental representation of the general meaning of information or experience, and gist-based intuition is reasoning or decision making based on these fuzzy representations.) As we discuss in some detail, ideas about emotion (as temptation and as a healthy cue) and personal experience with risks are being increasingly incorporated into contemporary theories, including traditional behavioral decision-making approaches.

We have mentioned decisions that result from deliberation, reaction, and intuition, but one might also ask about decisions that come about through imitation, habit, social conventions, and social heuristics (see Nisbett & Ross, 1980, for an excellent discussion of some of these classic issues). These social factors are reflected in perceived social norms, images or prototypes, perceived benefits, and other constructs that we have reviewed, and, thus, they are indirectly represented to some extent in the theoretical approaches that we discuss. For example, adolescents might follow a social heuristic to “do what the majority does,” which would be reflected in perceived social norms (beliefs about what the majority does) and perceived benefits (the belief that doing what the majority does ensures being accepted by one's peer group, a social benefit). One might imagine that responding to these social factors could be reactive (going along with the majority without thinking) or deliberative (calculating that one would pay too high a price socially by opposing the majority). Habits are also, again indirectly, related to decision making in standard dual-process theories, as they reflect the operation of an evolutionarily older, associative system (Kahneman, 2003; Sloman, 2002). However, although much evidence supports the effects of imitation, habits, and social conventions on behavior, the connections between these effects and constructs in decision theories of adolescent risk taking have yet to be fully elaborated. Therefore, we do not discuss these factors further, except to acknowledge that habits (and addictions) established in adolescence can perpetuate behaviors that older decision makers would not have initiated. We do

discuss the role of social payoffs and other rationalizations for adolescent risk taking in the context of theories of rationality. As we explain later, merely asserting that risk taking has social benefits (e.g., peer acceptance) does not necessarily justify such behavior nor does it prove that the behavior is rational.

Thus, the sections that follow begin with a discussion of the importance of the topic—why adolescent risky decision making is important and what problems it causes for individuals and society. Then, we turn to the kinds of behavioral change we should hope to achieve to address such problems, by discussing what is rational, adaptive, or good decision making for adolescents. With this ideal of good decision making in mind, we then discuss the main explanatory models of actual adolescent risk taking and the data that bear on major constructs of these models, such as how adolescents perceive risk (e.g., the myth of invulnerability) and what changes in risky decision making occur with development, as adolescents mature and gain experience in the world. In our concluding section, we draw out some key implications of current findings for different approaches to risk reduction and avoidance.

SIGNIFICANCE OF THE PROBLEM

Why Is Adolescent Risky Decision Making Important?

The scientific literature confirms the commonsense belief that adolescence is a period of inordinate risk taking. For example, three million new cases of sexually transmitted infections are identified in adolescents every year in the United States, and more than half of all new cases of HIV infection occur in people younger than 25 (Centers for Disease Control and Prevention, 2004). Moreover, adolescents have one of the most rapidly increasing rates of HIV infection (e.g., 37% more young people were living with AIDS in 2003 than in 1999), with an average of two new young people in the United States infected with HIV every hour (Centers for Disease Control and Prevention, 2004; Rosenberg, Biggar, & Goedert, 1994). Substance use also typically begins in adolescence, as do its adverse health consequences, such as the risky sexual and driving behavior associated with alcohol use (Bachanas et al., 2002; Fergusson & Lynskey, 1996; Strunin & Hingson, 1992; Tapert, Aarons, Sedlar, & Brown, 2001). Motor-vehicle accidents are the leading cause of deaths among those aged 15 to 20 years; 31% of young drivers killed in motor-vehicle crashes in 2003 had been drinking (National Center for Statistics and Analysis, 2003; Turner & McClure, 2003). Although Table 1 indicates decreasing prevalence rates for risky behaviors through 2003, it also shows that progress has recently stalled, that rates remain unacceptably high, and that some behaviors continue to increase (Fig. 1).

Apart from the immediate consequences of risky behaviors, adolescents' risk behaviors also strongly predict health problems in adulthood (U.S. Department of Health and Human Services, 1994). Behaviors that were begun as voluntary choices

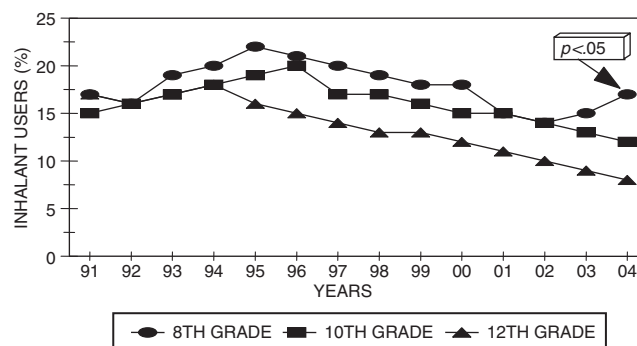


Fig. 1. Percentage of 8th, 10th, and 12th graders reporting lifetime use of inhalants from 1991 to 2004, showing significant increase among 8th graders (based on Johnston, O'Malley, Bachman, & Schulenberg, 2004).

to experiment can be perpetuated by addiction (Slovic, 2000, 2001). Although most drinkers do not progress to deep alcoholism, virtually all alcoholics started drinking in adolescence (Bonnie & O'Connell, 2004; Chambers, Taylor, & Potenza, 2003; Vaillant, 2003; Vaillant & Hiller-Sturmhöfel, 1996; see Table 2 for data pinpointing adolescence as a period of initial vulnerability to multiple risks). Prevention at the time when use is still a matter of deliberate choice is more successful and less costly and, thus, better for adolescents and for society, than dealing with an established addiction later. Delaying the onset of drinking and reducing the amount consumed decrease the risk of progressing to alcoholism.² Delay and reduction also allow the forebrain and other neurological structures that contribute to judgment and behavioral inhibition to mature, which should further reduce unhealthy risk taking (Crone & van der Molen, 2004; Dempster, 1992; Galvan et al., 2006; Hooper, Luciana, Conklin, & Yarger, 2004; Steinberg, 2005; Fig. 2). Similar arguments can be made for postponing sexual activity and certain other risky behaviors. Not only are immediate negative outcomes reduced, but older adolescents bring a more developed brain, as well as greater social and emotional maturity, to risky situations (e.g., Byrnes, 1998; Reyna, 1996).

²The problems we discuss in this article are not limited to the United States. For example, a recent report debunks the myth that European adolescents have fewer alcohol problems because their cultures teach them to handle alcohol responsibly from an early age; the report shows that a large majority of European countries had higher intoxication rates and binge drinking (five or more drinks in a row) rates among adolescents than the United States. Data collected from 15- and 16-year-olds in 35 European countries showed that European adolescents drink more often, drink more heavily, and get drunk more often than American adolescents do: In the United States, 22% binge drank in the past 30 days; in Denmark, that figure was 60%; in Germany, 57%; in Britain, 54%; in Italy, 34%; and in France, 28%. Intoxication rate in the last 30 days for U.S. adolescents was 18%, compared to 61% in Denmark, 53% in Ireland, 48% in Austria, and 46% in Britain. Only six European countries had lower intoxication rates than the United States. Data from Europe were collected as part of the European School Survey Project on Alcohol and Other Drugs, and the U.S. data were from the Monitoring the Future survey conducted annually among 8th, 10th, and 12th graders in the United States. These data have implications for hypotheses about the effects of accessibility of alcohol and for such public policies as raising drinking ages (see Grube, 2005).

TABLE 2
Adolescent Exposure to Risks and Early Onset of Risk-Taking Behavior

Risk/behavior	Data
Alcohol	40% of adult alcoholics report having initial alcoholism symptoms between the ages of 15 and 19.
Car accidents	Between the ages of 16 and 20, both sexes are at least twice as likely to be in accidents than are drivers between the ages of 20 and 50. These accidents are the leading cause of adolescent death.
Gambling	Pathological or problem gambling is found in 10% to 14% of adolescents, and gambling typically begins by age 12.
Sexual activity	Adolescents are more likely than adults to engage in impulsive sexual behavior, to have multiple partners, and to not use contraception. Younger teens (12–14 years) are more likely to engage in risky sexual behavior than are older teens (16–19 years).
STDs	Annually, 3 million adolescents contract a sexually transmitted disease. HIV infection is the seventh leading cause of death among 13- to 24-year-olds.

Note. Data sources include Bachanas et al. (2002); Chambers & Potenza (2003); Chambers, Taylor, & Potenza (2003); and Turner & McClure (2003).

Indeed, the likelihood of engaging in many risky activities is greatly reduced simply by aging. Generally speaking, the prevalence of illegal behaviors is lower during adulthood than during adolescence (Menard, 2002; Moffitt, 1993; National Research Council and Institute of Medicine, 2001). Both arrest data and self-report surveys reveal that crime rates peak during adolescence and young adulthood. The arrest rate for serious violent crimes rises rapidly during the adolescent years, reaches its height at age 18, and drops rapidly thereafter. One reason that violent crime rates fell in the late 1990s was the aging of the population; young people made up a smaller share of the total, producing lower crime rates by default. However, America's juvenile population has grown significantly over the past several years, rising from 13.3 million in 1990 to 14.8 million in 1995 to 15.7 million in 2000. The adolescent population is expected to peak in 2007 at 17.3 million. As the gateway to adulthood, adolescence represents a combination of increased accessibility to risk-taking opportunities (e.g., adolescents drive and have less adult supervision) coupled with immature risk attitudes, understanding, and self-regulation (e.g., Byrnes, 1998; Gottfredson & Hirschi, 1990; Reyna, 1996). Crime, smoking, drug use, alcoholism, reckless driving, and many other unhealthy patterns of behavior that play out over a lifetime usually debut in adolescence. Avoiding unhealthy risks or buying time during adolescence before exposure to risks can therefore set a different lifetime pattern. The public-policy implications of these observations are straightforward: Changing unhealthy behaviors in adolescence would have a broad impact on society, reducing the burdens of disease, injury, human suffering, and associated economic costs.

What Is Rational, Adaptive, or Good Decision Making for Adolescents?

Traditional Behavioral Decision-Making Models

Traditional behavioral decision-making models have been widely applied in decision research with both adolescents and adults, and they are the standard against which new behavioral approaches are compared. Following Edwards' (1954) original

formulation, comprehensive treatment of any decision requires three forms of interrelated research: *normative*, *descriptive*, and *prescriptive*. These characterize, in turn, rational decision making, actual behavior, and interventions that bridge the gap between the normative ideal and the descriptive reality (Bell, Raiffa, & Tversky, 1988; Fischhoff, 2005; von Winterfeldt & Edwards, 1986). (Our use of the term *normative* may be confusing to social scientists who use the same term to refer to the concept of the average, or norm, rather than the ideal; however, because use of the term to mean ideal is standard in decision research, we have adopted that usage here.)³ Rationality, in this approach, involves making choices that best realize the decision maker's goals, regardless of what those goals might be (we return to this topic in the next section). Although naturally presented in sequential terms, the three stages are inherently intertwined: Descriptive research about actual behavior can show that normative analyses have mischaracterized decision makers' goals (and, thus, seemingly irrational behavior can be seen as rational, given the decision makers' goals). Similarly, interventions can test the depth of researchers' understanding of descriptive results about actual behavior, showing that supposed causal mechanisms underlying behavior do not respond to valid interventions (and, thus, that researchers need to think harder about the causes of observed behaviors). We discuss the normative analysis of decision making in this section; we then offer a descriptive analysis of what is known about adolescent risky behaviors; finally, we discuss how these analyses lead to prescriptions (including policy implications) for improving adolescent decision making.

In the context of adolescent risk decisions, normative analyses ask questions such as what really matters to adolescents when contemplating behaviors, which options give them the best chances of achieving those outcomes, and what information would make those choices clearer? Descriptive research asks

³What is considered normative or ideal decision making, however, varies from theory to theory, although the classical view has been that the normative ideal is rationality, defined as consistency with the axioms of subjective expected utility theory (discussed in the text) and with the rules of logic and probability.

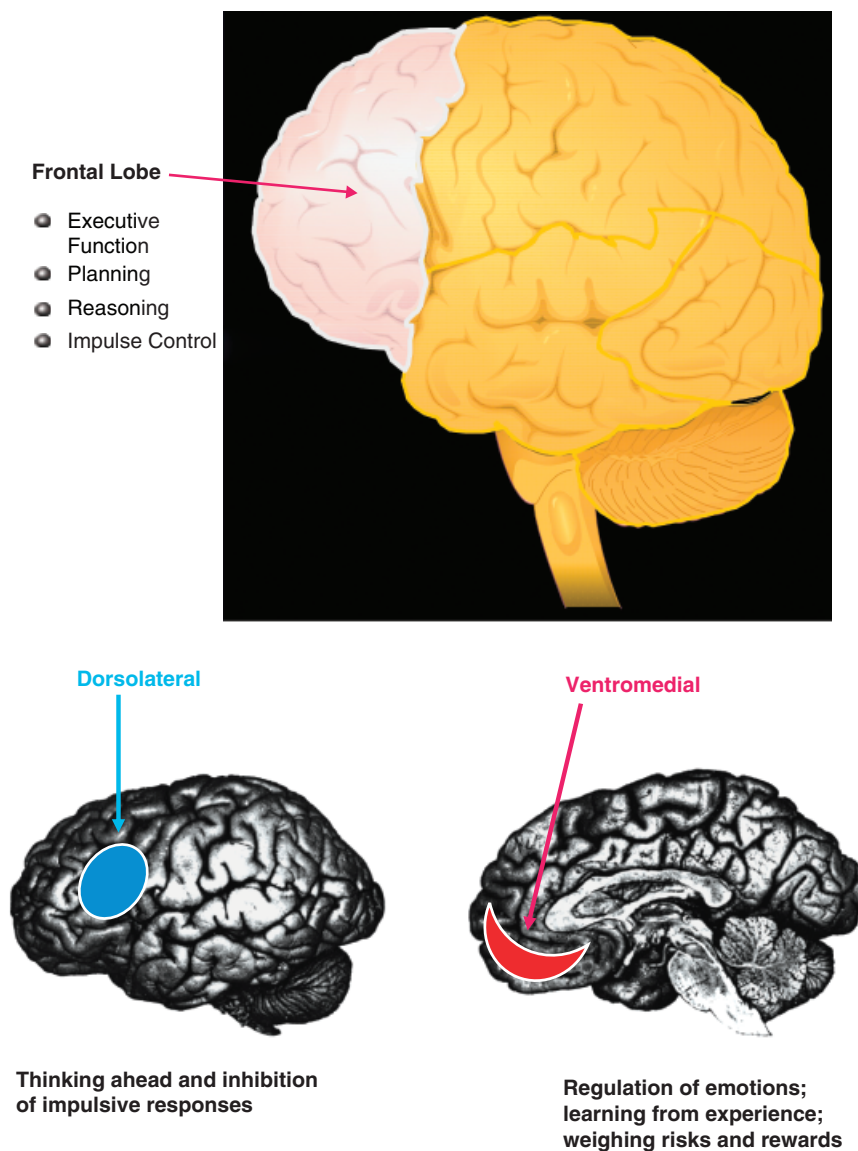


Fig. 2. Brain areas and functions showing significant development during adolescence. The frontal lobe (top panel, in pink) continues to mature into the mid-20s; its sub-areas, the dorsolateral and ventromedial areas (bottom panels) are associated with impulsivity, thinking ahead, and other decision factors.

questions such as how well do adolescents know what risks they are facing, how well can they anticipate how they will feel if things go wrong, and how well can they control their emotions when they need to think coherently? Prescriptive research asks questions such as do we understand adolescents well enough to help them appreciate the long-term consequences of their actions and do we understand their world well enough to reduce unmanageable social pressures?

More formally, the normative analysis of a choice identifies the options in the decision makers' best interests, given their goals and the information available to them, all integrated by the application of a rational decision rule. Customarily, that is an *expected utility* rule, which multiplies the utility (or attractive-

ness) of each outcome by the probability of its being obtained for each option. In these terms, rationality is a matter of consistency with a set of rules, such as *transitivity* (e.g., individuals who prefer A to B and B to C should also prefer A to C), because following such rules can be shown to result in reaching the decision makers' goals (i.e., maximizing the attractiveness, to that decision maker, of the chosen option; von Neumann & Morgenstern, 1944; Yates, 1990). Whether people actually adhere to such rules or pursue their own best interests is a detail left to descriptive research as opposed to normative analysis. In other words, people might not be capable of engaging in rational decision making, as defined by utility maximization or some other rule, but that should not be confused with what is defined

as normatively ideal (i.e., what prescription should aim to get as close as possible to, even if the normative ideal is never reached).

Behavioral decision theory does not tell people what to believe, but it stipulates that rational choices are ones that use decision makers' current beliefs in an orderly way. If those beliefs are inaccurate, then the resulting choices need not be optimal. The term *subjective expected utility* refers to choices based on intuitive probability judgments rather than the best available knowledge. The implication, then, is that decision making cannot be described as irrational when it requires knowledge that the decision maker did not have. Decisions can be wrong because of ignorance, but not necessarily irrational—a fundamental distinction when evaluating the decisions of adolescents, who may lack crucial knowledge and experience.

Normative analyses also recognize that people may rationally pursue goals that others dislike (e.g., adolescents who care more about good times and social approval than adults think is appropriate). Normative analyses recognize that people may make choices with unhappy outcomes because no better options were feasible (e.g., when dealing with bullying or sexual coercion). Normative analyses recognize that bad outcomes may follow good decisions, when chance intervenes, just as good luck may reward poor choices. Indeed, there is a term in decision analysis, *outcome bias*, for confusing the quality of decision processes and the consequences of decisions (Ritov & Baron, 1995).

Normative analyses of adolescents' circumstances can have disquieting results, as when they show adolescents to have the "wrong goals" or to be trapped in miserable situations with no good choices available to them. However, according to behavioral decision models, such analyses are essential to evaluating adolescents' performance and to designing interventions that encourage them to do things that adults want—or, to recognizing their contrary aspirations. In this view, good science and good policy require a full analysis of the decisions that people face.

A behavioral decision research perspective has little use for assessing people's understanding of facts that are absent from normative analyses, which include critical facts about goals, options, probabilities, and consequences. Descriptive research has, then, a vital role to play in identifying barriers to grasping those critical facts. For example, adolescents may know that "safe sex" is important but not what that term means (McIntyre & West, 1992). They may know that any unprotected sex runs some risk of pregnancy or sexually transmitted infection, in the sense that "you can get it the first time," but may not how to interpret the experience of getting through the first time safely (e.g., are they immune? infertile?; Downs, Bruine de Bruin, Murray, & Fischhoff, 2004).

In sum, according to behavioral decision theory, a normative analysis of a choice proceeds by describing it in terms that take full advantage of the best available information on the topic and then combining it with a rational decision process (such as maximizing subjective expected utility), in order to identify the

choice that best realizes the decision maker's goals. The behavioral decision perspective traditionally describes rationality in terms of achieving the decision maker's goals, however unacceptable or abhorrent those goals may be to others. Behavioral decision theory incorporates a normative ideal about how decisions should be made but not about what people should want or believe. Regardless of whether all of the tenets of the behavioral decision model are accepted, the tripartite distinction among normative, descriptive, and prescriptive perspectives on decision making is useful: Any program designed to prevent or change risky behaviors should be founded on a clear idea of what is normative (what behaviors, ideally, should the program foster?), descriptive (how are adolescents making decisions in the absence of the program?), and prescriptive (which practices can realistically move adolescent decisions closer to the normative ideal?).

Coherence Versus Correspondence Criteria for Rational Decision Making

As the reader might surmise, how to characterize a rational decision process has been a matter of debate. There are two sides to this debate, referred to as *coherence* and *correspondence*, respectively (Adam & Reyna, 2005; Doherty, 2003). A coherent decision process is internally consistent, often defined with respect to the constraints of relevant formal systems, such as logic or probability theory (e.g., Gilovich et al., 2002). We have already discussed an example of a coherence criterion, namely, that ordering of preferences should obey transitivity. Another example, taken from probability theory, is that people are said to violate coherence when they commit the conjunction fallacy: ranking the conjunctive event "A and B" as higher in probability than one of its component events (e.g., "B"); "feminist bank teller" cannot be a more likely description of a person than "bank teller" (Tversky & Kahneman, 1983). Theorists raised questions in the 1990s about whether logical fallacies such as the conjunction fallacy are really errors, speculating that they are instead the product of a mature intelligence that pays attention to the semantics and pragmatics (not just the logical form) of a problem. For example, it was speculated that participants rated a woman as more likely to be a feminist bank teller than a bank teller because they made the pragmatic inference that "bank teller" must refer to nonfeminist bank tellers. However, research testing these semantic and pragmatic explanations for human performance found them to account for only a small proportion of variance, despite their rhetorical appeal (e.g., Reyna, 1991; Slovic, Over, Slovic, & Stibel, 2003; Stanovich & West, 2000). A few participants interpreted "bank teller" as referring to nonfeminist bank tellers, but most did not—and yet, they still committed the conjunction fallacy. In other words, although people commonly make semantic and pragmatic inferences in everyday life, these purported inferences were generally not related to the logical fallacies participants committed in laboratory tasks illustrating heuristics and biases.

