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Judgment and Decision Making in Adolescence

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In this article, we review the most important findings to have emerged during the past 10 years in the study of judgment and decision making (JDM) in adolescence and look ahead to possible new directions in this burgeoning area of research. Three inter-related shifts in research emphasis are of particular importance and serve to organize this review. First, research grounded in normative models of JDM has moved beyond the study of age differences in risk perception and toward a dynamic account of the factors predicting adolescent decisions. Second, the field has seen widespread adoption of dual-process models of cognitive development that describe 2 relatively independent modes of information processing, typically contrasting an analytic (cold) system with an experiential (hot) one. Finally, there has been an increase in attention to the social, emotional, and self-regulatory factors that influence JDM. This shift in focus reflects the growing influence of findings from developmental neuroscience, which describe a pattern of structural and functional maturation that may set the stage for a heightened propensity to make risky decisions in adolescence.

Imagine, for a moment, that you are 16 years old. It is the spring of your sophomore year of high school, and you feel a newfound sense of optimism about your social prospects. Best of all, it is Friday night and you are ready to take advantage of your recently renegotiated curfew, now extended to 11 p.m. When pressed for your plans, you tell your parents that you are just going to the movies and then maybe hanging out at the coffee shop: No need to worry. In reality, you know that when your friends pick you up, you will head straight to the first big keg party to which you have ever been invited. Everyone will be there. But you will have to be careful, because these things get busted by the cops all the time, not to mention the fact that your parents will be waiting up for you when you get home. You are not really planning on drinking at the party, but if you do, you will definitely need some breath mints and a believable horror movie synopsis. That should be easy enough.

We begin our review with this exercise in creative visualization not to inspire fear and suspicion in those among our readers charged with parenting a teenager, but to illustrate the multitude of factors that dynamically shape adolescents' choices. On this one weekend evening, our hypothetical teenager will make a series of choices with potentially lasting consequences for his health, safety, criminal record, family relationships, and social status. These decisions are likely to be influenced not only by his capacity to accurately evaluate the relative costs and benefits of alternative courses of action, but also the social and emotional contexts in which he makes the decisions—the mix of excitement and anxiety he brings to the party, his in-the-moment assessment of social expectations, and his background fear of getting caught by police or parents, to name just a few. Stated simply, adolescent decision making is a complex and multiply determined phenomenon.

Fortunately, the last decade of scholarship on adolescent judgment and decision making (JDM) has seen remarkable progress in modeling this complexity. Building on normative models of rational decision making, the field has dramatically expanded its explanatory power by integrating research methods and theoretical insights from cognitive, developmental, social, and emotion perspectives, with a growing influence from the neurosciences. Indeed, this movement toward an interdisciplinary perspective has made it increasingly difficult to define the boundaries of adolescent JDM as a topic of investigation. After all, what domain of adolescent behavior does not involve some degree of JDM? Because space limitations preclude an exhaustive consideration of such an expansively defined literature, our review is necessary selective, guided by our assessment of the most important developments over the last decade within the traditional domains of interest to adolescent JDM researchers. Responding to public policy concerns regarding adolescents' relative competence to make decisions with long-term consequences for their health and well-being, the field has historically focused on identifying domains of immaturity in adolescent

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decision making. Although our review reflects this tradition, we emphasize that many, if not most, adolescents demonstrate remarkable decision-making competence across a variety of domains. Future research on adolescent JDM should aspire to integrate current models focused on adolescent immaturity with the growing literature documenting the biological, psychological, and contextual factors promoting positive youth development (Lerner, 2009).

Three inter-related developments in adolescent JDM research serve to organize this review. First, developmental research grounded in normative models of rational decision making has made significant gains in identifying the factors that influence adolescents' choices. Building on foundational work modeling the key components of rational decision making, early research in this tradition focused on identifying aspects of cognitive processing in which adolescents were deficient relative to adults, particularly with regard to decisions involving risk. In response to considerable evidence that adolescents evaluate risky decisions in a manner similar to adults (Reyna & Farley, 2006), research from the past decade has shifted from an examination of age differences in risk processing toward comprehensive modeling of the factors predicting adolescents' decisions. Such models have gained considerable explanatory power by examining the interplay of both risk *and benefit* perceptions, as well as the role of experience in modifying these views.

Second, following theoretical developments in the adult JDM literature (and related trends in cognitive and social psychology), the field has seen widespread adoption of dual-process models of cognitive development (see Jacobs & Klaczynski, 2005, for multiple examples). These models describe two relatively independent modes of information processing, typically contrasting an analytic (deliberative, controlled, reasoned, ''cold'') system with an experiential (intuitive, automatic, reactive, ''hot'') system (e.g., Epstein, 1994; Gerrard, Gibbons, Houlihan, Stock, & Pomery, 2008; Jacobs & Klaczynski, 2002; Reyna & Farley, 2006). Proponents of dual-process models argue that traditional cognitive development research has been limited by its singular focus on the analytic system, leading to theories of unidirectional maturational trajectories proceeding from intuitive to reasoned processing (Klaczynsi, 2005). Given evidence that the use of many heuristics actually *increases* in adulthood, dual-process proponents argue that developmental models of JDM must account for the distinct maturational trajectories of analytic and experiential systems. In this view, changes in JDM over the course of adolescence do not reflect a simple transition from experiential to analytic processing, but rather result from domain-specific shifts in the relative dominance of intuition and reason.

