Risk Taking in Adolescence

New Perspectives From Brain and Behavioral Science

Laurence Steinberg

Temple University

ABSTRACT—***Trying to understand why adolescents and young adults take more risks than younger or older individuals do has challenged psychologists for decades. Adolescents' inclination to engage in risky behavior does not appear to be due to irrationality, delusions of invulnerability, or ignorance. This paper presents a perspective on adolescent risk taking grounded in developmental neuroscience. According to this view, the temporal gap between puberty, which impels adolescents toward thrill seeking, and the slow maturation of the cognitive-control system, which regulates these impulses, makes adolescence a time of heightened vulnerability for risky behavior. This view of adolescent risk taking helps to explain why educational interventions designed to change adolescents' knowledge, beliefs, or attitudes have been largely ineffective, and suggests that changing the contexts in which risky behavior occurs may be more successful than changing the way adolescents think about risk.***

KEYWORDS—***adolescence; decision making; risk taking; brain development***

Adolescents and college-age individuals take more risks than children or adults do, as indicated by statistics on automobile crashes, binge drinking, contraceptive use, and crime; but trying to understand why risk taking is more common during adolescence than during other periods of development has challenged psychologists for decades (Steinberg, 2004). Numerous theories to account for adolescents' greater involvement in risky behavior have been advanced, but few have withstood empirical scrutiny (but see Reyna & Farley, 2006, for a discussion of some promising approaches).

Address correspondence to Laurence Steinberg, Department of Psychology, Temple University, Philadelphia, PA 19122; lds@temple.edu.

FALSE LEADS IN RISK-TAKING RESEARCH

Systematic research does not support the stereotype of adolescents as irrational individuals who believe they are invulnerable and who are unaware, inattentive to, or unconcerned about the potential harms of risky behavior. In fact, the logical-reasoning abilities of 15-year-olds are comparable to those of adults, adolescents are no worse than adults at perceiving risk or estimating their vulnerability to it (Reyna & Farley, 2006), and increasing the salience of the risks associated with making a potentially dangerous decision has comparable effects on adolescents and adults (Millstein & Halpern-Felsher, 2002). Most studies find few age differences in individuals' evaluations of the risks inherent in a wide range of dangerous behaviors, in judgments about the seriousness of the consequences that might result from risky behavior, or in the ways that the relative costs and benefits of risky activities are evaluated (Beyth-Marom, Austin, Fischoff, Palmgren, & Jacobs-Quadrel, 1993).

Because adolescents and adults reason about risk in similar ways, many researchers have posited that age differences in actual risk taking are due to differences in the information that adolescents and adults use when making decisions. Attempts to reduce adolescent risk taking through interventions designed to alter knowledge, attitudes, or beliefs have proven remarkably disappointing, however (Steinberg, 2004). Efforts to provide adolescents with information about the risks of substance use, reckless driving, and unprotected sex typically result in improvements in young people's thinking about these phenomena but seldom change their actual behavior. Generally speaking, reductions in adolescents' health-compromising behavior are more strongly linked to changes in the contexts in which those risks are taken (e.g., increases in the price of cigarettes, enforcement of graduated licensing programs, more vigorously implemented policies to interdict drugs, or condom distribution programs) than to changes in what adolescents know or believe.

The failure to account for age differences in risk taking through studies of reasoning and knowledge stymied researchers for some time. Health educators, however, have been undaunted, and they have continued to design and offer interventions qof unproven effectiveness, such as Drug Abuse Resistance

 Copyright © 2007 Association for Psychological Science

Education (DARE), driver's education, or abstinence-only sex education.