Given participants' actual interpretation of the materials and tasks, their reasoning was, in fact, flawed. (Empirically supported explanations for this flawed reasoning include an increasing and, mostly adaptive, reliance on gist representations with development.) Thus, when a person's statements or actions seem nonsensical, illogical, or self-contradictory—when they lack coherence—it raises doubts about his or her rationality.

The coherence view of rationality revolves around such questions as the following: Is reasoning logical—does it obey the rules of logic? Are decisions internally consistent with one another—do preferences exhibit coherence with respect to basic assumptions such as transitivity (i.e., within the same time frame, if A is preferred over B, and B is preferred over C, then A should be preferred over C) or invariance across superficial changes in packaging or phrasing of the same options? Regardless of what adolescents may be capable of, the normative question is whether they should, ideally, be logical or coherent (or whether adults may have to be coherent on their behalf). Although coherence does not guarantee reaching one's goals, it is a minimal condition for doing so.

In contrast, the correspondence view of rationality implies that reaching one's goals requires being in touch with reality, making judgments and decisions that produce good outcomes in the real world. It is not too far off to characterize coherence as mainly being about the decision process and correspondence as mainly being about the decision outcome. Correspondence has great appeal in characterizing adolescent rationality because it can be closely linked to desirable goals such as physical and psychological well-being. However, good outcomes are surprisingly difficult to define objectively (whereas logic and probability theory have explicit rules that provide a rationality calculus). Moreover, outcomes do not necessarily reflect the agency of the decision maker. For example, an adolescent or any other decision maker (e.g., a physician) can do everything right and have a bad outcome, and conversely (the outcome bias described earlier). To wit, Winston Churchill (the prime minister) was overweight, drank copiously, and smoked cigars, but he lived to 90, whereas Jim Fixx (the runner) reputedly lived a Spartan life of careful dieting and vigorous exercise, but he was dead at 52. Other factors, such as genetics, can sometimes determine outcomes, despite good or bad decision processes. In the long run and over large samples of people, however, rational decisions ought to lead to better outcomes. Thus, as a matter of public policy, it makes sense to foster rational decision processes (coherence) in adolescence in order to achieve desirable economic, psychological, and public health outcomes (correspondence; Baron & Brown, 1991; Beyth-Marom, Fischhoff, Quadrel, & Furby, 1991; Furby & Beyth-Marom, 1992). Both coherence and correspondence are desirable criteria for rational decision making.

As the preceding discussion relating coherence to correspondence suggests, the dichotomy between the view that rationality is fundamentally about formal considerations, such as

logical coherence, and the view that it is fundamentally about good outcomes in the real world has been challenged (Doherty, 2003). Recent theories of rationality have integrated these two approaches on the ground that each has limitations and that both coherence and correspondence are therefore necessary for ideal decision making (Reyna & Brainerd, 1994; Reyna, Lloyd, & Brainerd, 2003). Considering adolescent decision making simultaneously from these two perspectives, however, raises a number of foundational questions.

First, as we have indicated, traditional behavioral decision-making theory holds that rational decision processes help people achieve their goals. From a developmental perspective, we can anticipate that adolescents' goals evolve over time. A key question, here, is whether their short-term goals, such as peer acceptance, are incompatible with long-term goals, such as health promotion. Evidence indicates that the answer to this question is yes: Goals vary with age, and short- and long-term goals are often incompatible, even for adults (e.g., Loewenstein & Schkade, 1999). Traditional behavioral decision theory does not offer a means for deciding between present and future goals, although theorists have noted that the pleasures and pains of actual consumption sometimes differ from the anticipation of pleasures and pains when decisions are made (March, 1988). For example, studies indicate that most people rescued from suicide attempts are later glad that they were unsuccessful (e.g., Seiden's, 1978, classic study of survivors who jumped from the Golden Gate Bridge). Figure 3 presents a single, poignant example (for national statistics, see Anderson & Smith, 2003). Owing to their relative lack of experience, adolescents live in a more surprising world than adults do; they are less likely to be able to anticipate their future feelings and goals.

If objective evidence indicates that most adolescents who attempt suicide regret the attempt, that most adolescents who refuse chemotherapy ultimately are glad they were forced to take it, and so on, such findings ought to weigh heavily in considerations of what is rational. Note that we emphasize the use of appropriate scientific evidence in judging future goals. Even so, in applying a standard of what most people eventually want, that standard will be wrong for a minority of individuals. (Naturally, all measures should be taken to explain the costs and benefits of options to adolescents so that they have the greatest chance of coming to a mature perspective on their own.) In our view, however, it is worse to ignore good evidence about which course of action will produce better and more satisfying outcomes for the majority of adolescents. Thus we recommend that, in applying correspondence criteria for rationality to adolescents, scientific evidence concerning which behaviors, practices, or policies are likely to produce positive physical and psychological outcomes over the long term must be brought to bear. Again, correspondence criteria are not a substitute for coherence criteria, and our recommendation is that correspondence criteria be modified for adolescents in order to reflect developmental differences in their ability to anticipate future goals and outcomes.

Ten years ago, I tried
to kill myself in the A lot.

To whoever found me, to the paramedics, doctors,
and hospital staff: THANK YOU.
I truly appreciate the gift you gave me.

To my parents: I'm sorry. Thank you. I love you.

To family, friends, Cornell: thanks for welcoming me back.

It has been a good ten years. And whatever
the future holds, I am very happy to be here.

Fig. 3. Letter from a student who attempted suicide, published in the *Cornell Daily Sun* on September 14, 2005 (Ten years ago, I tried to kill myself in the A lot, 2005).

The second foundational question is whether coherence criteria for rationality are appropriately applied to adolescents. That is, are adolescents sufficiently advanced cognitively to be capable of achieving logical coherence? The answer to this question is a highly qualified yes (e.g., Steinberg, 2004; although it should be noted that even adults do not exhibit logical competence reliably across contexts). To observe adolescents' underlying reasoning competence, conditions must be optimal, and optimal conditions for making risky decisions are rare in everyday life. For example, using questionnaires and a laboratory behavioral task measuring risk preference and risk taking, Gardner and Steinberg (2005) showed that people made riskier decisions in the presence of peers than they did alone, and this effect was magnified for adolescents and youth compared to adults. The behavioral task mirrored real-life decisions involving reckless driving, such as the decision to run a yellow light and continue through an intersection—although, as it was a simulation, no consequential risk was involved (Fig. 4). Note that adolescents' were capable of making better decisions and showing more mature risk preferences without peers, evincing what Reyna and Brainerd (1994) termed “task variability” (the ability to exhibit a higher level of competence under one set of circumstances than under another, superficially different circumstance in which the same competence is relevant).

The basic qualitative rules of logic and probability theory are intuitively understood early in development (Falmagne, 1975; Fischbein, 1975; Huber & Huber, 1987; Reyna & Brainerd, 1994), although, again, such competence may not be reliably expressed across contexts at any age. Research suggests that adolescents can be coherent reasoners and can learn from experience about which behaviors lead to good outcomes. Crone, Vendel, and van der Molen (2003), for example, showed that adolescents could learn from positive and negative outcomes in

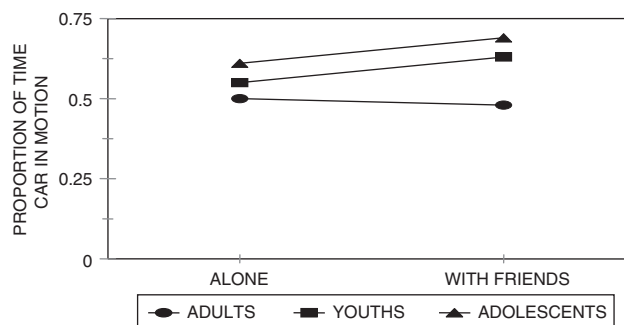


Fig. 4. Proportion of time car was in motion in a simulated driving task for adolescents (13–16 years old), youths (18–22 years old), and adults (over 24 years old), both alone and with friends in the car, in decisions to run a yellow light (based on Gardner & Steinberg, 2005; Steinberg, 2005).

a learning task linked to real-life decision-making competence, although those high in sensation seeking were oversensitive to rewards. In principle, barring temptations with high rewards and individual differences that reduce self-control—in other words, under ideal conditions—adolescents are capable of rational decision making to achieve their goals (i.e., they can be coherent reasoners who can learn to achieve desirable outcomes).

In practice, as we discuss in detail in a subsequent section, there is a considerable gap between ideal reasoning competence and actual performance in the laboratory or the real world. Therefore, much depends on the situation in which the decision is made. In the heat of passion, on the spur of the moment, in unfamiliar situations, when trading off risks and benefits favors bad long-term outcomes, and when behavioral inhibition is required for good outcomes, adolescents are likely to reason more poorly than adults (Amsel, Cottrell, Sullivan, & Bowden, 2005; Crone & van der Molen, 2004; Dempster, 1992; Hooper et al., 2004; Overton, 1990; Overton & Byrnes, 1991; Steinberg, 2004). However, in some situations (e.g., consent for nonemergency medical treatment), conditions that better tap underlying reasoning competence can be arranged (e.g., see Reyna & Brainerd, 1994, for a review). However, as indicated in our earlier discussion of adolescents' time horizons, even under good conditions, short-term goals (e.g., not losing hair in chemotherapy) are apt to weigh more heavily than long-term goals for adolescents, relative to adults.

As these two questions about adolescent rationality illustrate, healthy decision making is not the same thing as rational or normative decision making as traditionally defined. What is healthy in the narrow sense of promoting psychological and physical well-being may conflict with a decision maker's goals. If a decision maker's goal is to maximize immediate pleasure, for example, many kinds of unhealthy behavior, such as drinking and drug use, could be deemed rational (see Baron, 2003, for an unapologetic defense of the standard view). For example, theorists could make the case that drug use, smoking, or other risky activities maximize utility and are, therefore, rational. Some

theorists have attempted to fix this apparent shortcoming in traditional theories (i.e., the prediction that seemingly irrational self-destructive behavior could be construed as rational pursuit of personal goals) by appealing to notions of addiction and temporal discounting (the idea that delayed outcomes are valued less), among other concepts. Most decision theorists still accept the standard view because of the very real difficulties of evaluating other people's personal goals. Again, recent theories have begun to challenge the standard view on this point: Merely assisting people in achieving their own goals—no matter how misguided, inconsistent with reality, or self-destructive those goals might be—is being questioned by decision theorists and even rejected in some quarters (see Doherty, 2003). This shortcoming of traditional decision theory is another reason why we include correspondence (healthy outcomes) as well as internal coherence as criteria for rationality. In our view, having healthy goals that result in healthy outcomes is an essential aspect of human rationality, and, with respect to policy, society has a justifiable interest in promoting physical and psychological health (Byrnes, 1998; Payne, Bettman, & Johnson, 1993).

Despite common usage, healthy decision making is also not the same thing as “adaptive” decision making in the strict evolutionary sense. According to evolutionary theory, adaptive behavior leads to the preservation and propagation of one's genes. In this sense, smoking is adaptive (or, more precisely, not maladaptive) because most harmful consequences occur after procreation and child rearing have occurred. Similarly, early sexual promiscuity can be considered adaptive from an evolutionary perspective (see Baumeister, 2005, Geary, 2005, and Gigerenzer & Selten, 2001, for more elaborated approaches to selection pressures). The need for a protracted education (and thus deferred procreation) in an industrial society is a recent development historically and would not have been evolutionarily selected or preferred. Therefore, in a modern industrial economy, early pregnancy and child rearing is “maladaptive”—but only in a metaphorical sense—because it does not promote the physical or psychological health of oneself or one's offspring.

Evolutionary theory has been widely touted as a guide to what should be considered “smart” behavior in decision making (e.g., Gigerenzer, Todd, & the ABC Group, 1999). However, evolutionary theory about what is adaptive offers little guidance for public policy in the arena of adolescent decision making. On the contrary, some behaviors that are adaptive from an evolutionary perspective, such as early procreation, are precisely the behaviors that are not healthy in a modern society. Thus, adolescent decision making represents an important counterexample to assertions of contemporary evolutionary theories that what is adaptive in the evolutionary sense is also rational, healthy, or desirable behavior from either a theoretical or a public-policy perspective. Self-destructive behavior could be construed as adaptive from an evolutionary perspective and perhaps be rationalized as the pursuit of personal goals and, nevertheless, be unhealthy behavior that policy ought to discourage.

Given expected conflicts in adolescence between personal goals and healthy goals, the question arises as to whether it is ever rational to engage in unhealthy behaviors. The assumption that is implicit in this question is that people in their right minds or who are thinking logically would not intentionally harm themselves. The premise that one prefers not to be hurt and yet is doing something to hurt oneself does not make logical sense; the preference and the action seem to contradict one another. Assuming that people are in their right minds and thinking logically, the implication is that people who engage in unhealthy behaviors must not realize that the behaviors are harmful (or fully realize the extent of harm), or that there are other benefits to the behaviors that may not be readily apparent. Thus, there are ways behavior that seems nonsensical can, after the fact, be made sense of—e.g., by inferring compensating rewards or benefits. An argument for welfare reform, for example, was that the existing system encouraged adolescents to become pregnant because welfare benefits provided them with income (despite a lack of education) and an independent domicile away from their parents. Others have speculated that adolescents have babies so they can have someone to love or someone who will look up to them, especially if there are few other possible sources of love or admiration. There is no conclusive evidence to support either of these speculations. Nevertheless, it is important to acknowledge the benefits that adolescents derive from engaging in risky behaviors, such as gaining social acceptance from peers (and there is evidence that perceived benefits drive risk taking in adolescence; see below). The main problem with such accounts is that it is always possible, post hoc, to conjure up benefits that make any behavior appear rational. We would argue, instead, that it is possible to acknowledge the benefits that adolescents derive from specific behaviors and, thus, explain their motivations without necessarily characterizing their decisions as healthy, adaptive (in the context of modern society), or rational overall. (Again, we draw a distinction between evolutionarily adaptive—based on past selection pressures, which encouraged specific kinds of risk taking—with adaptive in the context of an individual's mental and physical health in modern society.)

Many of the behaviors we have discussed—smoking, drug use, and unsafe sexual activity—appear to offer immediate pleasures, whereas any adverse outcomes are generally longer term (e.g., Herrnstein, & Prelec, 1992). Another prominent example comes from the recent epidemic of adolescent obesity: Eating tasty fast foods (immediate pleasure) runs counter to the long-term goal of physical health (e.g., avoiding well-known delayed outcomes such as diabetes and cardiovascular disease). Temporal discounting, the tendency to weight immediate outcomes more heavily than future outcomes, is a robust characteristic of adult preferences in decision making (Loewenstein & Elster, 1992). The pleasure of receiving \$100 now is greater than that of receiving the same \$100 in a month or a year. In order to account for real behavior, models of experiential learning about risks also weight recent outcomes more heavily than those more

removed in time (i.e., outcomes more removed in the past; Busemeyer & Stout, 2002; Busemeyer, Stout, & Finn, in press; Hertwig, Barron, Weber, & Erev, 2004; Rottenstreich & Hsee, 2001; Weber, Shafir, & Blais, 2004). Because the environment changes, it makes sense to weight recent information more heavily than old information.

Thus, the argument could be made that a generally adaptive tendency to weight recent more than distant outcomes occasionally backfires by encouraging immediate feel-good behaviors, such as smoking, drug use, overeating, and risky sexual behavior. However, there is no evidence that differential weighting of immediate outcomes is adaptive in the sense that it promotes healthy outcomes in a modern society (but cf. Ainslie, 2001). On the contrary, planning ability, future orientation, lack of impulsivity, and delay of gratification have each been linked to socially desirable outcomes, such as higher educational attainment and lower propensity for risky and antisocial behaviors (Baron & Brown, 1991; Grisso et al., 2003; Metcalfe & Mischel, 1999; Fig. 5). Moreover, animals seem to have a shorter time horizon and are more impulsive than are human children, who, in turn, are more impulsive than human adults (Ainslie, 2001; Metcalfe & Mischel, 1999; Rachlin, 2000). Hence, both the ontogenetic and phylogenetic evidence favors the long view as more advanced than the short-term perspective, and as more likely to lead to positive outcomes in a modern society.

Although arguments about rationality have historically been axiomatic (e.g., von Neumann & Morgenstern, 1944; Savage, 1972) or philosophical (e.g., Harman, 1986), some researchers have argued that developmental data should play a central role (Jacobs & Klaczynski, 2002, 2005; Reyna & Brainerd, 1994, 1995; Reyna, Lloyd, & Brainerd, 2003). According to the latter argument, changes in behaviors with age and experience (developmental progress) can, like data about successful outcomes, be used as objective input into judgments of rationality. This recent use of developmental data should be distinguished from the use of anecdotes or suppositions about the nature of development to buttress philosophical claims about rationality, a practice that has a long tradition (e.g., Quine, 1964).

For instance, laboratory research has shown that children are risk takers and risk taking generally decreases, especially for higher levels of risk, in the period from childhood to adulthood (Levin & Hart, 2003; Reyna, 1996; Reyna & Ellis, 1994; Reyna & Mattson, 1994; Rice, 1995; but see Schlottmann & Tring, 2005). These developmental studies included risks that involved both gains and losses, and children were more likely to take risks overall (i.e., the results were not limited to taking risks involving gains). Although this pattern conforms to longstanding conventional wisdom about risk-taking propensity among youth, the demonstration of decreased risk taking with age under controlled laboratory conditions seems to contrast with the view that risk taking increases in adolescence relative to childhood (e.g., Dahl & Spear, 2004; Spear, 2000). The contrast is more apparent than real, however. The laboratory pattern (although

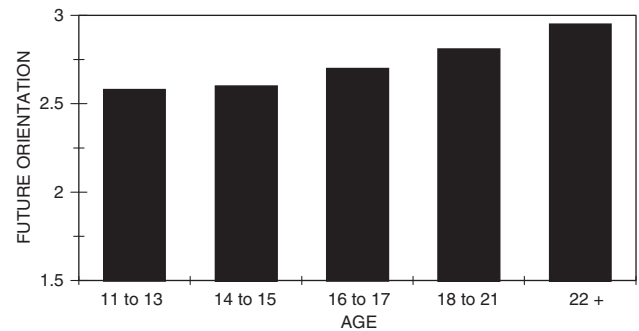


Fig. 5. Future orientation at different ages. Participants rated responses to the item, “I would rather save my money for a rainy day than spend it now on something fun” (based on Grisso et al., 2003).

qualified by individual differences) has been replicated and, ironically, suggests that adolescents’ preference for risks declines during the period in which exploration and opportunity (and thus, risk-taking behaviors) increase.

The developmental trend in risk taking in laboratory tasks is not subject to obvious alternative explanations, such as effects of social-motivational factors, rather than changes in risk preferences per se. For example, adolescents might not prefer to take risks in the real world but might do so anyway to impress their friends. The aforementioned experiments did not involve the presence of peers or other similar social factors that are known to be influential but that would cloud interpretation of the results regarding risk preferences. Children and adolescents prefer to take risks more than adults do, even when peers are not present to egg them on. This developmental trend cannot be directly compared to actual rates of risk taking in the real world, which are confounded by such factors as opportunity and thus do not necessarily reflect underlying risk preferences (but see Moffitt, 1993, and Spear, 2000, who speak to the important issue of the confluence of risk-taking propensity with real-world opportunity).

In the laboratory, one can control effectively for opportunity but less effectively for affect, emotional valence, social factors, and so on. Ethical constraints, for example, provide an upper limit on manipulations of negative affect. The absence of serious costs or consequences in laboratory risk-taking tasks could distort the estimate of underlying risk preferences based on these tasks. This issue applies generally to research using laboratory tasks that involve no serious consequences for performance and no direct representations of real-world health decisions, a classic hot-house phenomenon (i.e., an artificial environment that might not extrapolate to the real world; Agnew & Pyke, 1994; exceptions include work by Slovic, Peters, and colleagues, e.g., Finucane, Peters, & Slovic, 2003). One cannot assume that laboratory behavior does not generalize to the real world, and there are numerous examples of successful transfer (e.g., see Brainerd & Reyna, 2005; Parker & Fischhoff, 2005; Yechiam, Busemeyer, Stout, & Bechara, 2005), but neither can

the relation be assumed to be necessary. Nevertheless, developmental trends in laboratory risk taking can inform theorists about components of the psychology of risky decision making that then combine with other affective, social, and motivational factors in the real world.

Therefore, all other factors being equal, the developmental trend of decreased risk taking with age (mirrored in the real-world data) suggests that greater risk aversion is adaptive (in the broad sense) or rational, and that decision processes that support this aversion are more advanced than those that support risk taking. This developmental shift in greater risk aversion with age does not mean that risk taking is never rational, however. In particular, in situations of deficit (loss), deprivation, starvation, or when one has “nothing to lose,” risk taking may offer the only means of improving one’s situation, as research on foraging in animals indicates (Weber et al., 2004). Indeed, certain types of risk taking can have highly positive features and consequences that will be discussed later (Farley, 2001). However, research has shown that across situations of gain and loss, the global tendency to avoid risk increases from childhood to adulthood, and this robust trend cannot be ignored in deciding which behaviors and decision processes are likely to be rational. (We should remind the reader that we endorse both coherence and correspondence, or promoting healthy outcomes, and that these are separate and equally important considerations in judging rationality.) In short, we argue that empirical evidence about physical and mental health outcomes of behaviors, as well as developmental trends in behaviors, are relevant to claims about adolescent rationality.