The influence of dual-process theories can also be felt in a third research trend, a growth in attention to the social, emotional, and self-regulatory factors that influence adolescents' JDM. This shift in focus reflects the growing influence of findings from developmental neuroscience, which describe a pattern of structural and functional maturation that may set the stage for a heightened propensity to make risky decisions in adolescence. Social and emotional factors relevant to adolescent JDM include normative changes in core motivational processes, such as sensation seeking and sensitivity to reward and punishment, as well as age-related changes in the relative influence of contextual variables (e.g., the presence or absence of peers) on risk-taking behavior. Together, evidence for heightened sensitivity to social and emotional factors in early-to-middle adolescence has offered one plausible account for the corresponding prevalence of risk taking. Complementary to this focus on social and emotional factors, research has also described continued development in late adolescence of capacities supporting growth in self-regulatory competence, which is thought to contribute to a corresponding decline in risk taking. Consistent with the dual-process perspectives described above, this research has sought to push the field beyond the study of ''cold'' cognition and toward explication of the experiential factors that influence real-world, in-the-moment decision making.

BEYOND RISK PERCEPTION: EXPANDING THE STUDY OF RATIONAL DECISION MAKING

Before the mid-1990s, research on adolescent JDM focused largely on whether adolescents used adult-like cognitive processes when making decisions (for reviews, see Furby & Beyth-Marom, 1992; Quadrel, Fischhoff, & Davis, 1993). Much of this work stemmed from concerns about the high prevalence of risk behavior among adolescents (especially compared with adults) and the consequences of risk taking for adolescents' health. As a general rule, adolescents are more likely than adults over 25 to binge drink, smoke cigarettes, have casual sex partners, engage in violent and other criminal behavior, and have fatal or serious automobile crashes, the majority of which are caused by reckless driving or driving under the influence of alcohol. Because many of these behaviors appear inherently irrational when individuals understand their probable long-

term consequences, it was assumed that adolescents must be less competent than adults in one or more of the elements of rational decision making.

Normative models of JDM have historically emphasized five broad stages supporting competent decision making, including: (a) identifying options; (b) assessing the possible consequences of each option; (c) evaluating the desirability of each consequence; (d) estimating the probability of occurrence for each consequence; and (e) applying a decision algorithm to the above information to identify the option with the greatest subjective utility (Beyth-Marom, Austin, Fischhoff, Palmgren, & Jacobs-quadrel, 1993; Halpern-Felsher & Cauffman, 2001). Drawing upon these and similar models (e.g., Theory of Planned Behavior; Azjen, 1985), a great deal of research searched for the source of adolescents' heightened propensity to make risky choices by comparing adolescent and adult performance within specific stages of the decision-making process. Specifically, much of this work examined whether adolescents perceive the potential consequences of risk behavior (i.e., Stage b) and accurately assess the probability of those consequences occurring (i.e., Stage d) to the same degree as adults.

Contradicting popular conceptions of the typical adolescent as beset by an "invulnerability complex," adolescents were shown to be no worse than adults at perceiving risk or estimating their vulnerability to it, and studies found that increasing the salience of the risks associated with making a poor or potentially dangerous decision has comparable effects on adolescents and adults (for a discussion of false leads in the study of adolescent risk taking, see Millstein & Halpern-Felsher, 2002; Reyna & Farley, 2006; Rivers, Reyna, & Mills, 2008; Steinberg & Cauffman, 1996). Indeed, there appear to be few, if any, age differences in individuals' evaluations of the risks inherent in a wide range of dangerous behaviors (e.g., driving while drunk, having unprotected sex) or in their judgments about the seriousness of the consequences that might result from risky behavior (Beyth-Marom et al., 1993; although, see Cohn, Macfarlane, Yanez, & Imai, 1995, for an exception where adolescents judge lower risk than adults for "occasional" engagement in risk behavior).

Given evidence that adolescents do not differ much from adults in their capacity to rationally evaluate risk information, researchers have begun to look for other explanations of why adolescents, as a group, make riskier decisions than adults. As we will describe in later sections, this shift has led to expanded consideration of social, emotional, and self-regulatory factors differentiating adolescent from adult decision making. At the same time, research grounded in rational decision theory has made considerable progress in building models describing the cognitive factors that predict adolescents' health-risk decisions.

Before the last decade, the field's reliance on cross-sectional self-report studies produced a puzzling set of findings regarding the relation between risk perceptions and behaviors (for reviews, see Millstein & Halpern-Felsher, 2002; Reyna & Farley, 2006). Given the assumption that adolescents rationally evaluate costs and benefits to reach a decision, cognitive models typically predict that individuals who perceive lower risk will be more likely to engage in a given behavior. Although many studies have reported this expected negative correlation between risk perception and behavior (e.g., Benthin, Slovic, & Severson, 1993; Hemmelstein, 1995), others have found the opposite—that adolescents engaging in risk behavior perceive higher risks than do nonengagers (e.g., Cohn et al., 1995; Gerrard, Gibbons, & Bushman, 1996). To a degree, these contradictory findings can be accounted for by differences between studies with respect to the conditionality of risk perception assessments (Ronis, 1992). When risk perceptions are assessed unconditionally (i.e., "How likely are you to experience negative consequences from smoking?"), risk-takers accurately report a higher degree of personal risk than their peers who are not engaging in risk behavior. In contrast, when presented with conditional questions (i.e., "If you smoked, how likely are consequences?"), risk-takers tend to report lower risk perceptions than their risk-abstaining counterparts.