A NEW PERSPECTIVE ON RISK TAKING

In recent years, owing to advances in the developmental neuroscience of adolescence and the recognition that the conventional decision-making framework may not be the best way to think about adolescent risk taking, a new perspective on the subject has emerged (Steinberg, 2004). This new view begins from the premise that risk taking in the real world is the product of both logical reasoning and psychosocial factors. However, unlike logical-reasoning abilities, which appear to be more or less fully developed by age 15, psychosocial capacities that improve decision making and moderate risk taking—such as impulse control, emotion regulation, delay of gratification, and resistance to peer influence—continue to mature well into young adulthood (Steinberg, 2004; see Fig. 1). Accordingly, psychosocial immaturity in these respects during adolescence may undermine what otherwise might be competent decision making. The conclusion drawn by many researchers, that adolescents are as competent decision makers as adults are, may hold true only under conditions where the influence of psychosocial factors is minimized.

Evidence From Developmental Neuroscience

Advances in developmental neuroscience provide support for this new way of thinking about adolescent decision making. It appears that heightened risk taking in adolescence is the product of the interaction between two brain networks. The first is a socioemotional network that is especially sensitive to social and emotional stimuli, that is particularly important for reward processing, and that is remodeled in early adolescence by the hormonal changes of puberty. It is localized in limbic and paralimbic areas of the brain, an interior region that includes the amygdala, ventral striatum, orbitofrontal cortex, medial prefrontal cortex, and superior temporal sulcus. The second network is a cognitive-control network that subserves executive functions such as planning, thinking ahead, and self-regulation, and that matures gradually over the course of adolescence and young adulthood largely independently of puberty (Steinberg, 2004). The cognitive-control network mainly consists of outer regions of the brain, including the lateral prefrontal and parietal cortices and those parts of the anterior cingulate cortex to which they are connected.

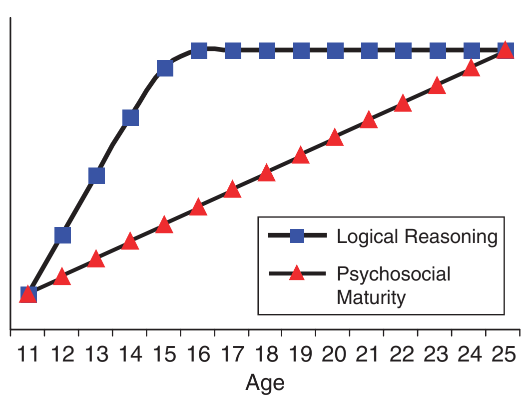

Fig. 1. Hypothetical graph of development of logical reasoning abilities versus psychosocial maturation. Although logical reasoning abilities reach adult levels by age 16, psychosocial capacities, such as impulse control, future orientation, or resistance to peer influence, continue to develop into young adulthood.

In many respects, risk taking is the product of a competition between the socioemotional and cognitive-control networks (Drevets & Raichle, 1998), and adolescence is a period in which the former abruptly becomes more assertive (i.e., at puberty) while the latter gains strength only gradually, over a longer period of time. The socioemotional network is not in a state of constantly high activation during adolescence, though. Indeed, when the socioemotional network is not highly activated (for example, when individuals are not emotionally excited or are alone), the cognitive-control network is strong enough to impose regulatory control over impulsive and risky behavior, even in early adolescence. In the presence of peers or under conditions of emotional arousal, however, the socioemotional network becomes sufficiently activated to diminish the regulatory effectiveness of the cognitive-control network. Over the course of adolescence, the cognitive-control network matures, so that by adulthood, even under conditions of heightened arousal in the socioemotional network, inclinations toward risk taking can be modulated.

It is important to note that mechanisms underlying the processing of emotional information, social information, and reward are closely interconnected. Among adolescents, the regions that are activated during exposure to social and emotional stimuli overlap considerably with regions also shown to be sensitive to variations in reward magnitude (cf. Galvan, et al., 2005; Nelson, Leibenluft, McClure, & Pine, 2005). This finding may be relevant to understanding why so much adolescent risk taking—like drinking, reckless driving, or delinquency—occurs in groups (Steinberg, 2004). Risk taking may be heightened in adolescence because teenagers spend so much time with their peers, and the mere presence of peers makes the rewarding aspects of risky situations more salient by activating the same circuitry that is activated by exposure to nonsocial rewards when individuals are alone.