We cannot leave the topic of rationality without mentioning the most recent theoretical development. Current theories of rationality emphasize dual processes in reasoning and decision making, with two corresponding systems of rationality (Chaiken & Trope, 1999; Epstein, 1994; Kahneman, 2003; Klaczynski, 2005; Sloman, 2002; Stanovich & West, 2000; similar precursor dual theories include Piaget’s and Freud’s). The first system is fast, associative, and intuitive, whereas the second one is slow, deliberative, and analytical. Theorists speculate that the intuitive system is older evolutionarily and allows the organism to respond quickly to predators but produces reasoning biases and fallacies, whereas the analytical system avoids such biases and fallacies but incurs the burden of lengthy deliberation. Another model, fuzzy-trace theory, draws on evidence for independent gist and verbatim-memory representations of experience, but differs from other dual-process models in emphasizing that there are degrees of rationality and that intuition is an advanced form of reasoning; such claims are based on empirical evidence comparing decision making by children and adolescents to that of adults and decision making of adult novices to that of experts (Reyna, 2004a, 2005; Reyna & Brainerd, 1991b, 1995; Reyna et al., 2003; Reyna, Lloyd, & Whalen, 2001). (As we discuss in greater detail in the next section, intuition—fuzzy, gist-based thinking that unfolds in parallel to analytical deliberation and in

which few dimensions of information are processed when making a decision—can be argued to be an advanced form of reasoning for theoretical and empirical reasons, including the observation that such thinking appears to increase with age and expertise.)⁴ Dual-process approaches provide an explanation for why human decision making seems simultaneously impulsive and reflective, intuitive and analytical, qualitative and quantitative. The essential requirement for any scientific theory, however, is that it is predictive rather than merely superficially descriptive (e.g., a list of dichotomies), rhetorically compelling, or even explanatory (cf. Gigerenzer & Regier, 1996). Making novel and counterintuitive predictions is the highest and most diagnostic test of any theory that purports to apply to reality. As we discuss in the next section, dual-process models differ in their emphasis on underlying mechanisms and prediction, as opposed to descriptions, of behavior.

In summary, our consideration of rationality leads to the following conclusions:

- Long-term physical and psychological outcomes, or correspondence criteria, matter in judging behavior
- Adolescents are capable of coherent decision processes under circumscribed conditions, and rational (coherent) decision processes offer hope of good outcomes in the aggregate and over the long haul
- Evolutionary arguments must be made with caution and do not necessarily support the achievement of physical and mental health in an industrialized society
- Personal goals can be at odds with achieving physical and mental health—pointedly, for adolescents engaging in risky behaviors
- Unhealthy behaviors cannot be rationalized after the fact by inferring compensating benefits (although perceived benefits motivate adolescent risk taking, as we show later)
- Recent rewards are overweighted, especially by adolescents, but planfulness and delay of gratification generally produce better outcomes
- Developmental trends in behavior can join outcomes data in providing independent evidence of rationality, on the premise that behaviors that increase with age and experience are generally more advanced

⁴By “intuition” we mean fuzzy, impressionistic thinking using vague gist representations, but we distinguish mindless impulsive reaction from insightful intuition that reflects understanding of a situation or decision. Thus, there are two kinds of fast and simple ways of thinking: a stupid kind that represents the most primitive form of thinking and a smart kind that represents the highest form of thinking, insightful intuition. In the foundations of mathematics, intuition is a similarly advanced form of thinking (Reyna & Brainerd, 1991a). Using gist as a core concept, fuzzy-trace theory emphasizes meaning, implying that successful interventions to reduce risk that instill insightful intuition must focus on understanding rather than merely on persuasion or memorization of verbatim facts (see Reyna et al., 2005). Work conducted under the aegis of gestalt theory, a formative influence on fuzzy-trace theory, showed that, in contrast with rote learning, understanding promotes transfer of learning; this suggests that health curricula should promote deeper understanding in order to improve transfer of learning from the classroom to real-world decision making.

- 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

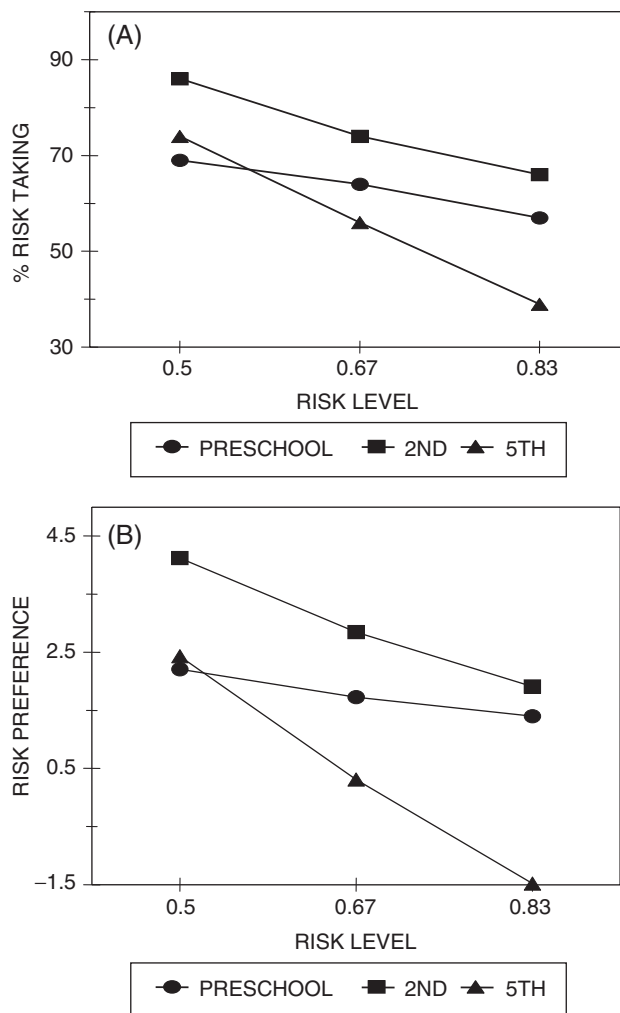


Fig. 6. Choice proportions for the risky, as opposed to sure, option (panel A) and risk-preference ratings on a 7-point happy-face scale (i.e., children pointed to smiley faces that varied from neutral to very happy; panel B) for 3 risk levels across gain and loss decisions for 44 preschoolers, 33 second 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

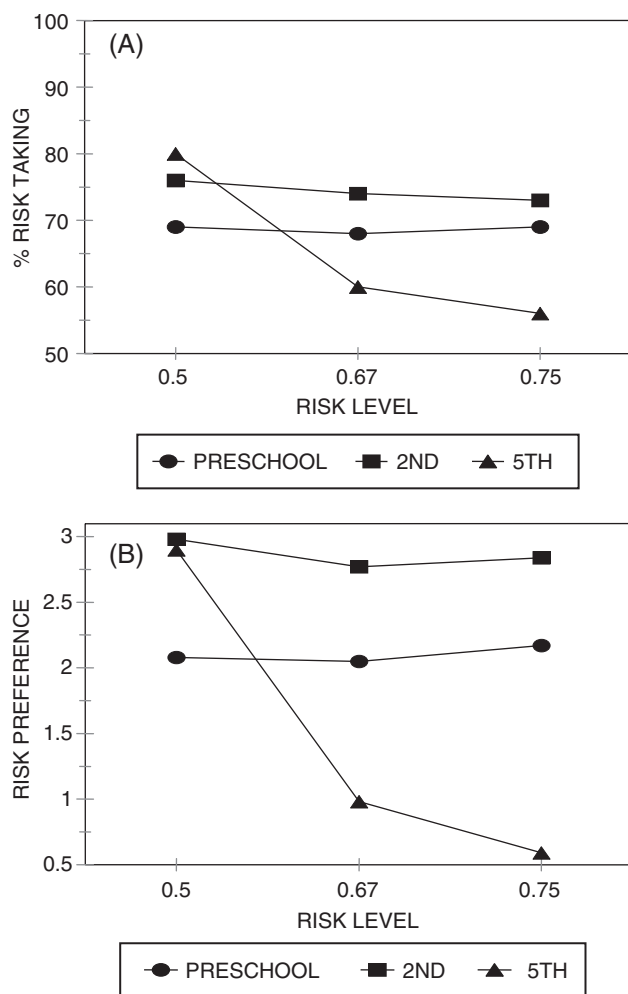


Fig. 7. Choice proportions for the risky, as opposed to sure, option (panel A) and risk-preference ratings on a 7-point happy-face scale (i.e., children pointed to smiley faces that varied from neutral to very happy; panel B) for 3 risk levels across gain and loss decisions for 44 preschoolers, 51 second 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).

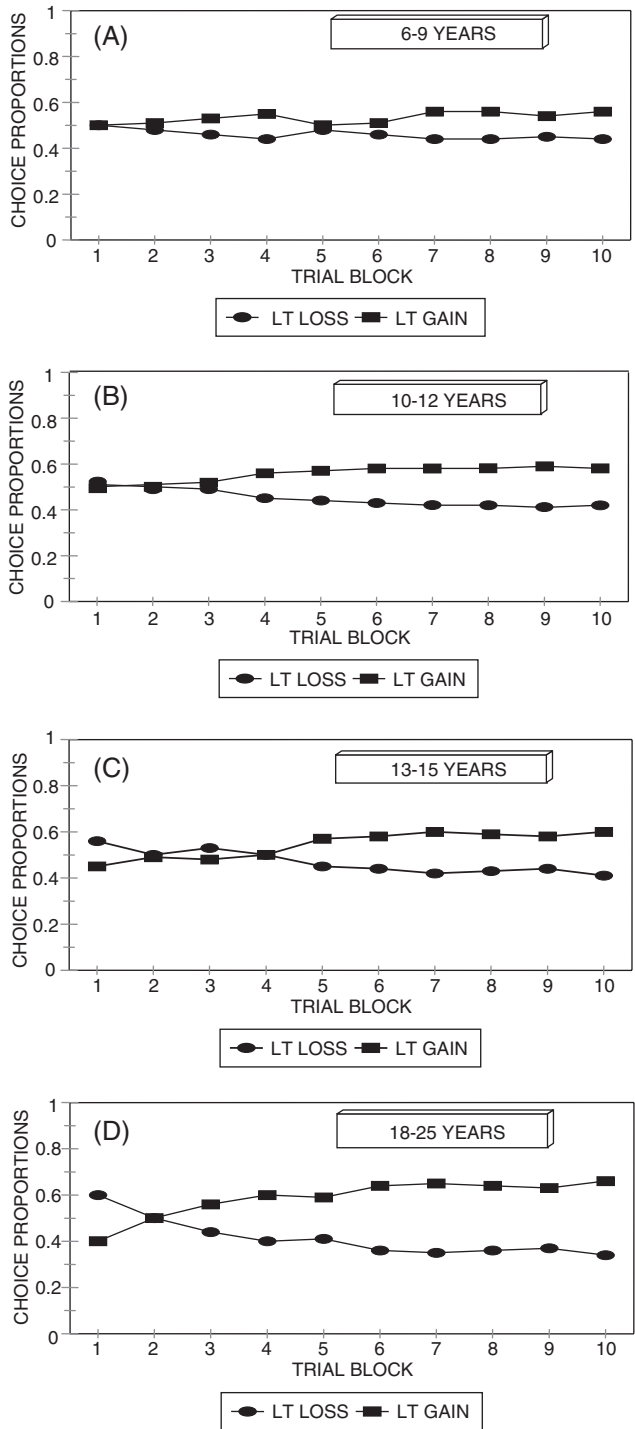


Fig. 9. Proportion of participants choosing decks that yield long-term (LT) gains versus those yielding LT losses, across ten blocks of learning trials in the Iowa Gambling Task for 6- to 9-year-olds (panel A), 10- to 12-year-olds (panel B), 13- to 15-year-olds (panel C), and 18- to 25-year-olds (panel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

(e.g., Arnett, 2000; Chapin, 2000, 2001a; Greening & Stoppelbein, 2000; Romer & Jamieson, 2001). However, other studies have shown no evidence of bias or have obtained mixed results (Benthin, Slovic, Severson, 1993; Ellen, Boyer, Tschann, & Shafer, 1996; Johnson, McCaul, & Klein, 2002; Whaley, 2000). To illustrate, Chapin (2001a) reported that, on a -3 to $+3$ scale, African American adolescents with sexual experience rated their risk of negative outcomes associated with sexual behavior as -1.64 , significantly lower than average, whereas adolescents without experience rated their risk as $-.52$. However, Ellen et al. (1996) found almost perfect calibration for adolescents' perception of risk for sexually transmitted diseases: 33% rated their risk as below average, 36% rated their risk as average, and 32% rated their risk as above average. Finally, Johnson et al. (2002) found that adolescents who were daily smokers and those engaged in unprotected sex estimated their risk of getting lung cancer or a sexually transmitted disease, respectively, as significantly higher than did adolescents not engaging in those behaviors (see also Chapin, 2001b; and Gerrard et al., 1996). Regarding the studies that found no difference, the failure to detect an optimistic bias among adolescents—a null effect—is not evidence that there is no bias, as methodological problems might have interfered with detecting an effect that was really there; nothing definitive can be inferred from null effects.

Thus, based on the literature as a whole, we can conclude that there is an overall tendency (we discuss exceptions presently) to view oneself as more invulnerable to risk than unspecified others are, whether this perception is due to illusions of control, motivated belief or self-enhancement, or nonmotivational information-processing constraints (Chambers & Windschitl, 2004). Weinstein and Lachendro (1982) evaluated an egocentric hypothesis that, when making comparative judgments, people consider their own risk-increasing or risk-decreasing behaviors but fail to fully consider such information as it applies to others. Contrary to a motivational account, Windschitl, Kruger, and Simms (2003) showed that people's estimates of the likelihood of winning a trivia game were influenced more by their own level of knowledge than by their estimates of their competitors' knowledge, even when attention was drawn to the latter by explicitly asking about it. If people rely, for nonmotivational reasons, on self-relevant information more than on other-relevant information, they should sometimes also make unfavorable comparison judgments when self-relevant information is unfavorable; this has been found to be the case (Chambers & Windschitl, 2004). Although nonmotivational information-processing factors (e.g., egocentric focus) seem to be sufficient to produce optimistic bias, motivational factors may also produce such a bias. Crucially, interventions to improve risk perceptions must be designed to address the source of the distortions—for example, denial of risk to rationalize behavior versus lack of awareness that others' risk-reduction strategies are similar to one's own (and do not sufficiently lower risk).

A slightly different question about perceived vulnerability is asked by dividing adolescents into lower- and higher-risk groups, such as nonsmokers and smokers or sexually abstinent and sexually active adolescents, and comparing their risk perceptions. That is, both groups of adolescents could exhibit an optimistic bias, although higher-risk groups might exhibit less of a bias than lower-risk groups might. In this case, although both groups' estimates would be biased, their relationship to one another would accurately reflect relative risk. Several studies have shown such a relationship—namely, that objectively higher-risk groups saw themselves as being at higher risk. For example, in addition to the Johnson et al. (2002), Chapin (2001b), and Gerrard et al. (1996) studies noted previously, Cohn, Macfarlane, Yanez, and Imai (1995) found that adolescents with more risk-taking experience (e.g., getting drunk) perceived that they were at greater risk than did those with less experience. Similarly, adolescents engaged in high-risk sexual behavior acknowledged being at significantly higher risk for HIV infection (Murphy, Rotheram-Borus, & Reid, 1998; see also Sneed et al., 2001). As Johnson et al. (2002) point out, estimates of general risk might be expected to differ from those of personal risk or risk of specific negative outcomes. For instance, smokers rated themselves as more vulnerable than nonsmokers on smoking-related items but not on other items (Milam, Sussman, Ritt-Olson, & Dent, 2000). Therefore, adolescents engaged in higher-risk activities sometimes seem to be aware that they are at higher risk but engage in those behaviors despite this awareness (and perhaps because of it—i.e., hopelessness may lead to self-destructive behaviors; Chapin, 2001b).

This seems counterintuitive from the perspective of many models because, as we have discussed, these models assume that higher risk perceptions should produce less risk-taking behavior. Many studies have shown that those engaging in risk taking perceive less risk than those who refrain from engaging in such behavior—a finding consistent with rational models (Fig. 10). For example, Benthin et al. (1993) found that adolescents who had experience with risky behaviors perceived the risks to be smaller, better known, and more controllable than did inexperienced adolescents. Ben-Zur and Reshef-Kfir (2003) showed that risk perception for HIV/AIDS decreased as relevant personal-risk behaviors increased; as in the Benthin et al. study, those taking more risks perceived those risks to be smaller. A longitudinal study of over 7,000 participants showed that smokers between ages 11 and 18 perceived less general and personal risk associated with smoking than nonsmokers did (Chassin, Presson, Rose, & Sherman, 2001; see also Halpern-Felsher, Biehl, Kropp, & Rubinstein, 2004). Arnett (2000) found that although only 18% of adolescent smokers denied that most lifelong smokers eventually die of smoking-related illnesses, 29% of them denied that this would happen to them if they smoked 30 to 40 years. Moreover, longitudinal studies have identified high risk perception as a deterrent to smoking (Brynin, 1999). Analogous findings have been reported for use of

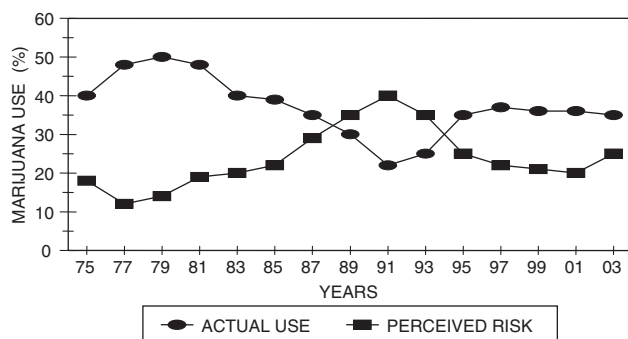


Fig. 10. Percentage of 12th graders who reported having used marijuana from 1975 to 2003, plotted against the percentage who perceived occasional marijuana use as risky (based on Johnston, O'Malley, Bachman, & Schulenberg, 2004).

alcohol (Gullone & Moore, 2000; Lundborg, & Lindgren, 2002; Wild, Hinson, & Cunningham, 2001) and marijuana (Hemmelstein, 1995; Lee, Su, & Hazard, 1998). Risk perception has also been associated with degree of use as well: Heavy smokers reported significantly lower perceived risk of smoking than did occasional smokers, and heavy marijuana users perceived lower risk than occasional users (Resnicow, Smith, Harrison, & Drucker, 1999).⁷

The literature that we have just reviewed presents an apparent conundrum, namely, evidence for both a positive and a negative relation between perceived risk and risk-taking behaviors: Those adolescents at higher risk because of their behavior often accurately perceive that they are at higher risk; and yet, other studies support the rational hypothesis that high risk perception is a protective factor, a counterbalance against perceived benefits. As Kotchik et al. (2001) explain, each of these inconsistent findings “conceptually make[s] some sense” (p. 502): Knowing that one is engaging in risky activities may lead to a heightened sense of personal risk, and it also makes sense that a reduced sense of vulnerability may contribute to greater risk taking.

One explanation for the contradictory findings has to do with different types of measurement. Fishbein (e.g., 2003) has shown that specific risk assessments that are conditional on protective behaviors reveal the theoretically expected relation that higher levels of perceived risk are associated with higher levels of protective behaviors or less risk taking (e.g., “How likely do you think it is that you could get AIDS by having vaginal sex with an occasional partner without wearing a condom?”). According to

Fishbein, theoretically, it is the behavior-specific risk measures (or outcome expectancies) that are linked to attitudes, which are, in turn, linked to intentions and behaviors. It could also be reasonably argued that more specific questions are less ambiguous and, thus, better reflect true assessments of risk. However, none of these arguments explains negative correlations between general risk assessments and protective behavior, other than that these correlations reflect an awareness by those who are engaging in risky behavior that they are likely to be at risk—which begs the question (but see Brewer et al., 2004). In addition, research suggests that judgments of risk are unlikely to be influenced by underlying conditionals, which are rarely spontaneously unpacked (e.g., Fischhoff, Slovic, & Lichtenstein 1978; Reyna & Adam, 2003). Thus, although specific risk assessments may be better measures of risk perceptions (and these perceptions relate positively to protective behaviors), without specific cues, people are more likely to think about risk in general terms (and these perceptions also relate to behaviors, but in the opposite direction—namely, negatively).

Another explanation for this inconsistency (i.e., evidence for both a positive and a negative relation between perceived risk and risk-taking behaviors)—one that is not incompatible with the measurement explanation—is that adolescents who engage in risky behaviors but fail to experience or only rarely experience negative outcomes may adjust risk estimates downward (Halpern-Felsher, Millstein, Ellen, Adler, Tschann, & Biehl, 2001). In this case, high risk perception is not necessarily protective—these adolescents have simply not put their perceptions to the test and discovered that bad outcomes are statistically rare. This explanation is more compelling for outcomes that are in fact rare, such as HIV infection, as opposed to pregnancy, which has a cumulative probability that approaches certainty after less than a year of unprotected sex (e.g., Reyna & Adam, 2003). Other high-risk groups who report high risk perception might, then, be those who had experienced bad outcomes more frequently. On analogy with the experiential learning studies such as the Bechara card task, however, some adolescents might be less able to learn from experience, persisting in self-destructive behaviors despite negative outcomes.

