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The Evolutionary Basis of Risky Adolescent Behavior: Implications for Science, Policy, and Practice

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This article proposes an evolutionary model of risky behavior in adolescence and contrasts it with the prevailing developmental psychopathology model. The evolutionary model contends that understanding the evolutionary functions of adolescence is critical to explaining why adolescents engage in risky behavior and that successful intervention depends on working with, instead of against, adolescent goals and motivations. The current article articulates 5 key evolutionary insights into risky adolescent behavior: (a) The adolescent transition is an inflection point in development of social status and reproductive trajectories; (b) interventions need to address the adaptive functions of risky and aggressive behaviors like bullying; (c) risky adolescent behavior adaptively calibrates over development to match both harsh and unpredictable environmental conditions; (d) understanding evolved sex differences is critical for understanding the psychology of risky behavior; and (e) mismatches between current and past environments can dysregulate adolescent behavior, as demonstrated by age-segregated social groupings. The evolutionary model has broad implications for designing interventions for high-risk youth and suggests new directions for research that have not been forthcoming from other perspectives.

Keywords: evolution and development, evolutionary psychology, environmental mismatch, bullying, intervention

Behaviors such as aggression, crime, promiscuity, reckless driving, and drug use are often called risky because they are likely to harm the individuals who engage in them, others around them, or society as a whole. Adolescents are more likely to engage in these behaviors than people at any other stage of the life cycle (Institute of Medicine [IOM] & National Research Council [NRC], 2011;

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Steinberg, 2008). Thus, the legal system, policymakers, and scientists have focused an enormous amount of attention on risky adolescent behavior as a problem in need of a solution.

Given the problems caused by risky adolescent behaviors, it is tempting to regard them as maladaptive. Indeed, the prevailing conceptual framework for thinking about these behaviors considers them to be negative or disturbed developmental outcomes arising from stressful life experiences (together with personal or biological vulnerabilities). According to this framework, children raised in supportive and well-resourced environments (e.g., who live in communities with social networks and resources for young people, who have strong ties to schools and teachers, who benefit from nurturing and supportive parenting that includes clear and consistent discipline, who are exposed to prosocial peers) tend to develop normally and exhibit healthy behavior and values. By contrast, children raised in high-stress environments (e.g., who experience poverty, discrimination, low neighborhood attachment, and community disorganization; who feel disconnected from teachers and schools; who experience high levels of family conflict and negative relationships with parents; who are exposed to delinquent peers) often develop abnormally and exhibit problem behaviors that are destructive to themselves and others. Different developmental outcomes are regarded as "adaptive versus maladaptive" depending on the extent to which they promote versus threaten young people's health, development, and safety. We refer to this set of guiding assumptions as the *developmental psychopathology model* of risky adolescent behavior.

Although the validity of the developmental psychopathology model seems self-evident, one purpose of this article and of this special section of *Developmental Psychology* is to show how it is incomplete—that it can lead scientists, policymakers, and practitioners to miss key insights about risky adolescent behavior that can inform intervention strategies for high-risk youth. To understand why, consider the basic definition of risk as "the possibility of suffering harm or loss" (YourDictionary.com, 2010). This definition, which forms the backbone of the "risk factor" approach to psychiatric and biomedical disorder, only captures the downside of risk without considering why people take risks. Risky behaviors are not maladaptive if the expected benefits outweigh the expected costs. People take calculated risks all the time, at all stages of the life cycle. One cannot legitimately regard risky behaviors as maladaptive based only on their costs.

Although some developmental psychopathology models recognize the importance of goals and motivation in explaining risky adolescent behavior (e.g., problem behavior theory; Jessor, 1987), theory and research are still dominated by pathologizing views of risk. The benefits of risky adolescent behavior—particularly the evolutionary fitness benefits—are rarely analyzed, built into models, or employed in the design of interventions. A central goal of this article is to extend the developmental psychopathology model to address, at a foundational level, "what's in it for the kids" who engage in risky adolescent behaviors.

High-risk behaviors can result in net harm in terms of a person's own phenomenology and well-being (e.g., producing miserable feelings or a shortened life), the welfare of others around the person, or the society as a whole but still be adaptive in an evolutionary sense. Consider, for example, risky behaviors that expose adolescents to danger and/or inflict harm on others but increase dominance in social hierarchies and leverage access to mates (e.g., Gallup, O'Brien, & Wilson, 2011; Palmer & Tilley, 1995; Sylwester & Pawlowski, 2011). "Risky" in this context does not equal "maladaptive." Although the problems associated with risky adolescent behaviors are real and there is a strong need to reduce them, regarding them as dysfunctional does not point to a solution. Rather, from an evolutionary perspective, viable solutions involve understanding the functions of risk taking in the contexts of adolescents' lives. As articulated below (Risky Adolescent Behavior: Five Key Insights From an Evolutionary Perspective), successful intervention depends on working with, instead of against, adolescent goals and motivations.