Such findings highlight both the role of experience as a modifier of risk perceptions and the need for longitudinal studies that assess risk perceptions *before* individuals engage in risk behavior. Although careful longitudinal research investigating prospective predictors of health-risk behavior is still much needed for a variety of domains, the last decade has seen progress in at least one area. Specifically, a number of longitudinal studies examining precursors of smoking initiation have provided strong evidence that adolescents who perceive a lower probability of harmful consequences are more likely to initiate smoking (Krosnick, Chang, Sherman, Chassin, & Presson, 2006; Rodriguez, Romer, & Audrain-Mcgovern, 2007; Song, Morrell, et al., 2009; Song, Glantz, & Halpern-Felsher, 2009). These studies provide an important reminder that, despite the inability to explain age differences in risk behavior, risk perception remains a valuable explanatory construct and a viable target for prevention efforts.

Recent research also has made progress in explicating the role of experience in modifying risk perceptions. As we discussed above, when adolescents

are asked how dangerous an activity would be *if* they were to engage in it, individuals experienced in the behavior consistently report lower risk perceptions than do those without experience. Although this finding can be explained in part by a presumed causal pathway from low-risk perception to subsequent risk engagement, it is also possible that experience with risk behavior causes individuals to adjust their risk judgments downward. This explanation is particularly plausible given the low frequency or long-term nature of negative consequences associated with many risk behaviors (e.g., lung cancer from smoking, infectious disease from unprotected sexual activity, motor vehicle crashes resulting from drunk driving). Although adolescents may initially adopt the high-risk estimates for these behaviors provided in health education classes, direct experiences with the behavior in the absence of serious negative consequences could create a downward shift in risk perception. Indeed, longitudinal research indicates that failing to experience a negative outcome is associated with decreased risk perceptions for alcohol use (Goldberg, Halpern-Felsher, & Millstein, 2002), drug use (Katz, Fromme, & D'Amico, 2000), drinking and driving (Nygaard, Waiters, Grube, & Keefe, 2003), and sexual activity (Millstein & Halpern-Felsher, 2002). These findings raise the concern that preventive efforts focused on bolstering adolescents' perceptions of health risks could backfire by leading those adolescents with "successful" risk-taking experiences to radically discount the validity of the health information message, thereby increasing their propensity to engage in further risk behavior. If the Partnership for a Drug Free America claims that smoking marijuana will transform your brain into a fried egg, and you nonetheless share a joint with friends on occasion and manage to maintain your GPA, then why trust what they say about cocaine and heroin?

Finally, much of the improvement in predicting adolescents' decision making has derived from an expanded consideration of the subjective benefits that adolescents associate with health-risk behaviors. For instance, one study found that adolescents' perceptions of the benefits (e.g., social status, pleasure) of alcohol and tobacco use prospectively predicts their decisions to drink and smoke 6 months later, above and beyond age, experience with the substance, and perceptions of risk (Goldberg et al., 2002; see also Halpern-Felsher, Biehl, Kropp, & Rubinstein, 2004; Meier, Slutke, Arndt, & Cadoret, 2007; Song, Morrell, et al., 2009). A recent meta-analysis of studies predicting sexual activity, alcohol and tobacco use, and nutrition behavior in adolescents ages 10–18 found that perceptions of benefits are stronger predictors than risk perceptions of all four behaviors (Peters et al., 2009). By considering the benefits that adolescents' derive from engaging in risk behavior, the field is approaching a much richer understanding of the subjective factors that shape adolescents' decisions (Michels, Kropp, Eyre, & Halpern-Felsher, 2005).

DUAL-PROCESS MODELS OF COGNITIVE DEVELOPMENT

Despite these improvements in modeling individual differences in adolescent health-risk behavior, many scholars have remained unsatisfied with the failure of rational decision theories to adequately describe *what develops* in adolescent JDM (e.g., Jacobs & Klaczynski, 2002; Reyna & Farley, 2006; Steinberg, 2003). As we noted above, most research on adolescent decision making conducted before the mid-1990s sought to identify gains in decision processing skills, largely based on the assumption that competence developed along a unidirectional, linear trajectory progressing from childhood intuition to mature, deliberative thinking in adulthood (Jacobs & Klaczynski, 2002). Investigators concerned with adolescent JDM have raised two strong challenges to this theoretical framework. First, the claim that decision processing develops over the course of childhood and adolescence toward an end state of rational, deliberate decision making is inconsistent with a wealth of evidence from the adult JDM literature that adult decision making is riddled with cognitive biases and heuristics (see Kahneman, Slovic, & Tversky, 1982). Indeed, as we will describe below, developmental studies suggest that certain heuristics and biases become *more* prevalent over the course of childhood and adolescence (Reyna & Farley, 2006). In essence, if the road of normative development leads to logically rigorous decision making, most adults fail to reach the destination. Second, given that few gains in logical reasoning or information processing are apparent after mid-adolescence (Kuhn, 2009), the development of rational competence cannot explain the many age differences observed between adolescents and adults in real-world decision making, particularly adolescents' heightened risk-taking behavior (Gerrard et al., 2008; Reyna & Farley, 2006; Steinberg, 2008). We discuss evidence for each of these critiques in turn and describe a class of dual process models that have been advanced to account for the seemingly paradoxical nature of adolescent cognitive development.