Although available evidence that bears on this experiential explanation is not yet extensive, preliminary support can be found in a handful of studies. In a longitudinal study of 395 adolescents, Goldberg, Halpern-Felsher, and Millstein (2002) reported that “good” alcohol outcomes were significantly related to later increases in drinking. In another longitudinal study, Katz, Fromme, and D’Amico (2000) found similar results for drug use (positive outcome experience at time 1 was associated with subsequent drug use at time 2)—but results for alcohol did not mirror the Goldberg et al. study. Any experience—with positive or negative outcomes—was positively associated with subsequent heavy alcohol use. A few studies have examined the effect of negative outcomes on risk perception rather than on risk-taking behaviors. Failing to experience negative outcomes

⁷One might question whether estimates of personal or objective risk have any stability or whether adolescents understand probability scales. First, estimates of objective risk sometimes differ by orders of magnitude from actual risk, so that an inference that objective and subjective estimates differ is probably a safe bet (e.g., Reyna & Adam, 2003). Second, statistically significant relations between risk estimates and other measures show that risk estimates have some degree of reliability. If adolescents could not use such scales reliably, risk estimates could not covary reliably with other measures. This is not to say that responses are interval scale measures or that respondents do not have any difficulties interpreting risk or probability scales.

decreased risk perception for drinking and driving in one study (Nygaard, Waiters, Grube, & Keefe, 2003). However, Halpern-Felsher, Millstein, Ellen, Adler, Tschann, and Biehl (2001) found that adolescents with negative experiences rated their risks for driving drunk, STDs, HIV, and pregnancy as lower than inexperienced adolescents did.

It is possible to imagine causal scenarios that might reconcile these apparently conflicting results. For example, a set of factors might dispose some adolescents to underestimate risks and, thus, to engage in risky behaviors. Once negative outcomes were experienced—which would vary as a function of the rarity of those outcomes and the vagaries of personal experience—perceptions of risk could increase and, then, exceed those of adolescents not disposed to engage in risky behaviors. (Conversely, extensive risk taking without experiencing negative outcomes would lead to complacency and lowered risk estimates.) Additional studies with longitudinal designs and better measures of putative causal factors are essential in order to disentangle the roles of risk perception and experience in explaining risky behavior.

Beyond these recommendations about longitudinal designs and improved measures, however, more sophisticated causal models that can be tested experimentally, as well as examined using correlational techniques, are also required. Opposing causal forces (events that both increase and decrease risky behavior for different underlying reasons) would need to be specified, properly measured, and actively manipulated. In other words, process models of adolescent risky decision making are needed. Hypothesis-driven research with true experiments would represent a sea change from the usual approach in this literature, which mainly consists of correlating survey ratings. Making experiments relevant to real-world problems requires ingenuity, but behavior in some laboratory risky decision-making tasks has been found to generalize to real life (e.g., Bechara et al., 1994; Zuckerman, 1994; 1999). As these conflicting results about perceived vulnerability so readily demonstrate, correlational and observational studies are necessary in studying adolescent risk taking, but they are not sufficient. If we are to solve practical problems produced by adolescent risk taking, we must have a deeper understanding of causal processes. The time has come for a more theory-driven approach in which alternative process models are tested in the laboratory and the real world.

Although the literature comparing risk perceptions of low- and high-risk adolescents has yielded contradictory findings, a clearer picture has emerged from comparing risk perceptions across age groups. Such developmental comparisons have focused on adolescents versus adults, because of developmental theories such as Elkind's (1967) that characterize adolescence as a fantasy period of personal fables, imaginary audiences, and feelings of invulnerability. Despite the lack of systematic evidence for Elkind's theory, the belief that adolescents consider themselves to be invulnerable is widespread among clinicians and members of the public; it is considered a truism and has

rarely been challenged. However, Fischhoff and Quadrel (1991) compared 86 matched pairs of adolescents and parents and found that adolescents did not exhibit the optimistic bias more than adults did (see also Millstein, 1993; Quadrel, Fischhoff, & Davis, 1993). In fact, both groups viewed parents as being at lower risk (i.e., as relatively less vulnerable) than adolescents. Quadrel et al. also examined beliefs about absolute invulnerability by comparing how many adults and adolescents affirmed that they were facing "no risk at all" for a given event such as an automobile accident. Again, subjects exhibited an optimistic bias because they assigned no risk about twice as often to themselves as to comparable acquaintances and friends; parents were also seen as at no risk more often than adolescents were, by both themselves and the adolescents. These results run contrary to Elkind's hypothesis that adolescents perceive themselves to be more invulnerable than adults perceive themselves to be.

In this connection, Millstein and Halpern-Felsher (2002a) noted that questions about risk should specify conditions that affect risks (e.g., risk of STDs if one has sex without a condom) and that parents who volunteer with their children for studies of risk may differ systematically from other, unrelated adults. Therefore, they compared risk estimates of 14 outcomes (ranging from natural hazards to personal risks, such as getting an STD) from 433 adolescents to those of 144 unrelated, childless adults, using specific questions. As in the earlier studies, adolescents gave significantly higher assessments of their own risk, compared to adults, even when differences in numeracy (the ability to think quantitatively) were controlled for. A greater proportion of adults (23.6%) demonstrated absolute invulnerability (risk estimates of 0%) than adolescents did (14.0%), again replicating earlier results. Boone, Lefkowitz, Romo, Corona, Sigman, and Kit-Fong Au (2003) found similar results for 111 Latino mother-adolescent pairs; adolescents believed that they were more at risk for AIDS than their mothers (see also Whaley, 2000).

Cohn et al. (1995) examined perceptions of both harmfulness and invulnerability, comparing 376 adolescents to 160 parents for the leading causes of their morbidity and mortality. These researchers, too, replicated age differences in results for optimistic bias, finding adolescents to be less optimistic than their parents were about avoiding injury and illness. However, they also found that adolescents rated experimental, occasional, and frequent engagement in risky activities as significantly less harmful than their parents did. Adolescent-parent differences were largest when the researchers evaluated the harmfulness of trying an activity "once or twice." The latter finding is consistent with fuzzy-trace theory's prediction (demonstrated in laboratory tasks, e.g., Reyna & Ellis, 1994) that adults process risks categorically or qualitatively rather than as a matter of degree, reflecting a developmental shift toward greater gist-based reasoning with age and experience (Reyna, 2004a; Reyna et al., 2005). In other words, adults would be more likely than adolescents to think about activities as harmful or not, rather than

making fine-grained distinctions about low frequencies of exposure to potential harm.

Consistent with these findings about perceived harmful consequences, Beyth-Marom, Austin, Fischhoff, Palmgren, and Jacobs-Quadrel (1993) reported that adults spontaneously provided more consequences for decisions (e.g., to drink and drive or smoke marijuana), and Halpern-Felsher and Cauffman (2001) reported that adults were more likely than adolescents were to spontaneously mention risks and benefits associated with decisions (see also Slovic, 1998). Overall, there was a modicum of evidence for differences in the ability to spontaneously consider outcomes or consequences of risk taking (see also Baron & Brown, 1991; Furby & Beyth-Marom, 1992). However, developmental differences between adolescents and adults in perceived harmfulness were generally small, and research directly addressing invulnerability uniformly disputed the widespread belief that adolescents think that they are more invulnerable than adults.

It is possible for relative risk perceptions of adolescents and adults to be ordered correctly, but for absolute risk perceptions to fall far from their objective marks. For a limited number of risks, each groups' estimates can be compared to actuarial or published estimates. Millstein and Halpern-Felsher (2002a) found that adolescents were more likely than adults were to overestimate risks for every outcome that could be evaluated, including low-probability events such as hurricanes, earthquakes, and HIV transmission from unprotected sex, as well as higher-probability events such as acquiring an STD (e.g., gonorrhea and chlamydia; Fig. 11). Fischhoff, Parker, Bruine de Bruin, Downs, Palmgren, Dawes, and Manski (2000) reported outcome expectations for a nationally representative sample of 3,544 adolescents from the 1997 National Longitudinal Study of Youth. Adolescents' estimates were close to actual statistical norms (e.g., the probability of becoming a mother by age 20), or they overestimated risks (e.g., the probability of serving time in jail or prison by age 20). The probabilities given to "die from any cause—crime, illness, accident, and so on" in the next year or by age 20 were much higher than statistical estimates.

Halpern-Felsher, Millstein, Ellen, Adler, Tschann, and Biehl (2001) also found consistent overestimation of eight risk-related outcomes—three related to alcohol, three related to unprotected sex, and two related to natural hazards. In other studies, adolescents have been found to overestimate some risks and to underestimate others (Cvetkovich & Grote, 1983; Foreit & Foreit, 1981; Kershaw, Ethier, Niccolai, Lewis, & Ickovics, 2003; Namerow, Lawton, & Philliber, 1987; Quadrel, 1990). Within adolescence, age trends in risk perception have been inconsistent, although there is some suggestion that risk perception decreases (Bernstein & Woodall, 1987; Brynin, 1999; Lundborg, & Lindgren, 2002; Smith & Rosenthal, 1995) or is U-shaped (Urberg & Robbins, 1984; for a review see Millstein & Halpern-Felsher, 2002b). (Once again, experience may play a role in older adolescents' decreased perception of risks; en-

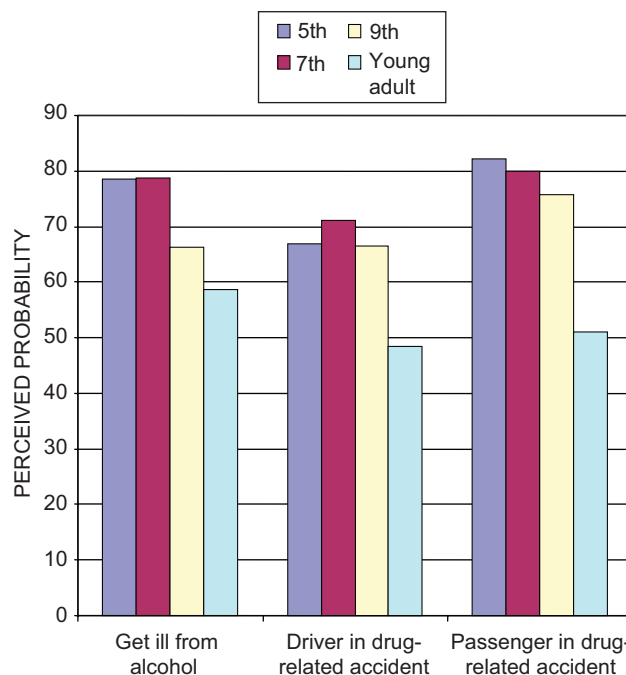


Fig. 11. Perceived probability of getting ill from alcohol, being the driver in a drug-related accident, and being the passenger in a drug-related accident for 5th, 7th, and 9th graders and a comparison group of young adults (based on Millstein & Halpern-Felsher, 2002a).

gaging in risk taking without immediate consequences may lower risk estimates.) Although there is some variability in the direction of differences between objective and subjective risk estimates, adolescents typically overestimate important risks, such as those associated with HIV infection, alcohol use, and smoking (i.e., lung cancer risk, Romer & Jamieson, 2001; Fig. 12).

If adolescents often overestimate risks and they do not perceive themselves to be invulnerable, then why do they engage in risky behaviors? Many proponents of the behavioral decision-making approach and of other rational models have argued that perceptions of benefits outweigh perceptions of risks. Consistent with this view, Halpern-Felsher, Biehl, Kropp, and Rubinstein (2004) found that adolescents who had tried smoking rated benefits higher (and risks lower) than did those who had never tried smoking; ratings of both benefits and risks were significant predictors of behavioral experience and intentions. Gilpin and Pierce (2003) also found that smokers were more likely to view smoking as beneficial. Goldberg et al. (2002) reported a similar pattern of perceived benefits and risks for experience with alcohol (see also Fromme, Katz, & Rivet, 1997; Parsons, Halkitis, Bimbi, & Borkowski, 2000). Parsons et al. (1997) found that perceived benefits were a stronger predictor of behavioral intention and change than were perceived risks for five risk-behavior categories; Benthin, Slovic, and Severson (1993) reported similar results for a larger sample of 30 activities but a smaller sample of students. Shapiro, Siegel, Scovill, and Hays (1998)

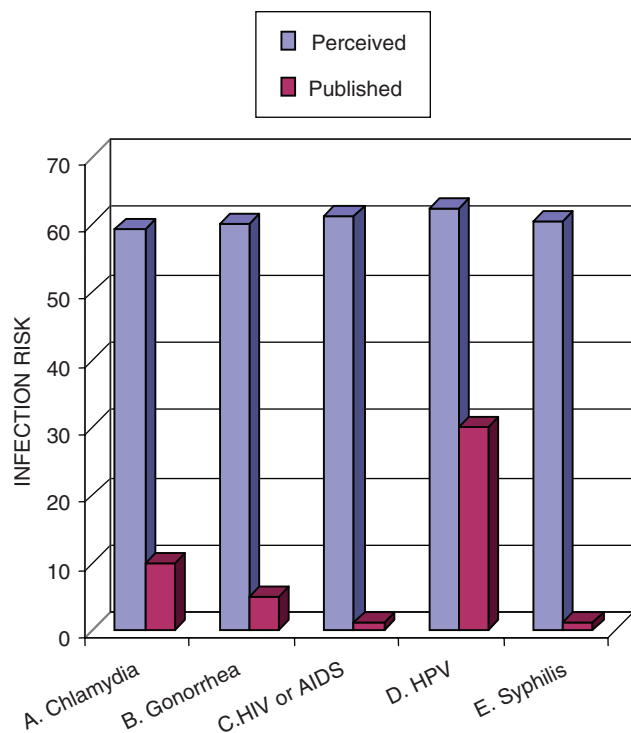


Fig. 12. Perceived probability, as judged by 254 9th to 12th graders, that a sexually active teenage girl would be at risk for sexually transmitted infections, compared to published estimates of risk (based on Reyna & Adam, 2003, and unpublished data).

found that perceived benefits were a significant predictor of a broad range of risky behaviors (from sexual to financial), but perceived risks were not significant (see also Ben-Zur & Reshef-Kfir, 2003). Only one study found that perceived risk was a better predictor of behavior than perceived benefits, but even that study found that both were significant (Rolison & Scherman, 2002). Thus, as rational decision-making theories suggest, consideration of the role of benefits is important in predicting adolescent risk taking: Perceived benefits may loom larger than perceived risks and offset them.

In summary, the key descriptive findings regarding adolescents' perception of risks are these:

- Much like adults do, most adolescents exhibit an optimistic bias, in which they view their own risks as less than those of comparable peers
- Research with adults suggests that this optimistic bias is probably due to egocentric focus rather than motivational factors, but little research on this point has been done with adolescents
- Objectively higher-risk groups sometimes estimate their risk as higher, and sometimes as lower, than lower-risk groups do, but different ways of asking questions change the answers
- The role of experienced outcomes may also explain these variable findings but preliminary evidence on this point is meager

- The optimistic bias is no more prevalent in adolescents than it is in adults, and, indeed, adolescents perceive themselves as more vulnerable than adults do
- When subjective and objective estimates of risk can be compared, adolescents tend to overestimate important risks (although they may underestimate harmful consequences and long-term effects, such as addiction; Weinstein, Slovic, & Gibson, 2004)
- Despite overestimation of risks, perceived benefits may drive adolescents' reactive behaviors and behavioral intentions, thereby accounting for risk-taking behaviors

DEVELOPMENTAL DIFFERENCES IN JUDGMENT AND DECISION MAKING

Précis of Developmental Findings Discussed Thus Far

Throughout this monograph, we have pointed out robust developmental trends. Compared to adults, children and adolescents have been found to be less able to delay gratification, inhibit their behavior, plan for or anticipate the future, spontaneously bring consequences to mind, or learn from negative consequences; and adolescents do not view consequences as being as harmful as adults do, especially if risky behaviors are engaged in only "once or twice." Children and adolescents also behave more impulsively (beyond individual differences that may linger into adulthood), reacting to immediate temptations without thinking and discounting future rewards more heavily than adults do, and their goals evolve in predictable directions that promote healthier long-term outcomes. Brain maturation is incomplete in adolescence, and changes in particular structures of the brain have been linked (correlationally) to these developmental differences in behavior.

Cognitive differences include a shift toward categorical or qualitative gist-based thinking, which explains increases in cognitive illusions with age (reflecting greater social knowledge and other globally adaptive but locally flawed thinking processes); increases in risk aversion in laboratory tasks (degrees of risk and reward matter less with maturity, compared to winning something versus nothing); and developmental differences in how degree of harm is viewed (adults do not make as fine-grained distinctions between experimenting with risky behaviors once or twice and experimenting more often). Thus, some risk taking in adolescence may be the result of quantitative trading off of benefits against risks, which gives way to more categorical risk avoidance with age. We have argued that developmental trends can be used as clues about what is rational; specific behaviors or thought processes that increase with maturity and experience are likely to be more advanced than those that decrease.

Because of the developmental differences that we have described, highly sophisticated logical and probabilistic reasoning competence, which can be demonstrated in children as young as 5 and 6 years old, is often not manifested under real-world

conditions of risky decision making. The fact that the competence is present, albeit in a dormant form, could be exploited in prevention programs. Contrary to popular wisdom, adolescents see themselves as more vulnerable than adults do, and they typically overestimate important risks. This overestimation appears to decline after early adolescence, presumably as exploration increases and rare negative consequences are not experienced, encouraging complacency.

Development of Risk Preference, Probability Judgment, and Risky Decision Making

Many of the developmental differences we have discussed thus far are contingent on knowledge and experience. For example, younger adolescents are likely to perceive risks as being high because of health curricula designed to reduce risk taking (Fischhoff, 2005). As adolescents become older, exploration increases, and risk estimation may decrease because adverse outcomes are not experienced or are experienced as neither immediate nor catastrophic. Such effects are contingent because different developmental trajectories could be expected with different exposure to information about risks. More fundamental differences have to do with changes in understanding of risk and probability, and in the processes of decision making, as adolescents mature.

A review of studies of children's and adolescents' understanding of risk and probability reveal three major theoretical approaches (for reviews, see Hoemann & Ross, 1982; Reyna & Brainerd, 1994): neo-Piagetian (logician), information-processing (computational), and fuzzy-trace theory (intuitionist). Dual processes have been assumed in all three of these approaches so their levels of theoretical complexity are roughly comparable. (The latter is an important consideration because no one approach is destined to be more successful because it uses more complex machinery.) In the first two, logic and analytical computation are seen as the zenith of development, and each is contrasted with developmentally primitive, intuitive thinking. Although the essence of advanced thought is formal logic for neo-Piagetians (Keating, 1980; Ward & Overton, 1990) and efficient information storage, retrieval, and processing for computationalists (Moore, Dixon, & Haines, 1991; Schlottmann, 2000, but see 2001; Schlottmann & Anderson, 1994), both types of theorists describe good decision making in terms similar to behavioral decision theory. That is, good decision making involves systematically and exhaustively considering the probabilities and outcomes or consequences associated with each option; multiplicatively combining these probabilities and outcomes; and choosing the option with greater expected utility, according to the values and goals of the individual. Hence, development involves acquisition of precise quantitative rules and improvements in memory capacity or logical reasoning (or both), which allow the weighing of more quantitative dimensions, more systematically (e.g., Hoemann & Ross, 1982; Siegler, 1991). For excellent reviews of developmental research on judgment

and decision making, see Jacobs and Klaczynski (2002, 2005) and Haines and Moore (2003).

Developmental data pose two serious problems for these views. The data in question are two results showing early precocity in judgment and decision making and results showing late-persisting cognitive illusions (Jacobs & Klaczynski, 2002; Reyna & Brainerd, 1994). Regarding early precocity in probability judgment, functional measurement techniques have revealed subtle quantitative processing of probabilities (i.e., taking into account the ratio of numerical frequencies to estimate probabilities) much earlier than predicted by neo-Piagetian or information-processing theories (e.g., Acredolo, O'Connor, Banks, & Horobin, 1989). Other methodological advances have similarly shown quantitative trading off for probability judgments in children as young as 5 or 6 (Davidson, 1991; Jacobs & Potenza, 1991; Kerkman & Wright, 1988). Trading off of probabilities and magnitudes of outcomes in choice has also been demonstrated in young children (Reyna, 1996; Reyna & Ellis, 1994; Schlottmann, 2000, 2001; Schlottmann & Anderson, 1994). It should be noted that early precocity is more compatible with information-processing than with neo-Piagetian theories because of the stage assumptions of the latter (Brainerd, 1981). Using an information-processing approach, Klayman (1985), for example, highlighted continuities between 12-year-olds' multiattribute decision making in a bicycle-selection task and adults' decision making. Nevertheless, both information-processing and neo-Piagetian theories explicitly predict that young children lack the memorial and reasoning competence to make accurate probability judgments or to properly trade off probabilities and outcomes in decision making, a prediction that runs counter to the findings of published studies. Indeed, later research on the same multiattribute task used by Klayman (e.g., Davidson, 1991) has shown that younger children are more likely than are older children and adults to systematically and exhaustively consider attributes, reversing the predicted developmental trend.