The competitive interaction between the socioemotional and cognitive-control networks has been implicated in a wide range of decision-making contexts, including drug use, social-decision processing, moral judgments, and the valuation of alternative rewards/costs (e.g., Chambers, Taylor, & Potenza, 2003). In all of these contexts, risk taking is associated with relatively greater activation of the socioemotional network. For example, individuals' preference for smaller immediate rewards over larger delayed rewards is associated with relatively increased activation of the ventral striatum, orbitofrontal cortex, and medial prefrontal cortex—all regions linked to the socioemotional network—presumably because immediate rewards are especially emotionally arousing (consider the difference between how you might feel if a crisp $100 bill were held in front of you versus being told that you will receive $150 in 2 months). In contrast, regions implicated in cognitive control are engaged equivalently across decision conditions (McClure, Laibson, Loewenstein, & Cohen, 2004). Similarly, studies show that increased activity in regions of the socioemotional network is associated with the selection of comparatively risky (but potentially highly rewarding) choices over more conservative ones (Ernst et al., 2005).

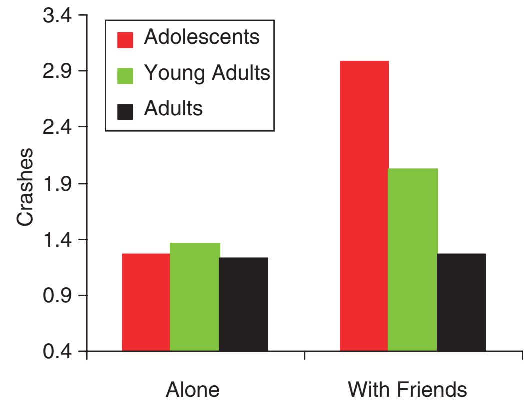

Fig. 2. Risk taking of adolescents, young adults, and adults during a video driving game, when playing alone and when playing with friends. Adapted from Gardner & Steinberg (2004).

Evidence From Behavioral Science

Three lines of behavioral evidence are consistent with this account. First, studies of susceptibility to antisocial peer influence show that vulnerability to peer pressure increases between preadolescence and mid-adolescence, peaks in mid-adolescence—presumably when the imbalance between the sensitivity to socioemotional arousal (which has increased at puberty) and capacity for cognitive control (which is still immature) is greatest—and gradually declines thereafter (Steinberg, 2004). Second, as noted earlier, studies of decision making generally show no age differences in risk processing between older adolescents and adults when decision making is assessed under conditions likely associated with relatively lower activation of brain systems responsible for emotion, reward, and social processing (e.g., the presentation of hypothetical decision-making dilemmas to individuals tested alone under conditions of low emotional arousal; Millstein, & Halpern-Felsher, 2002). Third, the presence of peers increases risk taking substantially among teenagers, moderately among college-age individuals, and not at all among adults, consistent with the notion that the development of the cognitive-control network is gradual and extends beyond the teen years. In one of our lab's studies, for instance, the presence of peers more than doubled the number of risks teenagers took in a video driving game and increased risk taking by 50% among college undergraduates but had no effect at all among adults (Gardner & Steinberg, 2005; see Fig. 2). In adolescence, then, not only is more merrier—it is also riskier.

What Changes During Adolescence?

Studies of rodents indicate an especially significant increase in reward salience (i.e., how much attention individuals pay to the magnitude of potential rewards) around the time of puberty (Spear, 2000), consistent with human studies showing that increases in sensation seeking occur relatively early in adolescence and are correlated with pubertal maturation but not chronological age (Steinberg, 2004). Given behavioral findings indicating relatively greater reward salience among adolescents than adults in decision-making tasks, there is reason to speculate that, when presented with risky situations that have both potential rewards and potential costs, adolescents may be more sensitive than adults to variation in rewards but comparably sensitive (or perhaps even less sensitive) to variation in costs (Ernst et al., 2005).