The Development of Heuristic Processing

A large body of research on adult JDM has demonstrated that although adults behave in accord with logical processing expectations on many JDM tasks, they also commonly show evidence of biases in judgment and reliance on heuristic "shortcuts" (Kahneman et al., 1982). Rather than interpret this "heuristics and biases" literature as evidence that adults are inherently irrational, some have suggested that rational (or "adaptive") decision making is supported by two separate, parallel modes of cognition—a conscious, *analytic* system responsible for logical, computational processing, and a pre-conscious, *experiential* system that supports quick, intuitive, heuristic processing, and is based in implicit memory (e.g., Epstein, 1994; Klaczynski, 2001; Stanovich, 1999). In response to mounting evidence in support of this and similar dual-process models of adult cognition, developmental JDM researchers have argued that theories of cognitive development focused on the maturation of logical competence have neglected a central aspect of cognition (Jacobs & Klaczynski, 2002). From this perspective, both the analytic and the experiential system mature over the course of development and together support the paradoxical mix of logic and bias observed in adult JDM.

Research guided by dual-process models of cognitive development has demonstrated age-related progressions in the use of different classes of heuristics that at first glance appear quite paradoxical. On the one hand, studies comparing younger and older adolescents on a variety of standard JDM tasks demonstrate growth in "normative" (i.e., logically coherent, heuristic-resistant) reasoning from early to middle adolescence (for a review, see Klaczynsi, 2005). For instance, middle adolescents show improvements in statistical reasoning, conditional reasoning, and covariation judgments and show less evidence of outcome bias and use of the "sunk cost" fallacy than early adolescents (Klaczynski, 2001; Klaczynski & Cottrell, 2004). Klaczynsi (2005) has argued that such improvements in normative reasoning are related to the maturation in adolescence of metacognitive skills; as adolescents develop the capacity and motivation to monitor and direct their thinking, they are more likely to resist the pull of certain heuristics and engage analytic processing systems.

On the other hand, evidence suggests that some biases and heuristics are engaged *more* frequently with age across childhood and adolescence (for reviews, see Jacobs & Klaczynski, 2002; Reyna & Farley, 2006). In particular, studies utilizing a variety of JDM tasks involving social content have demonstrated age-related increases in the tendency to incorrectly apply stereotype information to reasoning problems, resulting in more transitivity errors (e.g., Markovits & Dumas, 1999), conjunction fallacies (Davidson, 1995), and use of the representativeness heuristic (Jacobs & Potenza, 1991). Research on the development of the representativeness heuristic, the tendency to rely on salient features of a scenario rather than base rate information to inform likelihood judgments, nicely illustrates this phenomenon. For problems involving social content (e.g., Is the perky, outgoing girl a cheerleader or a member of the band?), adolescents show an increased propensity to favor stereotype-based information (e.g., cheerleaders are perky) over base rates (e.g., more girls are band members than cheerleaders; Jacobs & Klaczynski, 2002). In contrast, adolescents show developmental *gains* in the use of base-rate information on parallel problems that do not involve social content. In sum, adolescents are capable of engaging both analytical and heuristic processing systems when making judgments and decisions, but in contexts that activate their increasingly rich and salient social schemas, heuristic processing appears to gain influence over the course of adolescent development.

Reasoned and Reactive Pathways to Risk Behavior

The last decade has also seen the advancement of a growing number of dual-process models to describe the developmental mechanisms underlying the heightened incidence of risk-taking behavior in adolescence, relative to adulthood (e.g., Gerrard et al., 2008; Rivers et al., 2008; Steinberg, 2008). Expanding upon the rational decision models described in the first section of this review, these theories typically argue that age differences in risk behavior cannot be explained by the development of analytic competence alone, but rather result from developmental changes in the balance between two modes of processing—one that is deliberate and reasoned and one that is intuitive and reactive. Although the models share a similar conceptual framework, the distinctions between them are important enough to warrant a brief review of each.

The "prototype-willingness" model draws directly on the dual-process distinction between analytic and experiential cognition to argue that two different modes of processing influence risk-relevant decision making (Gerrard et al., 2008). The first mode—a "reasoned pathway"—is based on conscious, deliberate evaluation of the costs and benefits of choice alternatives and results in behavioral intentions, consistent with rational decision models

like the Theory of Planned Behavior (Azjen, 1985). Given that most adolescents claim that they do not intend to engage in risky behavior (Gerrard, Gibbons, & Gano, 2003), and yet many clearly do take risks when presented with the opportunity, this reasoned pathway through behavioral intentions leaves important variance in adolescent risk taking unexplained. Prototype-willingness theory contends that adolescents engage in unintended risk behavior via an alternative mode of processing, a ''social reaction pathway'' that is grounded in experiential processing, guided by social prototypes (i.e., schematic images of typical risk-takers), and reflected in individual differences in *behavioral willingness* to take risks if presented with the opportunity. An impressive body of evidence suggests that, in contrast to the poor predictive value of behavioral intentions for adolescent risk behavior, behavioral willingness prospectively predicts adolescents' engagement in behaviors as diverse as smoking, drinking, substance use, unprotected sex, reckless and intoxicated driving, and even tanning (for a review, see Gerrard et al., 2008). Recent evidence suggests that, as adolescents approach adulthood, the power of behavioral intentions to predict behavior grows, ultimately surpassing behavioral willingness (Pomery, Gibbons, Reis-bergan, & Gerrard, 2009). In essence, as adolescents' gain further experience navigating their social world, they begin to better understand their own behavioral tendencies and more accurately predict (and presumably control) their future decision making.