Regarding results concerning cognitive illusions, a problem for both neo-Piagetian and information-processing developmental theories is that cognitive illusions demonstrated in adults have been found to increase throughout childhood and adolescence—again, the reverse of the predicted developmental trend (Table 3). To take but a few examples, the representativeness heuristic in probability judgment is illustrated by weighting individuating information (often information that allows an individual to be easily stereotyped) more than appropriate quantitative information such as relative frequencies. For instance, Jacobs and Potenza (1991) showed that first graders could correctly make object and social judgments based on relative frequencies: If there were five black socks and three blue socks in a drawer, children correctly predicted that drawing a black sock was more likely than drawing a blue sock. As children became older, however, they were increasingly likely to reject social judgments based on relative frequencies in favor of stereotypes; for example, judging pretty, outgoing girls as more

likely to be cheerleaders regardless of the low frequency of cheerleaders. In the absence of stereotypes, object judgments remained unbiased. Increases with age in the availability heuristic (judging that events that come to mind easily must be more probable than events that are difficult to think of, e.g., that death by homicide is more likely than death by cardiovascular disease because the former is easier to think of due to media coverage), the conjunction fallacy (judging that a conjunction of events is more probable than either event by itself, e.g., that being killed by a drunk driver is more likely than being killed in any vehicular accident, including those involving drunk drivers and those not involving drunk drivers), and other cognitive illusions in probability judgment have also been demonstrated (e.g., Davidson, 1995).

Similarly, Reyna and Ellis (1994) have shown that framing effects in decision making—shifts in choices for the same options when they are described in terms of gains rather than in terms of losses—increase during childhood and adolescence (reflection effects, shifts in choices when gains and losses *actually* differ, have been found early in childhood; Reyna, 1996; Reyna & Mattson, 1994; Rice, 1995). Using detailed visual props and instructions, children were presented with choices such as the following: a choice between one toy for sure versus a 50% chance of winning two toys and a 50% chance of winning zero toys (communicated by a spinner with two colored halves and with zip-lock bags containing two toys on one half and an empty bag on the other half). Preschoolers made choices based on the quantitative bottom line involving both the probability and outcome dimensions: Although they were generally risk seeking, preschoolers modulated choices between sure things and risky options based on the degree of risk and on the number of prizes. When risk was too high, they chose the sure but smaller number of prizes. Elementary schoolers based choices mainly on which option offered more prizes, ignoring the dimension of magnitude of probabilities. Adolescents were the most likely to be qualitative reasoners, basing choices on neither the degree of risk nor on the number of prizes, especially for small numbers of prizes; instead they preferred the sure option in the gain frame, because winning something for sure was better than taking a risk and maybe winning nothing. They preferred the risky option in the loss frame because possibly losing nothing was better than losing something for sure. Adults also have been shown to prefer making such decisions qualitatively rather than quantitatively, consistent with fuzzy-trace theory (Reyna & Brainerd, 1991b, 1995; neural-network models have recently incorporated similar assumptions, Frank & Claus, 2006). These kinds of counterintuitive findings that seem implausible on their face but are predicted by theory are the most informative in testing alternative explanations for behavior. Studies have been reported in which not all of these illusions increased with age (e.g., Klaczynski, 2001), but even these studies often fail to confirm the age decline predicted by Neo-Piagetian or information-processing theories. Naturally, poor reasoning has also been

found to decline with age (e.g., Klaczynski & Cottrell, 2004); the contradiction between increasing cognitive competence and increasing intuitive illusions with age (e.g., Arkes & Ayton, 1999) is precisely what dual-process theories attempt to explain.

How does fuzzy-trace theory accommodate the seemingly contradictory trends of early precocity and increasing cognitive illusions with age that we have discussed? These contradictions can be demonstrated within a single study. For example, older children can be shown to make accurate judgments and decisions about objects but fail to use the same concepts to make accurate social judgments and decisions (i.e., they exhibit task variability; Jacobs & Potenza, 1991; Reyna & Brainerd, 1994; Schlottmann, 2001). However, younger children are able to demonstrate sophisticated quantitative competence in social judgment tasks, and, according to fuzzy-trace theory, they would be more likely to approach such a task quantitatively than older children and adults, who are more likely to be qualitative gist processors. Cognitive illusions are generally based on qualitative gist-based processing—for example, of social stereotypes and other interpretive processing (e.g., specific evidence for gist-based processing has been obtained in the tasks listed in Table 3). The social judgments that elicit illusions, for example, are based on cultural knowledge of social stereotypes that increases with development. Hence, fuzzy-trace theory accommodates these seemingly contradictory results of early precocity and late-persisting illusions because it is a dual-processes theory; each process is necessary to produce one of the contradictory developmental trends, and indeed, particular assumptions about those processes were initially used to predict both trends (e.g., Reyna & Ellis, 1994; see also Reyna, 2005).

On the one hand, according to fuzzy-trace theory, early precocity is explained by the finding that analytical competence is present early; children who cannot even count, let alone multiply, are able to trade off mentally using perceptual estimations of magnitudes. The data show that children grasp the idea that probabilities trade off against magnitudes of outcomes, they perceptually estimate those magnitudes, and they perform rough mental multiplication (e.g., Huber & Huber, 1987; Reyna & Ellis, 1994; Schlottmann, 2001). For example, children estimate relative areas of spinners in a probability task and magnitudes of piles of prizes in a decision-framing task, and they make decisions roughly according to expected value (provided that the task has the right perceptual supports, e.g., that probability can be perceptually estimated by comparing colored areas of spinners and magnitudes of outcomes can be perceptually estimated by comparing the sizes of piles of prizes; Reyna & Brainerd, 1994).

On the other hand, according to fuzzy-trace theory, increases in cognitive illusions in childhood and adolescence are predicted because of the increased reliance during this period on intuitive qualitative (i.e., gist-based) thinking that reflects knowledge, including social knowledge, and experience (e.g., Reyna, 1996; Reyna & Adam, 2003). The increased reliance on intuitive qualitative thinking also explains surprising increases

in false memories during childhood and adolescence that parallel increases in false reasoning or illusions, and are explained on similar grounds (Reyna, Mills, Estrada, & Brainerd, in press). (Factors such as emotion and social values also figure in fuzzy-trace theory, but space does not permit their elaboration here; see Reyna, 2004a and Reyna et al., 2005.) Thus, fuzzy-trace theory is a dual-processes approach that assumes both early analytical competence and developmental increases in intuitive reasoning (as a result of greater experience and knowledge), and consequent increases in cognitive illusions based on gist (Table 3). These developmental assumptions are the opposite of those of information-processing (computational) and neo-Piagetian (logicist) theories.

What are the implications of these differing theories for interventions to change thinking and reduce adolescent risk taking? As we have discussed, dual processes offer a solution to the dilemma that advanced reasoners seem to exhibit both greater analytic thinking and more pronounced intuitive cognitive illusions. The difference between fuzzy-trace theory and traditional behavioral decision theory, however, is that the former generally encourages simple gist-based intuition as a way to improve thinking (e.g., Lloyd & Reyna, 2001; Reyna, 1991), whereas the latter encourages information-rich quantitative thinking as a way to improve thinking. Moreover, the most advanced thinking in fuzzy-trace theory is not necessarily deliberative and analytical but, rather, unconscious and intuitive, and vice versa for behavioral decision theory. Consistent with the former, Dijksterhuis et al. (2006) recently demonstrated that for complex decisions, such as buying a car, nondeliberative thought produced better results than conscious deliberation did. Thus, fuzzy-trace theory offers a view of decision makers that is antithetical to classical decision theory's probability-calculating, utility-maximizing individuals.

The implications of these different theories of development for reducing risk taking are straightforward and divergent. Neo-Piagetian theory suggests that the formal, abstract thinking required for ideal decision making is largely absent in early adolescence and, for that matter, in adulthood for many (Keating, 1980; Winer & McGlone, 1993)—and it cannot be easily taught. Maturation through stages offers the only hope for reducing risk taking (i.e., most adolescents will naturally grow out of this stage of development), and standard health curricula, with their emphasis on accurate risk perceptions and analytical deliberation about risks and benefits, should be of little use until quite late in development (for a detailed discussion of this “developmental learning” perspective, see Inhelder, Sinclair, & Bovet, 1974). Information-processing (computational) or behavioral decision theories, in contrast, suggest that instruction in careful deliberation can be taught as a matter of explicit description of options, thorough consideration of consequences, and rational rules for combining probabilities with outcomes (see also Moshman, 2004, for a not-dissimilar approach to rationality in terms of metacognition). As our earlier review of explanatory theories of

risky decision making and key findings indicates, adolescents appear to rationally consider risks and benefits to some extent in their decision making. Behavioral intentions, based on perceived benefits and risks, successfully predict some risky behaviors. Increasing perceptions of risks and decreasing perceptions of benefits would, in turn, be required to reduce risk taking. But a hallmark of behavioral decision theory is that perceptions of risks and benefits are accurate; if adolescents overestimate risks, for example, improving the accuracy of risk perceptions would logically increase risk taking—a rational decision, perhaps, but not necessarily desirable from a societal or long-term health perspective.

According to fuzzy-trace theory, however, mature decision makers should not deliberate about the degree of risk and magnitude of benefits if there is a non-negligible chance of a catastrophic health-compromising outcome (Baird & Fugelsang, 2004; Reyna & Ellis, 1994; Reyna et al., 2005; Fig. 13). (For research on what negligible or “nil” risks are, based on fuzzy-trace theory, see Stone, Yates, & Parker, 1994; but suffice it to say it is a fuzzy concept.) Consistent with this prediction, Baird and Fugelsang, for example, found that adolescents showed longer reaction time than adults in response to questions such as, “Is it a good idea to swim with sharks?” as well as more diffuse brain activation. Metaphorically speaking, adolescents should not deliberate about the number of bullets in the chamber of a gun in Russian roulette just because there is a high potential payoff. No amount of payoff can compensate for the possibility of death in Russian roulette (assuming that the decision maker is not destitute), and similar reasoning applies to the risk of HIV/AIDS. Because mature decision making involves gist-based qualitative reasoning (e.g., avoid catastrophic risk), per fuzzy-trace theory, adults do not trade off quantitatively under specific circumstances. Exhortations such as “it takes once” to become pregnant or contract AIDS do not mean that the probability is 100% but, rather, that the qualitative possibility of catastrophe is sufficient that the risk should be avoided. Similar reasoning explains why adults prefer sure things and avoid gambles even

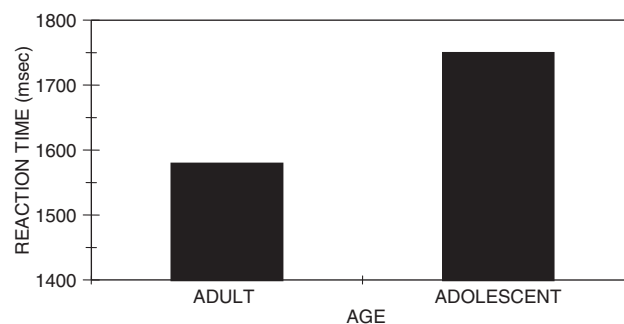


Fig. 13. Reaction time in milliseconds for adolescents and adults to questions such as, “Is it a good idea to set your hair on fire?”, “Is it a good idea to drink a bottle of Drano?”, and “Is it a good idea to swim with sharks?” (based on Baird & Fugelsang, 2004).

when expected values of gambles exceed that of the sure thing—when the gamble is taken once, decision makers will either end up winning something or winning nothing. The qualitative possibility of winning nothing is sufficient to avoid the risk, regardless of the probability of winning something (see Reyna et al., 2003).

The goal of instruction in fuzzy-trace theory, then, is to make gist-based decisions (involving risk-avoidant values) automatic and nondeliberative. Success in training reasoning using fuzzy-trace theory has been achieved with children (Reyna, 1991) and adults (Lloyd & Reyna, 2001), and experimentation is in progress on instruction to reduce adolescent risk taking. To be sure, the implications of fuzzy-trace theory and behavioral decision theory are diametrically opposed, the latter encouraging trading off risks and rewards and the former discouraging such trading off. Because some adolescent decisions appear to be reactive (as in behavioral willingness), rather than rationally deliberative (as in behavioral intentions), a combination of approaches could be more effective than either of them alone (Gerrard, Gibbons, Brody, Murry, Cleveland, & Mills, in press).

GENERAL DISCUSSION: IMPLICATIONS OF DATA AND DEVELOPMENT FOR RISK REDUCTION AND AVOIDANCE

Interventions to reduce risk taking have been developed from explanatory models, and those that combine multiple components have achieved limited success in changing behavior (see, for example, Baron & Brown, 1991; Kirby, 2001; Romer, 2003, for reviews). These components have traditionally included perceptions of risks, benefits, social norms, perceived control, and self-efficacy, as well as practiced skills, such as refusal skills for rejecting sexual activity (for a review of randomized controlled trials for interventions to reduce premature pregnancy and sexually transmitted diseases, see Reyna et al., 2005). Traditional models incorporate these components in a behavioral decision framework that, despite differences in individual models, generally emphasizes conscious behavioral intentions and expectations rather than unconscious emotional and cognitive reactions to environmental triggers. For some adolescents, the traditional models seem to apply; these adolescents take risks because perceived benefits outweigh risks, and long-term consequences are not considered or are undervalued. For other adolescents, the evidence indicates that behavioral willingness and perceptions of the gist or images involved in a decision determine risky behavior. These adolescents do not intend or expect to take risks, and their own rational deliberation might favor behaviors that are different than the actions they have taken impulsively or under the influence of emotion. Still other adolescents, and mature adults, apparently resist taking risks not out of any conscious deliberation or choice but because they intuitively grasp the gists of risky situations, retrieve appropriate risk-avoidant values, and never proceed

down the slippery slope of actually contemplating tradeoffs between risks and benefits.⁸

The policy implication for the first group of adolescents, the risky deliberators, is that traditional behavioral decision making approaches, such as health-belief models or the theory of planned behavior, should be effective in reducing risk taking, provided that adolescents can be convinced that risks outweigh benefits or that competing benefits are more desirable (e.g., playing sports, staying in school). This approach would backfire if, as is likely, adolescents discover that risks are lower than they believed or, for the third group of intuitive gist-based decision makers, that analyzing risks and benefits favors risk taking. The second group of adolescents, the risky reactors, will be unaffected by traditional interventions because risk taking for them is spontaneous and disjoint from rational contemplation of risks and benefits. Gist-based interventions could be more effective for the second and third groups—interventions that stress automatic (nonconscious) encoding of cautionary cues in the environment (getting the gist of risky situations) and repeated practice at retrieving and implementing risk-avoidant values in simulated contexts. Although research supports effectiveness of some pieces of such an intervention, this approach has not been widely extended to reducing risk taking in field-based studies. Clearly, development of psychometric instruments, including behavioral measures, that successfully distinguished the different kinds of risk takers and avoiders would be crucial for matching adolescents with the kinds of programs that are likely to be effective for them (although these mappings may change over time and decision domains, in contrast to those for stable traits such as thrill seeking).

Most traditional interventions, such as the ones we have just discussed, involve verbal instruction (although role playing and skills practice are increasingly used). However, recent laboratory research has shown that decisions reverse when risks are described verbally versus experienced as outcomes in a learning task. That is, risky options are avoided when they are described verbally but are preferred when outcomes are experienced (in both instances, risks are rare, such as for HIV infection, and accompanied by benefits). For this reason, the role of experience is increasingly prominent in theories of risky decision making. For example, intuitions about risky situations are generally not innate (although evolution factors into social perceptions) but, rather, arise mainly from social learning and experience. As dramatically illustrated in Figure 9, the ability to learn from

⁸Although we discuss these typologies of risk takers and avoiders as though they applied to different people (and there are broad developmental and individual differences), the truth is more complicated. A dominant decision-making approach may occasionally give way to a less preferred mode. For different decisions, the same person may be a risky reactor, a risky deliberator, or an intuitive (gist-based) risk avoider. Hence, the mature adult (or adolescent) may have lapses of maturity. The phrase “never proceed down a slippery slope” properly applies to decisions rather than people, and applies to those instances in which the decision maker has avoided the risky route. None of this should be interpreted to mean that there are not reliable differences across age groups and across individuals.

experienced outcomes, good and bad, develops considerably with age, from childhood through young adulthood. The implication for policy is that younger children and adolescents should be sheltered from risky experiences and supervised to thwart negative exploration; they will not be able to benefit from negative experiences. Furthermore, experience with risk-taking behaviors in the absence of negative consequences may increase feelings of invulnerability, which would explain the decrease in risk perceptions from early to late adolescence as exploration and experience accrue. This kind of approach acknowledges that, until adolescents are able to make better decisions, it is important to modify the environments in which they develop, rather than simply focus on improving their decision processes.

Neuropsychological research and research on impulsivity, sensation seeking, and related concepts indicate that some individuals will have greater difficulty learning from negative outcomes, especially outcomes that are mixed (that have some benefits or pleasures associated with them) or are negative over the long run rather than immediately. Valid and reliable measures of some of these individual differences exist today and have predictive validity for certain real-life functioning. The policy questions are whether early identification can be applied fairly across racial and ethnic groups and whether identification will cause more harm than good (Farley, 1996). More importantly, it is not clear how effective interventions to counteract individual differences are or how effective they could be, given appropriate early identification. The latter question, like many we have considered, is an empirical one that can be answered with further research. It is clear, however, that merely informing impulsive, sensation-seeking, or neurologically less-developed adolescents about risks is unlikely to be effective. Other traits or states that make adolescents more vulnerable to risk taking, such as depression, can be effectively treated, and early identification for those conditions is likely to reduce unhealthy behaviors such as risky sexual activities (Romer, 2003). External social factors, such as the presence of peers, continue to be borne out as contributors to adolescent risk taking, and policies that reduce social pressures, such as restricting the number of passengers for beginning drivers, are supported by research.

As this discussion illustrates, the effectiveness of interventions differs depending on the underlying causes of risky behaviors. In a literature dominated by correlational studies, however, there is great need for better causal models of risky behavior and for study designs, such as longitudinal and experimental designs, that permit causal inferences. One of the areas in which this need for causal research is dramatically demonstrated is the heavily researched question of how risk perception is related to risk-taking behavior. Despite the large quantity of research on this question, the answer is far from clear. Contradictory findings have emerged regarding relations between risk perceptions and behavior—i.e., perceiving risks to

be high is either a protective factor associated with lower risk taking, as rational models assume, or, conversely, is recognized by adolescents as part and parcel of their risk-taking behaviors. Conditional assessments and other methodological improvements have clarified some of these relations. However, research that merely catalogs behaviors or correlates variables is simply not adequate for testing sophisticated causal hypotheses that are required for confident applications in the real world. Translational research should explicitly address how basic causal mechanisms transfer, or fail to transfer, from the laboratory to consequential real-world settings.

Although additional research is needed, certain key findings from the extant literature are particularly informative about the causes and remediation of risky behaviors in adolescence. The theories of adolescent risk taking that we have discussed can be evaluated by their ability to accommodate counterintuitive findings such as the following:

- Despite conventional wisdom, adolescents do not perceive themselves to be invulnerable, and perceived vulnerability declines with increasing age
- Although the object of many interventions is to enhance the accuracy of risk perceptions, adolescents typically overestimate important risks such as HIV and lung cancer
- Despite increasing competence in reasoning, some biases in judgment and decision making grow with age, producing more “irrational” violations of coherence among adults than among adolescents and younger children. (This occurs because of a known developmental increase in gist processing with age, which also accounts for developmental increases in risk aversion.)

An implication of these findings is that traditional interventions stressing accurate risk perceptions are apt to be ineffective or backfire because young people already feel vulnerable and overestimate their risk.

This descriptive analysis of actual decision making can be compared to a normative analysis in order to determine where performance falls short of a normative ideal and how much those failures matter.⁹ A normative analysis based on coherence criteria (e.g., is the thinking process behind these decisions logical?) has the important virtue that it defines a minimum criterion for good decision making. Correspondence criteria, such as whether there are positive outcomes that result from behaviors, are also important for evaluating decision performance, despite the difficulty in applying such criteria to single cases and despite the conflict between evolutionarily selected behaviors, such as early procreation, and positive outcomes in a modern society. Although decision-specific performance evaluations are possible and to some extent necessary, there is obviously value to general theories of decision performance—which not only

⁹Note that, in this section, we use the word “descriptive” in its more encompassing meaning in decision-making research, to refer to any empirical research—including theory-driven explanatory and predictive research—about what people actually do, in contrast with normative ideals or prescriptions.

predict performance in multiple settings but also identify the psychological processes producing them. In addition to their inherent theoretical interest, those processes provide indications for improving performance.