It thus appears that the brain system that regulates the processing of rewards, social information, and emotions is becoming more sensitive and more easily aroused around the time of puberty. What about its sibling, the cognitive-control system? Regions making up the cognitive-control network, especially prefrontal regions, continue to exhibit gradual changes in structure and function during adolescence and early adulthood (Casey, Tottenham, Liston, & Durston, 2005). Much publicity has been given to the finding that synaptic pruning (the selective elimination of seldom-used synapses) and myelination (the development of the fatty sheaths that "insulate" neuronal circuitry)—both of which increase the efficiency of information processing—continue to occur in the prefrontal cortex well into the early 20s. But frontal regions also become more integrated with other brain regions during adolescence and early adulthood, leading to gradual improvements in many aspects of cognitive control such as response inhibition; this integration may be an even more important change than changes within the frontal region itself. Imaging studies using tasks in which individuals are asked to inhibit a "prepotent" response–like trying to look away from, rather than toward, a point of light—have shown that adolescents tend to recruit the cognitive-control network less broadly than do adults, perhaps overtaxing the capacity of the more limited number of regions they activate (Luna et al., 2001).

In essence, one of the reasons the cognitive-control system of adults is more effective than that of adolescents is that adults' brains distribute its regulatory responsibilities across a wider network of linked components. This lack of cross-talk across brain regions in adolescence results not only in individuals acting on gut feelings without fully thinking (the stereotypic portrayal of teenagers) but also in thinking too much when gut feelings ought to be attended to (which teenagers also do from time to time). In one recent study, when asked whether some obviously dangerous activities (e.g., setting one's hair on fire) were "good ideas," adolescents took significantly longer than adults to respond to the questions and activated a less narrowly distributed set of cognitive-control regions (Baird, Fugelsang, & Bennett, 2005). This was not the case when the queried activities were not dangerous ones, however (e.g., eating salad).

The fact that maturation of the socioemotional network appears to be driven by puberty, whereas the maturation of the cognitive-control network does not, raises interesting questions about the impact—at the individual and at the societal levels—of early pubertal maturation on risk-taking. We know that there is wide variability among individuals in the timing of puberty, due to both genetic and environmental factors. We also know that there has been a significant drop in the age of pubertal maturation over the past 200 years. To the extent that the temporal disjunction between the maturation of the socioemotional system and that of the cognitive-control system contributes to adolescent risk taking, we would expect to see higher rates of risk taking among early maturers and a drop over time in the age of initial experimentation with risky behaviors such as sexual intercourse or drug use. There is evidence for both of these patterns (Collins & Steinberg, 2006; Johnson & Gerstein, 1998).

IMPLICATIONS FOR PREVENTION

What does this mean for the prevention of unhealthy risk taking in adolescence? Given extant research suggesting that it is not the way adolescents think or what they don't know or understand that is the problem, a more profitable strategy than attempting to change how adolescents view risky activities might be to focus on limiting opportunities for immature judgment to have harmful consequences. More than 90% of all American high-school students have had sex, drug, and driver education in their schools, yet large proportions of them still have unsafe sex, binge drink, smoke cigarettes, and drive recklessly (often more than one of these at the same time; Steinberg, 2004). Strategies such as raising the price of cigarettes, more vigilantly enforcing laws governing the sale of alcohol, expanding adolescents' access to mental-health and contraceptive services, and raising the driving age would likely be more effective in limiting adolescent smoking, substance abuse, pregnancy, and automobile fatalities than strategies aimed at making adolescents wiser, less impulsive, or less shortsighted. Some things just take time to develop, and, like it or not, mature judgment is probably one of them.

The research reviewed here suggests that heightened risk taking during adolescence is likely to be normative, biologically driven, and, to some extent, inevitable. There is probably very little that can or ought to be done to either attenuate or delay the shift in reward sensitivity that takes place at puberty. It may be possible to accelerate the maturation of self-regulatory competence, but no research has examined whether this is possible. In light of studies showing familial influences on psychosocial maturity in adolescence, understanding how contextual factors influence the development of self-regulation and knowing the neural underpinnings of these processes should be a high priority for those interested in the well-being of young people.