Similar to the dual-process model of cognition proposed by Jacobs and Klaczynski (2002), the ''fuzzy-trace'' model of adolescent risk taking draws upon evidence of developmental increases in heuristic processing to argue that cognitive maturation entails not only growth in reasoning capacity, but also the increasing application of intuition to JDM (Reyna & Farley, 2006; Rivers et al., 2008). This developmental pattern is exemplified by age differences in framing effects on risk taking. Whereas adults show a differential tendency to gamble when a choice is framed in terms of a loss versus a gain (i.e., preferring the risky option to avoid a loss, but preferring the ''sure thing'' to guarantee a small gain), young children do not differentiate between gain/loss frames; framing effects become progressively more common with age (Reyna & Ellis, 1994). Fuzzy trace theory interprets these findings as evidence for developmental maturation of ''gist-based'' processing—the adaptive tendency to rely on simple, categorical intuitions, derived from experience, to guide JDM. In the problems described above, adult preferences are more likely to be guided by the simple intuition that ''it is better to win some money than to win none.'' In contrast, children and adolescents make choices that reflect logically ''normative'' evaluation of loss and gain probabilities. Applied to real-world risk taking, this model suggests that adolescents lack the experience with negative consequences to support mature, categorical avoidance of risky choices and instead show an overreliance on conscious evaluation of the costs and benefits of risky behavior, which often favor the risky choice. Thus, in contrast to the prototype-willingness model, which argues that adolescents' *over*-reliance on experiential processing increases their tendency to engage in risky behavior, fuzzy trace theory claims that adolescents' heightened propensity toward taking risks derives from their *under*-reliance on intuition.

Finally, recent work from our lab (and others) has drawn on findings from developmental neuroscience to argue that the differential maturational trajectories of two core neurobiological systems creates a window of vulnerability for increased risk taking in adolescence (e.g., Casey, Getz, & Galvan, 2008; Chambers, Taylor, & Potenza, 2003; Dahl, 2004; Steinberg, 2008). We describe and review evidence for these models in the following section, which discusses important gains in our understanding of social, emotional, and self-regulatory influences on adolescent JDM.

EMOTION, CONTEXT, AND SELF-REGULATION

Let us return for a moment to the hypothetical teenager who introduced this review. Headed to his first big keg party, he was not exactly *intending* to drink, but he knew he would have to be very careful not to get caught if he did. Based on the research described in the first section of this review, we know that a variety of cognitive factors will influence his decision of whether or not to drink at the party, most notably his perceptions of the risks and benefits involved. However, a dual-process perspective suggests that decision making is influenced by not only cognitive inputs, but also feelings: the excitement of being with friends, the thrill of crossing parental or legal boundaries, and the fear of getting caught are all plausible affective contributions to our teenager's in-the-moment decision of whether or not to drink.

Research with adult populations has identified several pathways by which affect contributes to the decision-making process (for reviews, see Loewenstein, Weber, Hsee, & Welch, 2001; Winkielman, Knutson, Paulus, & Trujillo, 2007). First, the *anticipated* emotional outcomes of behavioral alternatives

contribute to cognitive assessments of their expected value (Loewenstein et al., 2001). The teenager at the keg party might imagine that joining his friends in drinking beer will lessen his social anxiety and increase his positive emotion, whereas abstaining will make him feel excluded and increase his anxiety. These anticipated emotional consequences contribute to his global evaluation of the desirability of the risky choice.

Second, direct emotional responses to qualities of the choice alternatives—that is, *anticipatory* emotions—influence their evaluation, and motivate approach or avoidance behavior (Loewenstein et al., 2001). Research grounded in inferential models of the influence of emotion on cognition suggests that individuals adaptively consult their feelings as a source of information when making a judgment about a given target (e.g., ''the affect heuristic''; Slovic, Peters, Finucane, & MacGregor, 2005). Returning to the keg party, if our teenager had a prior negative experience drinking beer, he may respond with a degree of disgust to the smell of spilled beer around the keg, and this aversive emotion might influence his behavior either indirectly (by contributing to a negative evaluation of the desirability of drinking) or directly (through heightened avoidance motivation).

A third class of affective inputs has variously been referred to as *incidental* emotion or background mood, and includes emotions elicited by factors not related to the decision itself (Loewenstein et al., 2001). Dating back to Zajonc's seminal affective priming studies (Zajonc, 1980), research on the interplay of emotion and cognition has demonstrated the influence of pre-existing or experimentally elicited affective states on perception, memory, judgment, and behavior (Winkielman et al., 2007). For instance, individuals surveyed on a sunny day rate their life satisfaction as higher than those contacted on a rainy day (Schwarz & Clore, 1983), and experimental elicitation of positive or negative emotion is associated with corresponding shifts toward optimistic or pessimistic judgments about risk (Johnson & Tversky, 1983). Indeed, recent experimental work suggests that emotions—whether consciously experienced or not—may modulate an individual's sensitivity to unrelated incentive stimuli, biasing the individual toward approach- or avoidance-related behavior (Winkielman, Berridge, & Wilbarger, 2005). Returning to the keg party one last time, our hypothetical teenager is likely bombarded with socioemotional stimuli, perhaps in the form of a crowd of friends' smiling faces. If these smiling faces elicit a positive emotional response from our teenager, his elevated mood may sensitize him to respond appetitively to the incentive value of the cup of beer he is subsequently offered. In effect, his immersion in a happy crowd might sensitize him to perceive the beer as more appealing.