The normative analysis that we discussed distinguishes what is rational, good, healthy, or adaptive, coming down on the side of promoting positive long-term physical and mental health outcomes (i.e., correspondence criteria for rationality, but modified to reflect developmental differences between adolescents and adults). We also argue that coherence can promote healthy outcomes under specific circumstances, and that coherence in itself is a separate and valuable indication of a rational decision process. We reject the argument that behaviors are adaptive simply because people engage in them, which is a misunderstanding of evolutionary theory. People who take unhealthy risks often agree that their behavior is irrational, on sober reflection, but they gave in to temptation or were not thinking at the time of the decision and are worse off for having done so. In this review, we have identified two kinds of evidence that favor our definition of rational risk taking: (a) outcomes evidence showing that a significant number of adolescents who are impulsive (i.e., have difficulty delaying gratification), are sensation seeking, are thrill seeking, are motivated by affect, have negative affect and avoidant personalities, or are otherwise reactive to immediate emotions have poorer social, economic, and health outcomes than those who are lower on each of these dimensions; and (b) developmental evidence, both ontogenetic and phylogenetic, showing that these behaviors, and risk-taking preference generally, decline with development and that concomitant negative outcomes also decline. (Although the literature has focused on poor life outcomes, the potential for positive outcomes has received little attention; see above and Farley, 2001.) However, differences in risk-taking propensity may provide sufficient variation in behaviors across individuals to garner the potential benefits for society that come from seeking challenge, creating innovation, and taking healthy risks.

Normatively ideal decision making need not be achievable by any human being; it provides a paragon to which humans should aspire, but the prescribed processes used to approach that goal need not resemble ideal reasoning (e.g., a slightly sloppy process might bring human decision makers closer to the goal than a strictly logical one). Prescriptive approaches bridge the gap between the normative and the descriptive accounts, focusing on those decisions that matter most. Such approaches can be generally divided into persuasive and nonpersuasive. The latter follow most directly from the *laissez faire* perspective of traditional decision theory, which makes no judgments about the desirability of adolescents' goals. Best codified in the procedures of decision analysis, these approaches attempt to help decision makers understand their situations and themselves well enough to reach the best choice of their own accord. Decision analysis reflects both a philosophical commitment to decision-maker autonomy and a practical faith in its possibility.

Persuasive approaches may arise from challenging either assumption. That is, they may reflect the belief that it is one's duty to instruct others about what they should do, or resignation to the practical necessity of doing so in situations in which effective independent action is too risky. Known developmental differences in temporal discounting, impulsivity, and future orientation between adolescents and adults favor persuasive approaches.

This distinction or, rather, continuum between persuasion and nonpersuasion is reflected in the main approaches to risk reduction and avoidance. Some approaches have focused on how adolescents evaluate risks and benefits (e.g., abstinence programs stressing the benefits of avoiding sex outside of marriage). Some have focused on how adolescents estimate the probabilities of these outcomes (e.g., social-norms programs countering the pluralistic ignorance leading adolescents to overestimate the frequency of risk behavior, and hence the chance of being socially approved). Some have focused on changing those probabilities (e.g., social-skills training programs cultivating refusal skills). Some have focused on increasing adolescents' general judgment and decision-making skills. Some have focused on increasing adolescents' reliance on these skills (e.g., by teaching emotional control or directing conflicts to mediation). Some have tried to reshape adolescents' world, so that they have better options from which to choose, so that even poor choices have less drastic consequences.

The limited effectiveness of these programs in the short term and their tendency to wane in effectiveness in the long term (e.g., more than 6 months to a year) suggest not that intervention is futile but that the incorporation of additional explanatory and predictive factors is needed to reduce adolescent risk taking (or, alternatively, to acknowledge the rationality or adaptiveness of risk-taking behaviors in this population in the environments they face). According to fuzzy-trace theory, for example, effective interventions should stress more enduring qualitative (rather than quantitative) gist representations of risk and should facilitate the developmental progression from analytical processing of risks and rewards (e.g., trading off) to intuitive all-or-none categorical avoidance of dangerous risks. (A randomized field trial is currently underway to test this approach.) Alternatively, better ways to inculcate rational trading off may reduce intentional risk taking, consistent with behavioral decision theory.

More generally, most interventions to reduce risk taking aim to enhance the accuracy of risk perceptions, to overcome adolescents' belief that they are invulnerable, and to transform intuitive, biased adolescent decision makers into analytical, unbiased adults. Ironically, according to the data, each of these aims is misguided. To the extent that adolescents base decisions on precise notions of risk, enhancing accuracy is likely to lower some risk perceptions and thereby increase risk taking. Because adolescents already believe they are at greater risk than adults, and objectively higher-risk adolescents often correctly believe

that they are at greater risk than lower-risk adolescents are, devoting energy to combating feelings of invulnerability would seem to be a waste. Adolescents take risks even though they realize that they are vulnerable to undesirable consequences; according to fuzzy-trace theory, they are taking calculated risks that are “worth it” from a compensatory quantitative perspective. However, from a global categorical perspective (e.g., avoid catastrophic risks as a first principle) that is shared by most adults, these risks are not worth it. In the latter view, counting the number of bullets in the chamber of the gun does not make Russian roulette a rational choice.

Finally, data suggest that analytical reasoning is the preferred mode of decision making in childhood and, to some extent, in adolescence, and is a source of developmental differences in preferences for risk. That is, controlled experiments have shown that risk taking declines with increasing age, even without peer influences or motivating social contexts, apparently because analytical processing of risks and rewards gives way to the cruder, qualitative processing that produces phenomena such as risk avoidance, framing effects, and other biases. The implications of recent data are that enhancing the precision and comprehensiveness of information and integrating it more precisely and comprehensively are unlikely to yield anything other than incremental improvements in risk reduction and avoidance. Regardless of the outcome of comparisons of alternative models

and interventions, however, the tripartite division of behavioral decision theory into normative, descriptive, and prescriptive considerations will remain a useful meta-theoretical framework for evaluating policy implications—regarding the gambles to take with adolescents’ welfare, given our current state of knowledge—and research implications—regarding critical normative, descriptive, and prescriptive gaps in our understanding.

In sum, there are some fundamental principles that emerge from our review of theory and data. They can be exploited immediately to fine-tune ongoing interventions to reduce adolescent risk, to design more effective interventions, and to guide research on interventions. For ease of reference, they are set forth in Table 4.

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TABLE 4
Empirically Supported Recommendations for Policy and Practice

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1. Reduce risk by retaining or implementing higher drinking ages, eliminating or lowering the number of peers in automobiles for young drivers, and avoiding exposure to potentially addictive substances (rather than, for example, exposing minors to alcohol to teach them to drink responsibly).
 2. Develop psychometric instruments that reliably distinguish risky deliberators who make decisions on the basis of perceived risks and benefits from those who merely react to environmental triggers.
 3. Develop reasoned arguments and facts-based interventions (including information about social norms) for the risky deliberators, focusing on reducing perceived benefits of risky behaviors (and increasing perceived benefits of alternative behaviors) and spelling out consequences of risk taking. For younger or less mature adolescents, short-term costs and benefits should be highlighted.
 4. Identify factors that move adolescents away from considering the degree of risk and the amount of benefit in risky behaviors toward categorical avoidance of major risks until they are developmentally prepared to handle the consequences.
 5. Monitor and supervise younger adolescents rather than relying on them to make reasoned choices or to learn from the school of hard knocks, especially if assessments indicate that they are willing to take risks that they neither intend nor expect to take. Remove opportunity (e.g., by occupying their time with positive activities).
 6. Practical self-binding strategies (avoiding situations that are likely to elicit temptation or that require behavioral inhibition) should be identified and encouraged.
 7. Encourage the development of positive prototypes (gists) or images of healthy behaviors and negative images of unhealthy behaviors using visual depictions, films, novels, serial dramas and other emotionally evocative media.
 8. Emphasize understanding of risk communications (e.g., why HIV, human papilloma virus, and herpes simplex virus are not treatable with antibiotics), and deriving the gist or bottom line of messages that will endure in memory longer than verbatim facts. Harmful consequences may not be understood because young people lack relevant experience; develop intuitive understanding of risky behaviors and their consequences.
 9. Do not assume that adolescents think that they are immortal. On the contrary, provide concrete actions that they feel capable of taking that will reduce their risk. Teach self-efficacy, help them practice skills, and show them how they can control specific risk factors.
 10. Provide frequent reminders of relevant knowledge and risk-avoidant values; even medical experts fail to retrieve what they know about sexually transmitted diseases without cues. (Repeating the same message over and over is likely to be ineffective, so changes in wording and presentation are required.)
 11. Provide practice at recognizing cues in the environment that signal possible danger before it is too late to act.
 12. Treat comorbid conditions, such as depression.
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REFERENCES

- Acredolo, C., O'Connor, J., Banks, L., & Horobin, K. (1989). Children's ability to make probability estimates: Skills revealed through application of Anderson's functional measurement methodology. *Child Development, 60*, 933–945.
- Adam, M.B., & Reyna, V.F. (2005). Coherence and correspondence criteria for rationality: Experts' estimation of risks of sexually transmitted infections. *Journal of Behavioral Decision Making, 18*, 169–186.
- Agnew, N.M., & Pyke, S.W. (1994). *The science game: An introduction to research in the social sciences*. Englewood Cliffs, NJ: Prentice Hall.
- Ainslie, G. (1992). *Picoeconomics: The strategic interaction of successive motivational states within the person*. Cambridge, England: Cambridge University Press.
- Ainslie, G. (2001). *Breakdown of will*. New York, NY: Cambridge University Press.
- Ajzen, I. (1989). Attitude structure and behavior. In A.R. Pratkanis, S.J. Breckler, & A.G. Greenwald (Eds.), *Attitude structure and function* (pp. 241–274). Hillsdale, NJ: Erlbaum.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179–211.
- Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.
- Amsel, E., Cottrell, J., Sullivan, J., & Bowden, T. (2005). Anticipating and avoiding regret as a model of adolescent decision-making. In J. Jacobs & P. Klaczynski (Eds.), *The development of judgment and decision-making in children and adolescence* (pp. 119–154). Mahwah, NJ: Erlbaum.
- Anderson, R.N., & Smith, B.L. (2003). Deaths: Leading causes for 2001. *National Vital Statistics Report, 52*(9), 1–86.
- Arkes, H.R., & Ayton, P. (1999). The sunk cost and Concorde effects: Are humans less rational than lower animals? *Psychological Bulletin, 125*, 591–600.
- Armitage, C.J., & Conner, M. (2001). Efficacy of the theory of planned behavior: A meta-analytic review. *British Journal of Social Psychology, 40*, 471–499.
- Arnett, J.J. (2000). Optimistic bias in adolescent and adult smokers and nonsmokers. *Addictive Behaviors, 25*, 625–632.
- Bachanas, P.J., Morris, M.K., Lewis-Gess, J.K., Sarett-Cuasay, E.J., Flores, A.L., Sirl, K.S., & Sawyer, M.K. (2002). Psychological adjustment, substance use, HIV knowledge, and risky sexual behavior in at-risk minority females: Developmental differences during adolescence. *Journal of Pediatric Psychology, 27*, 373–384.
- Baird, A.A., & Fugelsang, J.A. (2004). The emergence of consequential thought: Evidence from neuroscience. *Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences, 359*, 1797–1804.
- Baron, J. (2003). *Thinking and deciding*. Cambridge, England: Cambridge University Press.
- Baron, J., & Brown, R.V. (1991). *Teaching decision making to adolescents*. Hillsdale, NJ: Erlbaum.
- Baumeister, R.F. (2005). *The cultural animal: Human nature, meaning, and social life*. New York: Oxford University Press.
- Bechara, A., Damasio, A., & Damasio, H. (2000). Emotion, decision making, and the orbitofrontal cortex. *Cerebral Cortex, 10*, 295–307.
- Bechara, A., Damasio, A., Damasio, H., & Anderson, S. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*, 7–15.
- Becker, M.H. (1990). Theoretical models of adherence and strategies for improving adherence. In S.A. Shumaker, E.B. Schron, J.K. Ockene, C.T. Parker, J.L. Probstfield, & J.M. Wolle (Eds.), *Handbook of behavior change*. New York: Springer.
- Bell, D.E., Raiffa, H., & Tversky, A. (1988). *Decision making: Descriptive, normative, and prescriptive interactions*. Cambridge, England: Cambridge University Press.
- Benthin, A., Slovic, P., & Severson, H. (1993). A psychometric study of adolescent risk perception. *Journal of Adolescence, 16*, 153–168.
- Ben-Zur, H., & Reshef-Kfir, Y. (2003). Risk taking and coping strategies among Israeli adolescents. *Journal of Adolescence, 26*, 255–265.
- Bernstein, E., & Woodall, W.G. (1987). Changing perspectives of riskiness in drinking, drugs and driving: An emergency department based alcohol and substance abuse prevention program. *Annals of Emergency Medicine, 16*, 1350–1354.
- Beyth-Marom, R., Austin, L., Fischhoff, B., Palmgren, C., & Jacobs-Quadrel, M.J. (1993). Perceived consequences of risky behaviors: Adults and adolescents. *Developmental Psychology, 29*, 549–563.
- Beyth-Marom, R., Fischhoff, B., Quadrel, M.J., & Furby, L. (1991). Teaching decision making to adolescents: A critical review. In J. Baron & R.V. Brown (Eds.), *Teaching decision making to adolescents* (pp. 19–59). Hillsdale, NJ: Erlbaum.
- Bonnie, R.J., & O'Connell, M.E. (2004). *Reducing underage drinking: A collective responsibility*. Washington, DC: National Academies Press.
- Boone, T.L., Lefkowitz, E.S., Romo, L., Corona, R., Sigman, M., & Kit-Fong Au, T. (2003). Mothers' and adolescents' perceptions of AIDS vulnerability. *International Journal of Behavioral Development, 27*, 347–354.
- Brainerd, C.J. (1981). Working memory and the developmental analysis of probability judgment. *Psychological Review, 88*, 463–502.
- Brainerd, C.J., & Reyna, V.F. (2005). *The science of false memory*. New York: Oxford University Press.
- Brainerd, C.J., Reyna, V.F., & Mojardin, A.H. (1999). Conjoint recognition. *Psychological Review, 106*, 160–179.
- Breiner, M.J., Stritzke, W.G.K., & Lang, A.R. (1999). Approaching avoidance: A step essential to the understanding of craving. *Alcohol Research and Health, 23*, 197–206.
- Brewer, N.T., Chapman, G.B., Gibbons, F.X., Gerard, M., McCaul, K.D., & Weinstein, N.D. (in press). A meta-analysis of the relationship between risk perception and health behavior: The example of vaccination. *Health Psychology*.
- Brewer, N.T., Weinstein, N.D., Cuite, C.L., & Herrington, J. (2004). Risk perceptions and their relation to risk behavior. *Annals of Behavioral Medicine, 27*, 125–130.
- Brown, L., DiClemente, R., & Park, T. (1992). Predictors of condom use in sexually active adolescents. *Journal of Adolescent Health, 13*, 651–657.
- Brynin, M. (1999). Smoking behaviour: Predisposition or adaptation? *Journal of Adolescence, 22*, 635–646.
- Busemeyer, J.R., & Stout, J.C. (2002). A contribution of cognitive decision models to clinical assessment: Decomposing performance on the Bechara gambling task. *Psychological Assessment, 14*, 253–262.
- Busemeyer, J.R., Stout, J.C., & Finn, P. (in press). Using computational models to help explain decision making processes of substance

- abusers. In D. Barch (Ed.), *Cognitive and affective neuroscience of psychopathology*. New York: Oxford University Press.
- Byrnes, J.P. (1998). *The nature and development of decision making: A self-regulation model*. Mahwah, NJ: Erlbaum.
- Caffray, C.M., & Schneider, S.L. (2000). Why do they do it? Affective motivators in adolescents' decisions to participate in risk behaviours. *Cognition & Emotion, 14*, 543–576.
- Cardinal, R., & Howes (2005). Effects of lesions of the nucleus accumbens core on choice between small certain rewards and large uncertain rewards in rats. *BMC Neuroscience, 6*, 37. Retrieved June 6, 2006, from <http://www.biomedcentral.com/1471-2202/6/37>
- Centers for Disease Control and Prevention. (2004). Youth Risk Behavior Surveillance—United States, 2003. *Morbidity and Mortality Weekly Report, 53*(SS02), 1–96.
- Chaiken, S., & Trope, Y. (1999). *Dual-process theories in social psychology*. New York: Guilford.
- Chambers, R.A., & Potenza, M.N. (2003). Neurodevelopment, impulsivity, and adolescent gambling. *Journal of Gambling Studies, 19*, 53–84.
- Chambers, R.A., Taylor, J.R., & Potenza, M.N. (2003). Developmental neurocircuitry of motivation in adolescence: A critical period of addiction vulnerability. *American Journal of Psychiatry, 160*, 1041–1052.
- Chambers, J.R., & Windschitl, P.D. (2004). Biases in social comparative judgments: The role of nonmotivated factors in above-average and comparative-optimism effects. *Psychological Bulletin, 130*, 813–838.
- Chapin, J.R. (2000). Third-person perception and optimistic bias among urban minority at-risk youth. *Communication Research, 27*, 51–81.
- Chapin, J.R. (2001a). It won't happen to me: The role of optimistic bias in African American teens' risky sexual practices. *Howard Journal of Communications, 12*, 49–59.
- Chapin, J.R. (2001b). Self-protective pessimism: Optimistic bias in reverse. *North American Journal of Psychology, 3*, 253–261.
- Chassin, L., Pillow, D.R., Curran, P.J., Molina, B.S., & Barrera, M. (1993). Relation of parental alcoholism to early adolescent substance use: A test of three mediating mechanisms. *Journal of Abnormal Psychology, 102*, 3–19.
- Chassin, L., Presson, C.C., Rose, J.S., & Sherman, S.J. (2001). From adolescence to adulthood: Age-related changes in beliefs about cigarette smoking in a Midwestern community sample. *Health Psychology, 20*, 377–386.
- Cloninger, C.R., Svrakic, D.M., & Przybeck, T.R. (1993). A psychobiological model of temperament and character. *Archives of General Psychiatry, 50*, 975–990.
- Cohn, L.D., Macfarlane, S., Yanez, C., & Imai, W.K. (1995). Risk-perception: Differences between adolescents and adults. *Health Psychology, 14*, 217–222.
- Conner, M., & Sparks, P. (1996). The theory of planned behaviour and health behaviours. In M. Conner & P. Norman (Eds.), *Predicting health behaviour: Research and practice with social cognition models* (pp. 121–162). Buckingham, UK: Open University Press.
- Cooper, M.L., Agocha, V.B., & Sheldon, M.S. (2000). A motivational perspective on risky behaviors: The role of personality and affect regulatory process. *Journal of Personality, 68*, 1059–1088.
- Crawford, A.M., Pentz, M.A., Chou, C., Li, C., & Dwyer, J.H. (2003). Parallel developmental trajectories of sensation seeking and regular substance use in adolescents. *Psychology of Addictive Behaviors, 17*, 179–192.
- Crisp, B.R., & Barber, J.G. (1995). The effect of locus of control on the association between risk perception and sexual risk-taking. *Personality & Individual Differences, 19*, 841–845.
- Crone, E.A., & van der Molen, M.W. (2004). Developmental changes in real life decision-making: Performance on a gambling task previously shown to depend on the ventromedial prefrontal cortex. *Developmental Neuropsychology, 25*, 251–279.
- Crone, E.A., Vendel, I., & van der Molen, M.W. (2003). Decision-making in disinhibited adolescents and adults: Insensitivity to future consequences or driven by immediate reward? *Personality and Individual Differences, 34*, 1–17.
- Crosby, R.A., DiClemente, R.J., Wingood, G.M., Sionean, C., Cobb, B.K., Harrington, K., Davies, S.L., Hook, E.W., & Oh, M.K. (2001). Correlates of using dual methods for sexually transmitted diseases and pregnancy prevention among high-risk African-American female teens. *Journal of Adolescent Health, 28*, 410–414.
- Cvetkovich, G., & Grote, B. (1983). Adolescent development and teenage fertility. In D. Byrne & W.A. Fisher (Eds.), *Adolescents, sex and contraception* (pp. 109–123). Hillsdale, NJ: Erlbaum.
- Dahl, R.E., & Spear, L.P. (2004). *Adolescent brain development: Vulnerabilities and opportunities*. New York: New York Academy of Sciences.
- Davidson, D. (1991). Children's decision-making examined with an information-board procedure. *Cognitive Development, 6*, 77–90.
- Davidson, D. (1995). The representativeness heuristic and the conjunction fallacy effect in children's decision making. *Merrill-Palmer Quarterly, 41*, 328–346.
- Dawes, R.M. (1979). The robust beauty of improper linear models. *American Psychologist, 34*, 571–582.
- Dawes, R.M., & Corrigan, B. (1974). Linear models in decision making. *Psychological Bulletin, 81*, 95–106.
- Dempster, F.N. (1992). The rise and fall of the inhibitory mechanism: Toward a unified theory of cognitive development and aging. *Developmental Review, 12*, 45–75.
- Dijksterhuis, A., Bos, M.W., Nordgren, L.F., & van Baaren, R.B. (2006). On making the right choice: The deliberation-without-attention effect. *Science, 311*, 1005–1007.
- Doherty, M.E. (2003). Optimists, pessimists, and realists. In S.L. Schnieder & J. Shanteau (Eds.), *Emerging perspectives on judgment and decision research* (pp. 643–679). New York: Cambridge University Press.
- Downey, A.M., & O'Rourke, T.W. (1976). The utilization of attitudes and beliefs as indicators of future smoking behavior. *Journal of Drug Education, 6*, 283–295.
- Downs, J.S., Bruine de Bruin, W., Murray, P.J., & Fischhoff, B. (2004). When "it only takes once" fails: Perceived infertility predicts condom use and STI acquisition. *Journal of Pediatric and Adolescent Gynecology, 17*, 224.
- Dudley, C., O'Sullivan, L.F., & Moreau, D. (2002). Does familiarity breed complacency? HIV knowledge, personal contact and sexual risk behavior of psychiatrically referred Latino adolescent girls. *Hispanic Journal of Behavioral Sciences, 24*, 353–368.
- Edwards, W. (1954). The theory of decision making. *Psychological Bulletin, 51*, 380–417.
- Elkind, D. (1967). Egocentrism in adolescence. *Child Development, 38*, 1025–1034.
- Ellen, J.M., Boyer, C.B., Tschann, J.M., & Shafer, M. (1996). Adolescents' perceived risk for STDs and HIV infection. *Journal of Adolescent Health, 18*, 177–181.