We call the study of risky adolescent behavior from an evolutionary perspective the *evolutionary model,* in contrast to the developmental psychopathology model. The two models are not mutually exclusive, and both share the same practical goal of reducing problem behaviors for the long-term benefit of individuals and society (regardless of the evolutionary adaptiveness of the behavior). The evolutionary model, however, can help achieve that goal through increased understanding of the adaptive logic and motivation that underlie so many risky adolescent behaviors. As discussed below, even when risky behavior is genuinely pathological (i.e., maladaptive from both an evolutionary and a developmental psychopathology perspective), a detailed understanding of adaptations in the context of past and present environments is often needed to understand the nature of the pathology (see Key Insight 5).

In the remainder of this article, we first articulate the main tenets of the evolutionary model and compare them with the developmental psychopathology model in more depth. Then we describe five key insights from the evolutionary model. Each insight concludes with a discussion of implications for intervention for high-risk youth. The other articles in this special section of *Developmental Psychology* describe and test various aspects of the evolutionary model in more detail.

The Evolutionary Model Contrasted With the Developmental Psychopathology Model

Taking a risk can be beneficial or costly. The riskier the choice, the greater the potential benefits but the less likely they are to be realized; thus, higher risk means greater variability in outcomes. Given the alternatives available to a person, risk taking can be the best choice in some situations. Furthermore, a given choice might seem dysfunctional according to others' views of how to behave but still be the best choice for the person in question. Indeed, frequent losses do not, by themselves, make a choice maladaptive. The costs of losing must be weighed against the benefits of winning. This is how human-related fields such as economics and animal-related fields such as behavioral ecology study risk (Daly & Wilson, 2001; Figueredo & Jacobs, 2010). Because evolution by natural selection is driven by differences among individuals in reproductive success, the evolutionary significance of any risky behavior ultimately depends on its costs and benefits with respect to the organism's fitness (i.e., the contribution of offspring to future generations). Individuals are not necessarily adapted to strive for reproductive success directly but rather to strive for more tangible goals such as food, safety, status, sex, and optimal parental investments that reliably led to reproductive success over evolutionary history. Cultural evolution adds another layer of

complexity in humans, causing people to strive for culturally defined goals that do not necessarily contribute to genetic fitness (Richerson & Boyd, 2005).

The emphasis of the evolutionary model on fitness costs and benefits leads to a different way of thinking about environmental stress and adversity, as well as about environmental resources and support, than is found in the developmental psychopathology literature. According to the developmental psychopathology model, positive or supportive environments, by definition, promote "good" developmental outcomes (as defined by dominant Western values; e.g., health, happiness, secure attachment, high self-esteem, emotion regulation, educational and professional success, stable marriage), whereas negative or stressful environments, by definition, foster "bad" developmental outcomes (as defined by that same value system; e.g., poor health, insecure attachment, substance abuse, conduct problems, depression, school failure, teenage pregnancy). Moreover, these "bad" outcomes are often studied as if they are intrinsically unwarranted and costly—a dysfunctional outcome, as opposed to possibly being the best choice under the circumstances. In contrast, from an evolutionary perspective, environments that are positive in character disproportionately afford resources and support that enhance fitness, whereas environments that are negative in character disproportionately embody stressors and adversities that undermine fitness.

The evolutionary model posits that natural selection shaped human neurobiological mechanisms to detect and respond to the fitness-relevant costs and benefits afforded by different environments. Most important, these responses are not arbitrary but function adaptively to calibrate developmental and behavioral strategies to match those environments (e.g., Belsky, Steinberg, & Draper, 1991; Chisholm, 1999; Ellis, 2004). This view of development challenges the prevailing psychopathology analysis of dysfunctional outcomes within settings of adversity. In particular, an evolutionary perspective contends that both stressful and supportive environments have been part of the human experience throughout our history, and that developmental systems shaped by natural selection respond adaptively to both kinds of contexts (Ellis, Boyce, Belsky, Bakermans-Kranenburg, & Van IJzendoorn, 2011). Thus, stressful environments do not so much disturb development as direct or regulate it toward strategies that are adaptive under stressful conditions (or at least were adaptive during human evolutionary history).[1]