Given that these emotion effects have all been demonstrated in studies of adult samples, it is important to examine their relevance for understanding the development of adolescent decision making. However, recent research suggests that two broad patterns in adolescent neurobehavioral development may combine to confer unique adolescent susceptibility to socioemotional influences on JDM (e.g., Casey et al., 2008; Chambers et al., 2003; Dahl, 2004; Steinberg, 2008). First, around the time of puberty, developmental changes in the dynamics of dopamine (e.g., Laviola, Pascucci, & Pieretti, 2001) and oxytocin (e.g., Chibbar, Toma, Mitchell, & Miller, 1990) neurotransmission are thought to alter the sensitivity of a network of brain regions we refer to as the *incentive processing system*. Increased sensitivity in this network, which includes regions involved in reward (e.g., ventral striatum) and social information (e.g., medial prefrontal cortex) processing, may contribute to normative increases in sensation seeking and sensitivity to socioemotional stimuli in early adolescence (Spear, 2009).

In contrast, prolonged structural refinements over the course of adolescence and early adulthood in regions associated with *cognitive control* (e.g., dorsolateral prefrontal and posterior parietal cortex) are thought to support older adolescents' emerging capacity to regulate their behavior (Casey et al., 2008). Although the details of these structural refinements and their relation to behavioral improvements remain a matter of debate, there is now extensive evidence demonstrating late adolescent changes in gray and white matter density, as well as gains in the coherence of white matter connections within and between cortical and subcortical regions (see Paus, 2009, for a review of the evidence). At the functional level, adolescents show progressive gains in the efficient (i.e., focal) recruitment of prefrontal and parietal circuits thought to support mature cognitive control, including the ability to suppress impulsive responding (Durston et al., 2006). In sum, to the degree that adolescents are primed to seek out and respond to rewards, and at the same time possess immature self-regulatory skills, the influence of socioemotional stimuli is likely to loom large for their decision making.

Because of space limitations, we will forgo a detailed review of the neuroscientific evidence in support of this model (see Casey et al., 2008; Chambers

et al., 2003; Dahl, 2004; Steinberg, 2008), and instead focus on related developments in social, emotional, and self-regulatory behavior in adolescence. However, we note that the application of neuroscience to the study of adolescent JDM has been one of the most dramatic (and fruitful) developments in the field's last decade. Not only has neuroscience provided new evidence to inspire and constrain our hypotheses about adolescent behavioral development, it has also hastened the emergence of JDM as a nexus for research integrating cognitive, social, and affective perspectives on adolescent development.

Developmental Trends in Reward Motivation, Affective Learning, and Sensitivity to Peer Influence

It has long been known that self-reported sensation seeking (i.e., the motivation to seek out novel, varied, and highly stimulating experiences) declines between adolescence and adulthood (e.g., Zuckerman, Eysenck, & Eysenck, 1978). Although Zuckerman (1969) originated the hypothesis that sensation seeking increases from childhood to early adolescence before beginning its decline, only recently have studies been conducted with samples broad enough in age range to confirm this curvilinear developmental trend (e.g., Romer & Hennessy, 2007; Steinberg et al., 2008). Importantly, one study found that the growth in sensation seeking observed in the transition from childhood to adolescence was more closely related to pubertal status than age (Martin et al., 2002), suggesting that observed age trends reflect normative biological development (rather than, for instance, changing peer norms). This interpretation is further supported by observations of adolescent peaks in reward seeking in studies of rodents and nonhuman primates (Spear, 2009). Relating to our earlier discussion of the influence of anticipated emotion, sensation seeking may increase adolescents' propensity to make risky decisions by imbuing risky options with strong reward value. Indeed, research has consistently found a positive relation between sensation seeking and engagement in a variety of risk behaviors (e.g., Arnett, 1992; Roberti, 2004; Zuckerman, 1994; Zuckerman & Kuhlman, 2000), with at least one recent study reporting that this relation is mediated by the degree to which adolescents expect that risk taking will produce positive feelings (i.e., their anticipated affect; Romer & Hennessy, 2007).

Studies utilizing affective learning paradigms further suggest that adolescents are not necessarily hypersensitive to all emotional stimuli, but rather respond more strongly to reward than punishment feedback. According to the somatic marker hypothesis, motivational behavior is guided by subtle affective learning from prior experience with reinforcement and/or punishment outcomes; such learning is thought to result in anticipatory feelings that bias the individual toward approach or avoidance in future encounters with the stimulus (Damasio, 1994). Research utilizing age-appropriate variants of the Iowa Gambling Task (IGT) has shown developmental gains over the course of childhood and adolescence in the capacity to adjust behavior in response to conflicting reward and punishment feedback (e.g., avoiding choices that result in small immediate gains but large long-term losses; Crone & Van der Molen, 2004; Crone, Vendel, & Van Der Molen, 2003). Furthermore, these gains appear related to gradual maturation of the capacity to learn from punishment outcomes (Crone, Bunge, Latenstein, & Van Der Molen, 2005), reflected in stronger anticipatory autonomic arousal when confronted with a previously punished choice (Crone & Van der Molen, 2007). Finally, a recent study that assessed a large sample of 10–30-year-olds on a variant of the IGT that produces separate measures of reward and punishment sensitivity found that, whereas sensitivity to punishment matures in a linear trajectory across development, reward sensitivity evinces a peak in adolescence before declining into adulthood, similar to the pattern observed for sensation seeking (Cauffman et al., 2010). Findings from this same program of work, discussed in a later section, also indicate that adolescents may be especially drawn to *immediate* rewards (Steinberg, Graham, et al., 2009). In sum, evidence is beginning to accumulate suggesting that adolescents are not only overly sensitive to rewards, but also relatively deficient in anticipating and learning from punishment.