- Epstein, S. (1994). Integration of the cognitive and psychodynamic unconscious. *American Psychologist*, *49*, 709–724.
- Eysenck, H.J. (1967). *The biological basis of personality*. Springfield, IL: Charles C. Thomas.
- Falmagne, R.J. (1975). *Reasoning: Representation and process in children and adults*. Hillsdale, NJ: Erlbaum.
- Farley, F. (1996). From the heart. *American Psychologist*, *51*, 772–776.
- Farley, F. (2001). A genetic model of creativity and the Type T personality complex with educational implications. In M.D. Lynch & C.R. Harris (Eds.), *Fostering creativity in children K-8* (pp. 71–77). Needham Heights, MA: Allyn and Bacon.
- Fergusson, D.M., & Lynskey, M.T. (1996). Alcohol misuse and adolescent sexual behaviors and risk taking. *Pediatrics*, *98*, 91–96.
- Finucane, M.L., Peters, E., & Slovic, P. (2003). Judgment and decision making: The dance of affect and reason. In S.L. Schneider & J. Shanteau (Eds.), *Emerging perspectives on judgment and decision research* (pp. 327–364). New York: Cambridge University Press.
- Fischbein, E. (1975). *The intuitive sources of probabilistic thinking in children*. Dordrecht: D. Reidel Co.
- Fischhoff, B. (2005). Development of and in behavioral decision research. In J.E. Jacobs & P. Klaczynski (Eds.), *The development of judgment and decision making in children and adults*. Mahwah, NJ: Erlbaum.
- Fischhoff, B., Parker, A.M., Bruine de Bruin, W., Downs, J., Palmgren, C., Dawes, R., & Manski, C.F. (2000). Teen expectations for significant life events. *Public Opinion Quarterly*, *64*, 189–205.
- Fischhoff, B., & Quadrel, M. (1991). Adolescent alcohol decisions. *Alcohol Health and Research World*, *15*, 43–51.
- Fischhoff, B., Slovic, P., & Lichtenstein, S. (1978). Fault trees: Sensitivity of assessed failure probabilities to problem representation. *Journal of Experimental Psychology: Human*, *4*, 330–344.
- Fishbein, M. (2003). Toward an understanding of the role of perceived risk in HIV prevention research. In D. Romer (Ed.), *Reducing adolescent risk: Toward an integrated approach*. Thousand Oaks, CA: Sage.
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.
- Fisher, W.A., Fisher, J.D., & Rye, B.J. (1995). Understanding and promoting AIDS-preventive behavior: Insights from the theory of reasoned action. *Health Psychology*, *14*, 255–264.
- Floyd, D.L., Prentice-Dunn, S., & Rogers, R.W. (2000). A meta-analysis of research on protection motivation theory. *Journal of Applied Social Psychology*, *30*, 407–429.
- Foreit, J.R., & Foreit, K.G. (1981). Risk-taking and contraceptive behavior among unmarried college students. *Population and Environment*, *4*, 174–188.
- Frank, M.J., & Claus, E.D. (2006). Anatomy of a decision: Striato-orbitofrontal interactions in reinforcement learning, decision making, and reversal. *Psychological Review*, *113*, 300–326.
- Fromme, K., Katz, E.C., & Rivet, K. (1997). Outcome expectancies and risk-taking behavior. *Cognitive Therapy & Research*, *21*, 421–442.
- Furby, L., & Beyth-Marom, R. (1992). Risk taking in adolescence: A decision-making perspective. *Developmental Review*, *12*, 1–44.
- Galvan, A., Hare, T.A., Parra, C.E., Penn, J., Voss, H., Glover, G., & Casey, B.J. (2006). Earlier development of the accumbens relative to orbitofrontal cortex might underlie risk-taking behavior in adolescents. *Journal of Neuroscience*, *26*, 6885–6892.
- Gardner, M., & Steinberg, L. (2005). Peer influence on risk taking, risk preference, and risky decision making in adolescence and adulthood: An experimental study. *Developmental Psychology*, *41*, 625–635.
- Garon, N., & Moore, C. (2004). Complex decision-making in early childhood. *Brain and Cognition*, *55*, 158–170.
- Geary, D.C. (2005). *The origin of mind: Evolution of brain, cognition, and general intelligence*. Washington, DC: American Psychological Association.
- Gerrard, M., Gibbons, F.X., Benthin, A.C., & Hessling, R.M. (1996). A longitudinal study of the reciprocal nature of risk behaviors and cognitions in adolescents: What you do shapes what you think and vice versa. *Health Psychology*, *15*, 344–354.
- Gerrard, M., Gibbons, F.X., Brody, G.H., Murry, V.M., Cleveland, M.J., & Wills, T.A. (in press). A theory-based dual focus alcohol intervention for pre-adolescents: The strong African-American families program. *Journal of Addictive Behavior*.
- Gibbons, F.X., Gerrard, M., Blanton, H., & Russell, D.W. (1998). Reasoned action and social reaction: Willingness and intention as independent predictors of health risk. *Journal of Personality and Social Psychology*, *74*, 1164–1181.
- Gibbons, F.X., Gerrard, M., & Lane, D.J. (2003). A social reaction model of adolescent health risk. In J. Suls, & K.A. Wallston (Eds.), *Social psychological foundations of health and illness. Blackwell series in health psychology and behavioral medicine* (pp. 107–136). Malden, MA: Blackwell.
- Gibbons, F.X., Gerrard, M., Vande Lune, L.S., Wills, T.A., Brody, G., & Conger, R.D. (2004). Context and cognitions: Environmental risk, social influence, and adolescent substance use. *Personality and Social Psychology Bulletin*, *30*, 1048–1061.
- Gigerenzer, G., & Regier, T. (1996). How do we tell an association from a rule? Comment on Sloman (1996). *Psychological Bulletin*, *119*, 23–26.
- Gigerenzer, G., & Selten, R. (2001). *Bounded rationality: The adaptive toolbox*. Cambridge, MA: MIT Press.
- Gigerenzer, G., Todd, P.M., & the ABC Group (1999). *Simple heuristics that make us smart*. New York: Oxford University Press.
- Gilovich, T., Griffin, D.W., & Kahneman, D. (2002). *Heuristic and biases: The psychology of intuitive judgment*. New York: Cambridge University Press.
- Gilpin, E.A., & Pierce, J.P. (2003). Concurrent use of tobacco products by California adolescents. *Preventive Medicine*, *36*, 575–584.
- Goldberg, J.H., Halpern-Felsher, B.L., & Millstein, S.G. (2002). Beyond invulnerability: The importance of benefits in adolescents' decision to drink alcohol. *Health Psychology*, *21*, 477–484.
- Gottfredson, M.R., & Hirschi, T. (1990). *A general theory of crime*. Stanford, CA: Stanford University Press.
- Greenberg, M.T., Domitrovich, C., & Bumbarger, B. (2000). The prevention of mental disorders in school-aged children: Current state of the field. *Prevention and Treatment*, *4*(1), Article 0001a. Retrieved June 6, 2006, from <http://journals.apa.org/prevention/volume4/pre0040001a.html>.
- Greenberg, M.T., Kusche, C.A., Cook, E.T., & Quamma, J.P. (1995). Promoting emotional competence in school-aged children: The effects of the PATHS curriculum. *Development and Psychology*, *7*, 117–136.
- Greening, L., & Stoppelbein, L. (2000). Young drivers' health attitudes and intentions to drink and drive. *Journal of Adolescent Health*, *27*, 94–101.
- Grisso, T., Steinberg, L., Woolard, J., Cauffman, E., Scott, E., Graham, S., Lexcen, F., Reppucci, N.D., & Schwartz, R. (2003). Juveniles' competence to stand trial: A comparison of adolescents' and

- adults' capacities as trial defendants. *Law and Human Behavior*, 27, 333–363.
- Grube, J. (2005, May). *Youth drinking rates and problems: A comparison of European countries and the United States*. Washington, DC: U.S. Department of Justice, Office of Justice Programs, Office of Juvenile Justice and Delinquency Prevention.
- Gullone, E., & Moore, S. (2000). Adolescent risk-taking and the five-factor model of personality. *Journal of Adolescence*, 23, 393–407.
- Haines, B.A., & Moore, C. (2003). Integrating themes from cognitive and social cognitive development into the study of judgment and decision making. In S.L. Schneider & J. Shanteau (Eds.), *Emerging perspectives on judgment and decision research* (pp. 246–286). New York: Cambridge University Press.
- Halpern-Felsher, B.L., Biehl, M., Kropp, R.Y., & Rubinstein, M.L. (2004). Perceived risks and benefits of smoking: Differences among adolescents with different smoking experiences and intentions. *Preventive Medicine*, 39, 559–567.
- Halpern-Felsher, B.L., & Cauffman, E. (2001). Costs and benefits of a decision: Decision-making competence in adolescents and adults. *Journal of Applied Developmental Psychology*, 22, 257–273.
- Halpern-Felsher, B.L., Millstein, S.G., Ellen, J.M., Adler, N., Tschann, J., & Biehl, M. (2001). The role of behavioral experience in judging risks. *Health Psychology*, 20, 120–126.
- Harman, G. (1986). *Change in view*. Cambridge, MA: MIT Press.
- Hemmelstein, N. (1995). Adolescent marijuana use and perception of risk. *Journal of Alcohol & Drug Education*, 41, 1–15.
- Herrnstein, R.J., & Prelec, D. (1992). A theory of addiction. In G. Loewenstein & J. Elster (Eds.), *Choice over time* (pp. 331–361). New York: Russell Sage Press.
- Hertwig, R., Barron, G., Weber, E.U., & Erev, I. (2004). Decisions from experience and the effect of rare events in risky choice. *Psychological Science*, 15, 534–539.
- Hoemann, H.W., & Ross, B.M. (1982). Children's concepts of chance and probability. In C.J. Brainerd (Ed.), *Children's logical and mathematical cognition* (pp. 95–121). New York: Springer-Verlag.
- Hooper, C.J., Luciana, M., Conklin, H.M., & Yarger, R.S. (2004). Adolescents' performance on the Iowa Gambling Task: Implications for the development of decision-making and ventromedial prefrontal cortex. *Developmental Psychology*, 40, 1148–1158.
- Horvath, P., & Zuckerman, M. (1993). Sensation seeking, risk appraisal, and risky behavior. *Personality and Individual Differences*, 14, 41–52.
- Huba, G.J., Wingard, J.A., & Bentler, P.M. (1979). Beginning adolescent drug use and peer-adult interaction patterns. *Journal of Consulting and Clinical Psychology*, 47, 265–276.
- Huber, B.L., & Huber, O. (1987). Development of the concepts of comparative subjective probability. *Journal of Experimental Child Psychology*, 44, 304–316.
- Inhelder, B., Sinclair, H., & Bovet, M. (1974). *Learning and the development of cognition*. Cambridge, MA: Harvard University Press.
- Isen, A.M., & Labroo, A.A. (2003). Some ways in which positive affect facilitates decision making and judgment. In S. Schneider & J. Shanteau (Eds.), *Emerging perspectives on judgment and decision research* (pp. 365–393). NY, Cambridge.
- Jacobs, J.E., & Klaczynski, P.A. (2002). The development of judgment and decision-making during childhood and adolescence. *Current Directions in Psychological Science*, 11, 145–149.
- Jacobs, J.E., & Klaczynski, P.A. (2005). *The development of judgment and decision making in children and adolescents*. Mahwah, NJ: Erlbaum.
- Jacobs, J.E., & Potenza, M. (1991). The use of judgment heuristics to make social and object decisions: A developmental perspective. *Child Development*, 62, 166–178.
- Janz, N.K., & Becker, M.H. (1984). The health belief model: A decade later. *Health Education Quarterly*, 11, 1–47.
- Johnson, R.J., McCaul, K.D., & Klein, W.M.P. (2002). Risk involvement and risk perception among adolescents and young adults. *Journal of Behavioral Medicine*, 25, 67–82.
- Johnston, L.D., O'Malley, P.M., Bachman, J.G., & Schulenberg, J.E. (2004). *Monitoring the Future national survey results on drug use, 1975–2003: Volume I, Secondary school students* (NIH Publication No. 04-5507). Bethesda, MD: National Institute on Drug Abuse.
- Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist*, 58, 697–720.
- Katz, E.C., Fromme, K., & D'Amico, E.J. (2000). Effects of outcome expectancies and personality on young adults' illicit drug use, heavy drinking, and risky sexual behavior. *Cognitive Therapy & Research*, 24, 1–22.
- Keating, D.P. (1980). Thinking processes in adolescence. In J. Adelson (Ed.), *Handbook of adolescent psychology*. New York: Wiley.
- Kerkman, D.D., & Wright, J.C. (1988). An exegesis of two theories of compensational development: Sequential decision theory and information integration theory. *Developmental Review*, 8, 323–360.
- Kerr, A., & Zelazo, P.D. (2004). Development of “hot” executive function: The Children's Gambling Task. *Brain & Cognition*, 55, 148–157.
- Kershaw, T.S., Ethier, K.A., Niccolai, L.M., Lewis, J.B., & Ickovics, J.R. (2003). Misperceived risk among female adolescents: Social and psychological factors associated with sexual risk accuracy. *Health Psychology*, 22, 523–532.
- Kershaw, T.S., Niccolai, L.M., Ethier, K.A., Lewis, J.B., & Ickovics, J.R. (2003). Perceived susceptibility to pregnancy and sexually transmitted disease among pregnant and nonpregnant adolescents. *Journal of Community Psychology*, 31, 419–434.
- Kirby, D. (2001). Understanding what works and what doesn't work in reducing adolescent sexual risk-taking [electronic version]. *Family Planning Perspectives*, 33, 276–281.
- Klaczynski, P.A. (2001). Analytic and heuristic processing influences on adolescent reasoning and decision-making. *Child Development*, 72, 844–861.
- Klaczynski, P. (2005). Metacognition and cognitive variability: A dual-process model of decision making and its development. In J. Jacobs & P. Klaczynski (Eds.) *The development of judgment and decision making in children and adolescents* (pp. 39–76). Mahwah, NJ: Erlbaum.
- Klaczynski, P.A., & Cottrell, J.M. (2004). A dual-process approach to cognitive development: The case of children's understanding of sunk cost decisions. *Thinking and Reasoning*, 10, 147–174.
- Klaczynski, P.A., & Narasimham, G. (1998). Problem representations as mediators of adolescent deductive reasoning. *Developmental Psychology*, 34, 865–881.
- Klayman, J. (1985). Children's decision strategies and their adaptation to task characteristics. *Organizational Behavior & Human Decision Processes*, 35, 179–201.
- Kotchick, B.A., Shaffer, A., Forehand, R., & Miller, K.S. (2001). Adolescent sexual risk behavior: A multi-system perspective. *Clinical Psychology Review*, 21, 493–519.
- Lahey, B.B., Gordon, R.A., Loeber, R., Stouthamer-Loeber, M., & Farrington, D.P. (1999). Boys who join gangs: A prospective study of predictors of first gang entry. *Journal of Abnormal Child Psychology*, 27, 261–276.

- Lahti, J., Rääkkönen, K., Ekelund, J., Peltonen, L., Raitakari, O.T., & Keltikangas-Järvinen, L. (2006). Socio-demographic characteristics moderate the association between DRD4 and novelty seeking. *Personality and Individual Differences, 40*, 533–543.
- Lee, C., Su, Y., & Hazard, B.P. (1998). The contingent effects of risk perception on risk-taking behavior: Adolescent participative orientation and marijuana use. *Journal of Youth & Adolescence, 27*, 17–27.
- Levin, I., & Hart, S. (2003). Risk preferences in young children: Early evidence of individual differences in reaction to potential gains and losses. *Journal of Behavioral Decision Making, 16*, 397–413.
- Lloyd, F.J., & Reyna, V.F. (2001). A Web exercise in evidence-based medicine using cognitive theory. *Journal of General Internal Medicine, 16*, 94–99.
- Loewenstein, G. (1996). Out of control: Visceral influences on behavior. *Organizational Behavior and Human Decision Processes, 65*, 272–292.
- Loewenstein, G., & Elster, J. (1992). *Choice over time*. New York: Russell Sage Foundation.
- Loewenstein, G., & Schkade, D. (1999). Wouldn't it be nice? Predicting future feelings. In D. Kahneman & E. Diener (Eds.), *Well-being: The foundations of hedonic psychology* (pp. 85–105). New York: Russell Sage Foundation.
- Loewenstein, G.F., Weber, E.U., Hsee, C.K., & Welch, E.S. (2001). Risk as feelings. *Psychological Bulletin, 127*, 267–286.
- Lundborg, P., & Lindgren, B. (2002). Risk perceptions and alcohol consumption among young people. *Journal of Risk and Uncertainty, 25*, 165–183.
- Lynch, M.E., Coles, C.D., Corley, T., & Falek, A. (2003). Examining delinquency in adolescents differentially prenatally exposed to alcohol: The role of proximal and distal risk factors. *Journal of Studies on Alcohol, 64*, 678–686.
- March, J.G. (1988). Bounded rationality, ambiguity, and the engineering of choice. In D.E. Bell, H. Raiffa, & A. Tversky (Eds.), *Decision making: Descriptive, normative and prescriptive interactions* (pp. 33–58). Cambridge: Cambridge University Press.
- Markovits, H., & Dumas, C. (1999). Developmental patterns in the understanding of social and physical transitivity. *Journal of Experimental Child Psychology, 73*, 95–114.
- Maynard, R.A. (1997). *Kids having kids: Economic costs and social consequences of teen pregnancy*. Washington, DC: Urban Institute Press.
- McCaul, K.D., Sandgren, A.K., O'Neill, H.K., & Hinsz, V.B. (1993). The value of the theory of planned behavior, perceived control, and self-efficacy expectations for predicting health-protective behaviors. *Basic and Applied Social Psychology, 14*, 231–252.
- McIntyre, S., & West, P. (1992). What does the phrase “safer sex” mean to you? Understanding among Glaswegian 18 year olds in 1990. *AIDS, 7*, 121–126.
- Mellers, B.A. (2000). Choice and the relative pleasure of consequences. *Psychological Bulletin, 126*, 910–924.
- Menard, S. (2002, February). *Short- and long-term consequences of adolescent victimization. Youth Violence Research Bulletin*. Washington, DC: Office of Juvenile Justice and Delinquency Prevention and the Centers for Disease Control and Prevention.
- Metcalfe, J., & Mischel, W. (1999). A hot/cool system analysis of delay of gratification: Dynamics of willpower. *Psychological Review, 106*, 3–19.
- Milam, J.E., Sussman, S., Ritt-Olson, A., & Dent, C.W. (2000). Perceived invulnerability and cigarette smoking among adolescents. *Addictive Behaviors, 25*, 71–80.
- Millstein, S.G. (1993). Perceptual, attributional, and affective process in perceptions of vulnerability through the life span. In N.J. Bell & R.W. Bell (Eds.), *Adolescent risk taking* (pp. 55–65). Thousand Oaks, CA: Sage Publications.
- Millstein, S.G., & Halpern-Felsher, B.L. (2002a). Judgments about risk and perceived invulnerability in adolescents and young adults. *Journal of Research on Adolescence, 12*, 399–423.
- Millstein, S.G., & Halpern-Felsher, B.L. (2002b). Perceptions of risk and vulnerability. *Journal of Adolescent Health, 31*, 10–27.
- Millstein, S.G., & Igra, V. (1995). Theoretical models of adolescent risk-taking behavior. In S.E. Wallander & L. Siegel (Eds.), *Adolescent health problems: Behavioral perspectives* (pp. 52–71). New York: Guilford Press.
- Milne, S., Sheeran, P., & Orbell, S. (2000). Prediction and intervention in health-related behavior: A meta-analytic review of protection motivation theory. *Journal of Applied Social Psychology, 30*, 106–143.
- Moffitt, T.E. (1993). Adolescence-limited and life-course-persistent antisocial behavior: A developmental taxonomy. *Psychological Review, 100*, 674–701.
- Moffitt, T.E. (2003). Life-course persistent and adolescence-limited antisocial behavior. In B.B. Lahey, T.E. Moffitt, & A. Caspi (Eds.), *Causes of conduct disorder and juvenile delinquency* (pp. 49–75). New York: Guilford.
- Moffitt, T.E. (2005). The new look of behavioral genetics in developmental psychopathology: Gene–environment interplay in antisocial behaviors. *Psychological Bulletin, 131*, 533–554.
- Moore, C.F., Dixon, J.A., & Haines, B.A. (1991). Components of understanding in proportional reasoning: A fuzzy set representation of developmental progressions. *Child Development, 62*, 441–459.
- Morojele, N.K., & Stephenson, G.M. (1994). *Evaluation of the PROMIS Recovery Centre*. Canterbury, England: University of Kent.
- Moshman, D. (2004). From inference to reasoning: The construction of rationality. *Thinking and Reasoning, 10*, 221–239.
- Murphy, D.A., Rotheram-Borus, M.J., & Reid, H.M. (1998). Adolescent gender differences in HIV-related sexual risk acts, social-cognitive factors and behavioral skills. *Journal of Adolescence, 21*, 197–208.
- Namerow, P.B., Lawton, A.I., & Philliber, S.G. (1987). Teenagers' perceived and actual probabilities of pregnancy. *Adolescence, 22*, 475–485.
- National Center for Statistics and Analysis (2003). *Traffic safety facts—2003*. Washington, DC: National Highway Transportation and Safety Administration, U.S. Department of Transportation.
- National Research Council and Institute of Medicine. (2001). *Juvenile Crime, Juvenile Justice*. (J. McCord, C.S. Widom, & N.A. Crowell Eds.). Washington, DC: National Academy Press.
- Nisbett, R.E., & Ross, L. (1980). *Human inference: Strategies and shortcomings of social judgment*. Englewood Cliffs, NJ: Prentice-Hall.
- Nygaard, P., Waiters, E.D., Grube, J.W., & Keefe, D. (2003). Why do they do it? A qualitative study of adolescent drinking and driving. *Substance Use & Misuse, 38*, 835–863.
- Overton, W.F. (1990). *Reasoning, necessity, and logic: Developmental perspectives*. Hillsdale, NJ: Erlbaum.
- Overton, W.F., & Byrnes, J. (1991). Cognitive development. In R. Lerner, A. Petersen, & J. Brooks-Gunn (Eds.), *The encyclopedia of adolescence*. New York: Garland pp. 151–156.
- Parker, A.M., & Fischhoff, B. (2005). Decision-making competence: External validation through an individual-differences approach. *Journal of Behavioral Decision Making, 18*, 1–27.