Recommended Reading

Casey, B.J., Tottenham, N., Liston, C., & Durston, S. (2005). (See References)

Johnson, R., & Gerstein, D. (1998). (See References)

Nelson, E., Leibenluft, E., McClure, E., & Pine, D. (2005). (See References)

Spear, P. (2000). (See References)

Steinberg, L. (2004). (See References)

Acknowledgments—Thanks to Nora Newcombe for comments on an earlier draft and to Jason Chein for his expertise in developmental neuroscience.

REFERENCES

Baird, A., Fugelsang, J., & Bennett, C. (2005, April). *"What were you thinking?": An fMRI study of adolescent decision making*. Poster presented at the annual meeting of the Cognitive Neuroscience Society, New York.

Beyth-Marom, R., Austin, L., Fischoff, B., Palmgren, C., & Jacobs-Quadrel, M. (1993). Perceived consequences of risky behaviors: Adults and adolescents. *Developmental Psychology*, *29*, 549–563.

Casey, B.J., Tottenham, N., Liston, C., & Durston, S. (2005). Imaging the developing brain: What have we learned about cognitive development? *Trends in Cognitive Science*, *9*, 104–110.

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.

Collins, W.A., & Steinberg, L. (2006). Adolescent development in interpersonal context. In W. Damon & R. Lerner (Series Eds.) & N. Eisenberg (Vol. Ed.), *Handbook of Child Psychology: Social, emotional, and personality development* (Vol. 3, pp. 1003–1067). New York: Wiley.

Drevets, W.C., & Raichle, M.E. (1998). Reciprocal suppression of regional cerebral blood flow during emotional versus higher cognitive processes: Implications for interactions between emotion and cognition. *Cognition and Emotion*, *12*, 353–385.

Ernst, M., Jazbec, S., McClure, E.B., Monk, C.S., Blair, R.J.R., Leibenluft, E., & Pine, D.S. (2005). Amygdala and nucleus accumbens activation in response to receipt and omission of gains in adults and adolescents. *Neuroimage*, *25*, 1279–1291.

Galvan, A., Hare, T., Davidson, M., Spicer, J., Glover, G., & Casey, B.J. (2005). The role of ventral frontostriatal circuitry in reward-based learning in humans. *Journal of Neuroscience*, *25*, 8650–8656.

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.

Johnson, R., & Gerstein, D. (1998). Initiation of use of alcohol, cigarettes, marijuana, cocaine, and other substances in US birth cohorts since 1919. *American Journal of Public Health*, *88*, 27–33.

Luna, B., Thulborn, K.R., Munoz, D.P., Merriam, E.P., Garver, K.E., Minshew, N.J., et al. (2001). Maturation of widely distributed brain function subserves cognitive development. *Neuroimage*, *13*, 786–793.

McClure, S.M., Laibson, D.I., Loewenstein, G., & Cohen, J.D. (2004). Separate neural systems value immediate and delayed monetary rewards. *Science*, *306*, 503–507.

Millstein, S.G., & Halpern-Felsher, B.L. (2002). Perceptions of risk and vulnerability. *Journal of Adolescent Health*, *31S*, 10–27.

Nelson, E., Leibenluft, E., McClure, E., & Pine, D. (2005). The social re-orientation of adolescence: A neuroscience perspective on the process and its relation to psychopathology. *Psychological Medicine*, *35*, 163–174.

Reyna, V., & Farley, F. (2006). Risk and rationality in adolescent decision-making: Implications for theory, practice, and public policy. *Psychological Science in the Public Interest*, *7*, 1–44.

Spear, P. (2000). The adolescent brain and age-related behavioral manifestations. *Neuroscience and Biobehavioral Reviews*, *24*, 417–463.

Steinberg, L. (2004). Risk-taking in adolescence: What changes, and why? *Annals of the New York Academy of Sciences*, *1021*, 51–58.