Given this evidence for heightened sensation seeking and reward sensitivity, it is perhaps not that surprising that adolescents also demonstrate an exaggerated susceptibility to peer influences on risk-relevant decision making (Albert & Steinberg, in press-a). What could be more fun and rewarding than joining one's friends in exploring uncharted territory? Research has long indicated that adolescents are more likely than adults to take risks in the context of peer groups (rather than alone), and one of the best-documented predictors of adolescents' risky behavior is the behavior of their peers, a finding that has been attributed to a combination of social learning processes, opportunity effects, and the tendency for risk-takers to seek out similar friends (Prinstein & Dodge, 2008). One recent study suggests that the simple presence of peers differentially biases

adolescents toward increased risk-taking behavior (Gardner & Steinberg, 2005). In this study, adolescents (mean age = 14), youths (mean age = 19), and adults (mean age = 37) were tested on a computer driving task that mimicked the real-life decision of whether to run a series of yellow lights and risk being hit by an unseen car. Peer context was manipulated by randomly assigning each group of three participants to play the game either individually (alone in the room) or with two same-aged peers in the room. When tested alone, the three age groups engaged in a comparable amount of risk taking. In contrast, adolescents took twice as many risks when tested with their peers in the room (relative to the alone condition), whereas the college-aged group was approximately 50% riskier, and adults showed no differences in risky driving related to context.

Taken together, these developmental patterns are beginning to provide a plausible account of why adolescents sometimes demonstrate poor JDM in the real world, despite a mature capacity to understand and reason about the costs and benefits of their choices. Consistent with recent functional neuroimaging work demonstrating adolescent peaks in sensitivity to reward (e.g., Galvan et al., 2006) and social (e.g., Blakemore, 2008) stimuli, the behavioral research described above suggests that adolescents—more so than adults—are motivated to seek out novel and exciting experiences, more capable of learning from the positive than the negative consequences of those experiences, and more likely to take risks when in the presence of their peers. It is thus no great surprise that adolescents tend to make riskier decisions that adults, especially in peer contexts. This brings us to our final question: What developmental mechanisms might account for the normative decline in risky decision making observed across the transition from adolescence to adulthood?

The Development of Self-Regulatory Competence

In contrast to the relatively sudden changes in social, emotional, and reward processing that occur around the time of puberty, cognitive capacities supporting mature self-regulation appear to develop in a gradual, linear pattern over the course of adolescence, frequently extending into early adulthood (Steinberg, 2008). A growing body of evidence from cognitive neuroscience suggests that these improvements in cognitive control are supported by structural and functional maturation of a phylogenetically recent brain system that includes the lateral PFC, parietal association cortices, and parts of the anterior cingulate cortex, as well as enhanced connectivity between this system and subcortical areas (for a review, see Casey et al., 2008).

Whereas adolescents demonstrate adult-like competence in logical reasoning and information processing by about age 15 or 16, developmental improvements in higher-order executive functions known to simultaneously recruit multiple subregions of the PFC are evident across the course of adolescence and into early adulthood. For instance, improved performance is evident in late adolescence on tasks assessing response inhibition (e.g., Luna et al., 2001), strategic problem solving (e.g., Luciana, Collins, Olson, & Schissel, 2009), and flexible rule use (e.g., Crone, Somsen, Zanolie, & Van Der Molen, 2006). Furthermore, these age-related gains in executive function are reflected in a growing body of developmental neuroimaging research, which has generally demonstrated adolescent improvements in the efficient recruitment of task-relevant brain regions (e.g., dorsolateral PFC) supporting mature cognitive control (e.g., Durston et al., 2006).

Most importantly for the purposes of this discussion, improved coordination of cognitive and affective processes is also evident in late adolescence and early adulthood (Steinberg, 2008). Broadly speaking, as adolescents mature, they appear increasingly capable of regulating the social and emotional influences that previously biased their JDM toward risky behavior. For instance, self-report and behavioral evidence indicate a pattern of linear growth in impulse control extending through adolescence and into the twenties (e.g., Galvan, Hare, Voss, Glover, & Casey, 2007; Leshem & Glicksohn, 2007; Steinberg et al., 2008). Moreover, research utilizing temporal discounting paradigms demonstrates steady declines across adolescence in the tendency to choose small immediate rewards, rather than larger delayed rewards, reflecting the capacity or willingness to delay gratification in support of long-term goals (e.g., Olson, Hooper, Collins, & Luciana, 2007; Steinberg, Graham, et al., 2009). This pattern of gradual, prolonged maturation of self-regulatory capacity is further supported by evidence of late adolescent gains in future orientation (e.g., Steinberg, Graham, et al., 2009), planning (e.g., Albert & Steinberg, in press-b; Luciana et al., 2009), and metacognition (e.g., Klaczynsi, 2005). Finally, recent self-report evidence showing continued gains through at least age 18 in the ability to resist peer influence suggests that this emerging capacity for self-regulation extends to adolescents' social worlds (Steinberg & Monahan, 2007); moreover, recent neuroimaging research indicates that individual differences in resistance to peer pressure are correlated with relatively more

mature patterns of white matter organization (Paus et al., 2008). In sum, one compelling explanation for why adults tend to make more adaptive decisions than adolescents is that they have a more mature capacity to resist the pull of social and emotional influences and remain focused on long-term goals (Steinberg, Cauffman, Woolard, Graham, & Banich, 2009).