- Parsons, J., Halkitis, P., Bimbi, D., & Borkowski, T. (2000). Perceptions of the benefits and costs associated with condom use and unprotected sex among late adolescent college students. *Journal of Adolescence*, *23*, 377–391.
- Parsons, J.T., Siegel, A.W., & Cousins, J.H. (1997). Late adolescent risk-taking: Effects of perceived benefits and perceived risks on behavioral intentions and behavioral change. *Journal of Adolescence*, *20*, 381–392.
- Payne, J.W., Bettman, J., & Johnson, E.J. (1993). *The adaptive decision maker*. Cambridge: Cambridge University Press.
- Peters, E., & Slovic, P. (2000). The springs of action: Affective and analytical information processing in choice. *Personality and Social Psychological Bulletin*, *26*, 1465–1475.
- Quadrel, M.J. (1990). *Elicitation of adolescents' risk perceptions: Qualitative and quantitative dimensions*. Unpublished doctoral dissertation, Carnegie Mellon University.
- Quadrel, M.J., Fischhoff, B., & Davis, W. (1993). Adolescent (in)vulnerability. *American Psychologist*, *48*, 102–116.
- Quine, W.V.O. (1964). *Word and object*. Cambridge, MA: MIT Press.
- Rachlin, H. (2000). *The science of self-control*. Cambridge, MA: Harvard University Press.
- Resnicow, K., Smith, M., Harrison, L., & Drucker, E. (1999). Correlates of occasional cigarette and marijuana use: Are teens harm reducing? *Addictive Behaviors*, *24*, 251–266.
- Reyna, V.F. (1991). Class inclusion, the conjunction fallacy, and other cognitive illusions. *Developmental Review*, *11*, 317–336.
- Reyna, V.F. (1995). Interference effects in memory and reasoning: A fuzzy-trace theory analysis. In F.N. Dempster & C.J. Brainerd (Eds.), *Interference and inhibition in cognition* (pp. 29–59). San Diego, CA: Academic Press.
- Reyna, V.F. (1996). Conceptions of memory development with implications for reasoning and decision making. *Annals of Child Development*, *12*, 87–118.
- Reyna, V. (2004a). How people make decisions that involve risk: A dual-processes approach. *Current Directions in Psychological Science*, *13*, 60–66.
- Reyna, V.F. (2004b). Why scientific research? The importance of evidence in changing educational practice. In P. McCardle & V. Chhabra (Eds.), *The voice of evidence in reading research* (pp. 47–58). Baltimore, MD: Brookes Publishing.
- Reyna, V.F. (2005). Fuzzy-trace theory, judgment, and decision-making: A dual-processes approach. In C. Izawa & N. Ohta (Eds.), *Human learning and memory: Advances in theory and application – The 4th Tsukuba International Conference on Memory* (pp. 239–256). Mahwah, NJ: Erlbaum.
- Reyna, V.F., & Adam, M.B. (2003). Fuzzy-trace theory, risk communication, and product labeling in sexually transmitted diseases. *Risk Analysis*, *23*, 325–342.
- Reyna, V.F., Adam, M.B., Poirier, K., LeCroy, C.W., & Brainerd, C.J. (2005). Risky decision-making in childhood and adolescence: A fuzzy-trace theory approach. In J. Jacobs & P. Klaczynski (Eds.), *The development of judgment and decision-making in children and adolescents* (pp. 77–106). Mahwah, NJ: Erlbaum.
- Reyna, V.F., & Brainerd, C.J. (1991a). Fuzzy-trace theory and children's acquisition of scientific and mathematical concepts. *Learning and Individual Differences*, *3*, 27–60.
- Reyna, V.F., & Brainerd, C.J. (1991b). Fuzzy-trace theory and framing effects in choice: Gist extraction, truncation, and conversion. *Journal of Behavioral Decision Making*, *4*, 249–262.
- Reyna, V.F., & Brainerd, C.J. (1994). The origins of probability judgment: A review of data and theories. In G. Wright & P. Ayton (Eds.), *Subjective probability* (pp. 239–272). New York: Wiley.
- Reyna, V.F., & Brainerd, C.J. (1995). Fuzzy-trace theory: An interim synthesis. *Learning and Individual Differences*, *7*, 1–75.
- Reyna, V.F., & Ellis, S.C. (1994). Fuzzy-trace theory and framing effects in children's risky decision making. *Psychological Science*, *5*, 275–279.
- Reyna, V.F., & Kiernan, B. (1994). The development of gist versus verbatim memory in sentence recognition: Effects of lexical familiarity, semantic content, encoding instruction, and retention interval. *Developmental Psychology*, *30*, 178–191.
- Reyna, V.F., & Kiernan, B. (1995). Children's memory and metaphorical interpretation. *Metaphor and Symbolic Activity*, *10*, 309–331.
- Reyna, V.F., & Lloyd, F.J. (in press). Physician decision making and cardiac risk: Effects of knowledge, risk perception, risk tolerance, and fuzzy processing. *Journal of Experimental Psychology: Applied*.
- Reyna, V.F., Lloyd, F.J., & Brainerd, C.J. (2003). Memory, development, and rationality: An integrative theory of judgment and decision making. In S.L. Schneider & J. Shanteau (Eds.), *Emerging perspectives on judgment and decision research* (pp. 201–245). New York: Cambridge University Press.
- Reyna, V.F., Lloyd, F., & Whalen, P. (2001). Genetic testing and medical decision-making. *Archives of Internal Medicine*, *161*, 2406–2408.
- Reyna, V.F., & Mattson, S. (1994, November). *Risk and biases in decision making*. Paper presented at the 35th Annual Meeting of the Psychonomic Society, St. Louis, MO.
- Reyna, V.F., & Mills, B. (in press). Interference processes in fuzzy-trace theory: Aging, Alzheimer's disease, and development. In C. MacLeod & D. Gorfein (Eds.), *The place of inhibition in cognition*. Washington, DC: American Psychological Association.
- Reyna, V.F., Mills, B., Estrada, S., & Brainerd, C.J. (in press). False memory in children: Data, theory, and legal implications. In M. Toglia & D. Read (Eds.), *The handbook of eyewitness psychology: Memory for events*. Mahwah, NJ: Erlbaum.
- Rhodes, R.E., & Courneya, K.S. (2004). Differentiating motivation and control in the theory of planned behavior. *Psychology, Health & Medicine*, *9*, 205–215.
- Rice, C.L. (1995). *The effects of outcome attractiveness and framing on children's risky decision making*. Unpublished masters thesis, University of Arizona, Tucson.
- Ritov, I., & Baron, J. (1995). Outcome knowledge, regret, and omission bias. *Organizational Behavior and Human Decision Processes*, *64*, 119–127.
- Rogers, R.W. (1983). Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation. In J.T. Cacioppo, R.E. Petty, & D. Shapiro (Eds.), *Social psychophysiology: A sourcebook* (pp. 153–176). New York: Guilford.
- Rolison, M.R., & Scherman, A. (2002). Factors influencing adolescents' decisions to engage in risk-taking behavior. *Adolescence*, *37*, 585–596.
- Rolison, M.R., & Scherman, A. (2003). College student risk-taking from three perspectives. *Adolescence*, *38*, 689–704.
- Romer, D. (2003). *Reducing adolescent risk: Toward an integrated approach*. Thousand Oaks, CA: Sage Publications.
- Romer, D., & Jamieson, P. (2001). Do adolescents appreciate the risks of smoking? Evidence from a national survey. *Journal of Adolescent Health*, *29*, 12–21.
- Rosenberg, P.S., Biggar, R.J., & Goedert J.J. (1994). Declining age at HIV infection in the United States. *New England Journal of Medicine*, *330*, 789–790.

- Rothman, A.J., Klein, W.M., & Weinstein, N.D. (1996). Absolute and relative biases about personal risk. *Journal of Applied Social Psychology, 26*, 1213–1236.
- Rottenstreich, Y., & Hsee, C.K. (2001). Money, kisses, and electric shocks: On the affective psychology of risk. *Psychological Science, 12*, 185–190.
- Savage, L.J. (1972). *The foundations of statistics*. London: Wiley.
- Schlottmann, A. (2000). Children's judgments of gambles: A disordinal violation of utility. *Journal of Behavioral Decision Making, 13*, 77–89.
- Schlottmann, A. (2001). Children's probability intuitions: Understanding the expected value of complex gambles. *Child Development, 72*, 108–122.
- Schlottmann, A., & Anderson, N.A. (1994). Children's judgment of expected value. *Developmental Psychology, 30*, 56–66.
- Schlottmann, A., & Tring, J. (2005). How children reason about gains and losses: Framing effects in judgement and choice. *Swiss Journal of Psychology, 64*, 153–171.
- Seiden, R.H. (1978, Winter). Where are they now? A follow-up study of suicide attempters from the Golden Gate Bridge. *Suicide and Life-Threatening Behavior, 8*, 1–13.
- Shapiro, R., Siegel, A.W., Scovill, L.C., & Hays, J. (1998). Risk-taking patterns of female adolescents: What they do and why. *Journal of Adolescence, 24*, 143–159.
- Shedler, J., & Block, J. (1990). Adolescent drug use and psychological health: A longitudinal inquiry. *American Psychologist, 45*, 612–630.
- Sheppard, B.H., Hartwick, J., & Warshaw, P.R. (1988). The theory of reasoned action: A meta-analysis of past research with recommendations for modifications and future research. *Journal of Consumer Research, 15*, 325–343.
- Shure, M.B. (2003). A problem-solving approach to preventing early high-risk behaviors in children and preteens. In D. Romer (Ed.), *Reducing adolescent risk: Toward an integrated approach*. Thousand Oaks, CA: Sage Publications.
- Siegler, R.S. (1991). *Children's thinking* (2nd ed.). Upper Saddle River, NJ: Prentice-Hall.
- Sloman, S.A. (2002). Two systems of reasoning. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases* (pp. 379–396). New York: Cambridge University Press.
- Sloman, S.A., Over, D., Slovak, L., & Stibel, J.M. (2003). Frequency illusions and other fallacies. *Organizational Behavior and Human Decision Processes, 91*, 296–309.
- Slovic, P. (1998). Do adolescent smokers know the risk? *Duke Law Journal, 47*, 1133–1141.
- Slovic, P. (2000). What does it mean to know a cumulative risk? Adolescents' perceptions of short-term and long-term consequences of smoking. *Journal of Behavioral Decision Making, 13*, 259–266.
- Slovic, P. (2001). *Smoking: Risk, perception, and policy*. Thousand Oaks, CA: Sage Publications.
- Slovic, P., Finucane, M., Peters, E., & MacGregor, D.G. (2004). Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality. *Risk Analysis, 24*, 1–12.
- Smith, A.M.A., & Rosenthal, D.A. (1995). Adolescents' perceptions of their risk environment. *Journal of Adolescence, 18*, 229–245.
- Smith, G., Gerrard, M., & Gibbons, F. (1997). Self-esteem and the relation between risk behavior and perceptions of vulnerability to unplanned pregnancy in college women. *Health Psychology, 16*, 137–146.
- Sneed, C.D., Morisky, D.E., Rotheram-Borus, M.J., Ebin, V., Malotte, C.K., Lyde, M., & Gill, J.K. (2001). 'Don't know' and 'didn't think of it': Condom use at first intercourse by Latino adolescents. *AIDS Care, 13*, 303–308.
- Spear, L.P. (2000). The adolescent brain and age-related behavioral manifestations. *Neuroscience and Biobehavioral Reviews, 24*, 417–463.
- Stacy, A.W., Bentler, P.M., & Flay, B.R. (1994). Attitudes and health behavior in diverse populations: Drunk driving, alcohol use, binge eating, marijuana use, and cigarette use. *Health Psychology, 13*, 73–85.
- Stanovich, K.E., & West, R.F. (2000). Individual differences in reasoning: Implications for the rationality debate? *Behavioral and Brain Sciences, 23*, 645–726.
- Steinberg, L. (2003). Is decision making the right framework for research on adolescent risk taking? In D. Romer (Ed.), *Reducing adolescent risk* (pp. 18–24). Thousand Oaks, CA: Sage.
- Steinberg, L. (2004). Risk taking in adolescence: What changes and why? *Annals of the New York Academy of Sciences, 1021*, 51–58.
- Steinberg, L. (2005). Cognitive and affective development in adolescence. *Trends in Cognitive Science, 9*, 69–74.
- Steinberg, L., Dahl, R., Keating, D., Kupfer, D.J., Masten, A.S., & Pine, D. (2004). The study of developmental psychopathology in adolescence: Integrating affective neuroscience with the study of context. In D. Cicchetti (Ed.), *Handbook of developmental psychopathology* (pp. 1–96). New York: Wiley.
- Steinberg, L., & Morris, A.S. (2001). Adolescent development. *Annual Review of Psychology, 52*, 83–110.
- Stone, E.R., Yates, J.F., & Parker, A.M. (1994). Risk communication: Absolute versus relative expressions of low-probability risks. *Organizational Behavior and Human Decision Processes, 60*, 387–408.
- Strunin, L., & Hingson, R. (1992). Alcohol, drugs, and adolescent sexual behavior. *International Journal of the Addictions, 27*, 129–146.
- Sutton, S. (2001). Health behavior: Psychosocial theories. In N.J. Smelser & P.B. Baltes (Eds.), *International encyclopedia of the social and behavioral sciences* (pp. 6499–6506). Oxford, England: Elsevier.
- Swisher, J.D., & Hu, T. (1983). Alternatives to drug abuse: Some are and some are not. *Research Monograph Series, 47*, 141–153.
- Tapert, S.F., Aarons, G.A., Sedlar, G.R., & Brown, S.A. (2001). Adolescent substance use and sexual risk taking behavior. *Journal of Adolescent Health, 28*, 181–189.
- Ten years ago, I tried to kill myself in the A lot. (2005, September 14). *Cornell Daily Sun*, p. 6.
- Turner, C., & McClure, R. (2003). Age and gender differences in risk taking behavior as an explanation for high incidence of motor vehicle crashes as a driver in young males. *Injury Control and Safety Promotion, 10*, 123–130.
- Tversky, A., & Kahneman, D. (1983). Extension versus intuitive reasoning: The conjunction fallacy in probability judgment. *Psychological Review, 90*, 293–315.
- Urberg, K., & Robbins, R.L. (1984). Perceived vulnerability in adolescents to the health consequences of cigarette smoking. *Preventive Medicine, 13*, 367–376.
- U.S. Department of Health and Human Services. (1994). *Preventing tobacco use among young people: A report of the surgeon general*. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.
- U.S. Department of Health and Human Services. (2001). *Youth violence: A report of the surgeon general* (DHHS Publication. No. SG-YZ).

- Retrieved June 6, 2006 from <http://www.surgeongeneral.gov/library/youthviolence/toc.html>
- Vaillant, G.E. (2003). A 60-year follow-up of alcoholic men. *Addiction*, *98*, 1043–1051.
- Vaillant, G.E., & Hiller-Sturmhöfel (1996). The natural history of alcoholism. *Alcohol Health & Research World*, *20*, 152–161.
- van den Putte, B. (1993). *On the theory of reasoned action*. Unpublished doctoral dissertation, University of Amsterdam, The Netherlands.
- Vitaro, F., Brendgen, M., Ladouceur, R., & Tremblay, R.E. (2001). Gambling, delinquency, and drug use during adolescence: Mutual influences and common risk factors. *Journal of Gambling Studies*, *17*, 171–90.
- von Neumann, J., & Morgenstern, O. (1944). *Theory of games and economic behavior*. Princeton, NJ: Princeton University Press.
- von Winterfeldt, D., & Edwards, W. (1986). *Decision analysis and behavioral research*. Cambridge, England: Cambridge University Press.
- Ward, S.L., & Overton, W.F. (1990). Semantic familiarity, relevance, and the development of deductive reasoning. *Developmental Psychology*, *26*, 488–493.
- Weber, E.U., Shafir, S., & Blais, A. (2004). Predicting risk sensitivity in humans and lower animals: Risk as variance or coefficient of variation. *Psychological Review*, *111*, 430–445.
- Weinstein, N.D. (1980). Unrealistic optimism about future life events. *Journal of Personality and Social Psychology*, *39*, 806–820.
- Weinstein, N.D. (1982). Unrealistic optimism about susceptibility to health problems. *Journal of Behavioral Medicine*, *5*, 441–460.
- Weinstein, N.D. (1989). Optimistic biases about personal risks. *Science*, *246*, 1232–1233.
- Weinstein, N.D., & Lachendro, E. (1982). Egocentrism as a source of unrealistic optimism. *Personality and Social Psychology Bulletin*, *8*, 195–200.
- Weinstein, N.D., & Nicolich, M. (1993). Correct and incorrect interpretations of correlations between risk perceptions and risk behaviors. *Health Psychology*, *12*, 235–245.
- Weinstein, N.D., Rothman, A.J., & Nicolich, M. (1998). Use of correlational data to study effects of risk perceptions on precautionary behavior. *Psychology and Health*, *13*, 479–501.
- Weinstein, N.D., Slovic, P., & Gibson, G. (2004). Accuracy and optimism in smokers' beliefs about quitting. *Nicotine & Tobacco Research*, *6*, 375–380.
- Whaley, A.L. (2000). Differential risk perceptions for unintended pregnancy, STDs, and HIV/AIDS among urban adolescents: Some preliminary findings. *Journal of Genetic Psychology*, *161*, 435–452.
- Wild, T.C., Hinson, R., & Cunningham, J. (2001). Perceived vulnerability to alcohol-related harm in young adults: Independent effects of risky alcohol use and drinking motives. *Experimental & Clinical Psychopharmacology*, *9*, 117–125.
- Wilks, S.S. (1937). *Statistical inference*. Ann Arbor, MI: Edwards Brothers.
- Windschitl, P.D., Kruger, J., & Simms, E.N. (2003). The influence of egocentrism and focalism on people's optimism in competitions: When what affects us equally affects me more. *Journal of Personality and Social Psychology*, *85*, 389–408.
- Winer, G., & McGlone, C. (1993). On the uncertainty of conservation: Responses to misleading conservation questions. *Developmental Psychology*, *29*, 760–769.
- Wolford, C., & Swisher, J.D. (1986). Behavioral intention as an indicator of drug and alcohol use. *Journal of Drug Education*, *16*, 305–326.
- Yates, J.F. (1990). *Judgment and decision making*. Old Tappan, NJ: Prentice Hall.
- Yechiam, E., Busemeyer, J.R., Stout, J.C., & Bechara, A. (2005). Using cognitive models to map relations between neuropsychological disorders and human decision-making deficits. *Psychological Science*, *16*, 973–978.
- Zuckerman, M. (1979). *Sensation seeking: Beyond the optimal level of arousal*. Hillsdale, NJ: Erlbaum.
- Zuckerman, M. (1994). *Behavioral expressions and biosocial bases of sensation seeking*. New York: Cambridge University Press.
- Zuckerman, M. (1999). *Vulnerability to psychopathology: A biosocial model*. Washington, DC: American Psychological Association.
- Zuckerman, M. (2002). Personality and psychopathy: Shared behavioral and biological traits. In J. Glicksohn (Ed.), *The neurobiology of criminal behavior* (pp. 27–49). Dordrecht, The Netherlands: Kluwer Academic Publishers.