CONCLUDING COMMENTS AND FUTURE DIRECTIONS

As exemplified by the research and theory reviewed in this article, the last decade has witnessed a kind of redefinition of what it means to study JDM in adolescence. Moving beyond a relatively narrow focus on age differences in the rational processing of decision elements, the field has begun to grapple with the dynamic quality of adolescents' subjective decision-making experience—their beliefs and values, intentions and intuitions, emotions and self-awareness, all developing in the midst of a changing social world. We conclude our review by suggesting four lines of research that are needed to bolster this integrative progress and ultimately to inform better interventions and policies charged with supporting adolescents' well-being.

First, although research examining the cognitive predictors of adolescent health-risk behavior made important strides in the last decade—notably, by moving beyond a narrow focus on perceptions of risk and vulnerability, toward a broader view of the concerns that adolescents' themselves find salient—further longitudinal research is crucial for disentangling the reciprocal influence of perception and experience. We are certainly not the first to suggest this (see Millstein & Halpern-Felsher, 2002), but given the implications for the effectiveness of health-risk messages, the importance of understanding this perception–experience relation cannot be overstated. If adolescents develop inflated perceptions of risk based on the efforts of well-meaning health educators, but these perceptions are inherently unstable and subject to radical discounting in response to unpunished experience (i.e., the most probable outcome), then we are doing them a disservice by not honestly discussing the realistic costs and benefits of risk behavior. In addition to longitudinal studies better capable of modeling perception–experience interactions, experimental studies are needed that can examine the degree to which adolescents adjust their "instructed" risk perceptions in response to direct or vicarious experience with unpunished risk behavior.

Second, much of the credit for the field's increasingly integrative focus is due to the theoretical expansion provided by the dual-process models described in the second section of this review. Recognizing that adolescent JDM is notably inconsistent with their capacities and reported intentions, these theories proposed that something else must be at work. Taken together, this something else looks "hot," reactive, intuitive, experiential, not necessarily conscious, and often based on social stereotypes or prototypes. By opening the door to these domains of thinking and feeling, the field has greatly enhanced its explanatory power. We caution, however, that these dual-process explanations are themselves likely to represent heuristics of a sort; multiple separable processes contribute to adolescent JDM, and while conceptually useful, dual-process theories must remain flexible enough to avoid false dualities and rather attempt to model this complexity. This cautionary note aside, several of these theories converge in identifying particularly influential "hot" contributions to decision making. Research on social heuristics and social prototypes highlight the increasing importance of "social meanings" for guiding behavior in adolescence (Sunstein, 2008). Attention should continue to be given to the pathways by which these social meanings influence adolescent JDM and, in particular, the environmental factors (e.g., media, peers, parents, school) that shape the social meaning of risk behavior. Moreover, evidence that adolescents are slow to develop "gist-based" avoidance of risk, despite exposure to countless risk-avoidant messages, again raises interesting questions regarding the most effective way to present health-promoting information. If adolescents are differentially sensitive to the reward potential of their decisions—as suggested by developmental trends in sensation seeking and reward learning, as well as the influence of perceived benefits in predicting risk behavior—prevention research might gain more traction by working to strengthen adolescents' intuitive appreciation of the benefits of health-promoting behaviors (and challenge their intuitions about the benefits of risk taking).

Third, the field's enthusiasm (including our own) for the emerging work on the social neuroscience of adolescent JDM must be tempered by two observations. First, during the past decade research on the neural underpinnings of JDM in adolescence has far outpaced research on the very behaviors that the neuroscience is intended to inform. Indeed, as we note elsewhere (Steinberg, 2010), some of the best *behavioral* research on adolescents' reward seeking and self-regulation conducted in the past 10 years comes from functional imaging research on these phenomena.

Neuroimaging studies of JDM, while useful, need to be complemented by experimental and nonexperimental research on adolescent JDM in the real world. Much of the literature on novelty seeking and self-regulation outside the scanner is now very old.

Finally, as illustrated by the Gardner and Steinberg (2005) study of peer influences on risk taking cited previously, the social context in which adolescent JDM is assessed may have a profound influence on the conclusions one draws regarding age differences in decision making; studies of individuals making decisions on their own likely minimize differences between adolescents and adults. More research that takes the social context of JDM into account would be especially informative. Along similar lines, it is likely that age differences in JDM are accentuated under conditions of emotional arousal, just as they are when individuals are socially aroused. For example, a recent study that used a relatively simple experimental manipulation to increase the affective arousal of a decision-making task demonstrated substantially larger age differences in risk taking than were seen on an otherwise-identical low-arousal task (Figner, Mackinlay, Wilkening, & Weber, 2009). The social psychology literature is replete with examples of research on ways in which affective and social factors moderate JDM, but this work has, by and large, been adevelopmental, involving samples of college undergraduates. Developmentally informed work in this vein is sorely needed.

As we have detailed in this review, research on JDM during adolescence took several new directions during the past decade, moving away from studies that focus purely on rational processing and toward research that adds psychosocial factors into the mix and that attempts to link behavioral research with emergent models of adolescent brain development. By bridging work on biological, cognitive, emotional, and social development in adolescence, we will gain a deeper and richer understanding of the processes that influence JDM at keg parties and in the other real-world contexts in which adolescents spend time.

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