It is important to note that optimal adaptation (in the evolutionary sense) to challenging environments is not without real consequences and costs. Harsh environments often harm or kill people, and the fact that children and adolescents adapt developmentally to such rearing conditions (reviewed in Ellis, Figueredo, Brumbach, & Schlomer, 2009; Pollak, 2008) does not imply that such conditions either promote child well-being or should be accepted as unmodifiable facts of life (i.e., David Hume's "naturalistic fallacy"). Developmental adaptations to high-stress environments enable individuals to make the best of a bad situation (i.e., to mitigate the inevitable fitness costs), even though "the best" may still constitute a high-risk strategy that jeopardizes the person's health and survival (e.g., Mulvihill, 2005; Shonkoff, Boyce, & McEwen, 2009) and is harmful to the long-term welfare of the society as a whole. Furthermore, there are genuinely novel environments, such as Romanian or Ukrainian orphanages (Dobrova-Krol, Van IJzendoorn, Bakermans-Kranenburg, & Juffer, 2010; Nelson et al., 2007), that are beyond the normative range of conditions encountered over human evolution. Selection simply could not have shaped children's brains and bodies to respond adaptively to collective rearing by paid, custodial, nonkin caregivers (Hrdy, 1999). Exposures to such challenging yet evolutionarily unprecedented conditions can be expected to induce pathological development, not evolutionarily adaptive strategies.

Research on the effects of stressful environmental conditions on mental health is central to the field of developmental psychopathology. Much work in the area focuses on building empirically based models of child and adolescent behavioral problems that provide a direct link to malleable environmental factors, paving the way to prevention and treatment (Dishion & Patterson, 1999). Although this approach has been instrumental in developing empirically supported interventions (e.g., Chamberlain & Weinrott, 1990; Dishion, Nelson, & Kavanagh, 2003; Eddy, Reid, Stoolmiller, & Fetrow, 2003; Forgatch & Patterson, 2010), the developmental psychopathology model has led researchers to focus—first and foremost—on the role of environmental adversity in promoting health-risking behaviors and associated mental health problems. As such, the developmental psychopathology model has placed undue emphasis on the expected costs and largely ignored the expected benefits of risk taking, making it difficult to explain adolescent motives for risky behavior. This bias has led the field to largely neglect a critically important question: What is in it for the adolescent?[2] The paradigmatic example is peer aggression, as articulated below (see Key Insight 2).

Answering this question requires considering what is in it for the adolescent now versus later, given that the costs and benefits of risky behavior may be displaced in time. Benefits may accrue before costs, or costs can be incurred before benefits. For instance, some high-risk strategies may produce short-term gains (e.g., controlling neighborhood turf, acceptance into bad-boy cliques, many girlfriends, early reproduction) but long-term losses (e.g., loss of job opportunities, premature disability and death). Hence, economists and behavioral ecologists regard discounting future losses in favor of immediate gains as adaptive under certain circumstances. Conversely, long-term strategies trade off short-term losses (e.g., delaying immediate benefits such as employment, higher income, marriage, and reproduction by pursuing years of tertiary education) for long-term gains (e.g., someday possibly achieving high social and economic success). Although a psychopathology analysis may regard such long-term thinking and planning as desirable and short-term thinking and planning as undesirable, it is not always the case that long-term investment is economically rational. This is because many people fail to achieve those longer term objectives in spite of their best efforts and wind up incurring all of the early costs for no eventual

[1] This model is not intended to be all encompassing, as there are genuinely pathological conditions (e.g., genetic abnormalities, neurotoxins, head injury) that interfere with the ability of individuals to use adaptive strategies in a variety of contexts, particularly under stress.

[2] One exception to this rule is the substantial body of work analyzing the role of peer affiliation patterns, including affiliation with deviant peers, in gaining access to socially rewarding interactions (reviewed in Dishion, Piehler, & Myers, 2008). This work, however, has not modeled the evolutionary fitness benefits of such interactions.

benefit. Hence, economists and behavioral ecologists regard discounting immediate losses in favor of future gains as maladaptive under certain circumstances (such as being a saver rather than a spender in a highly inflationary economy).

Because different risk-taking strategies are potentially adaptive or maladaptive depending on context, one can expect natural selection to favor risk-taking strategies that are contingent upon reliable and valid environmental cues to current and future conditions. Central to this perspective is the concept of conditional adaptations:

> Evolved mechanisms that detect and respond to specific features of childhood environments, features that have proven reliable over evolutionary time in predicting the nature of the social and physical world into which children will mature, and entrain developmental pathways that reliably matched those features during a species' natural selective history. (Boyce & Ellis, 2005, p. 290; for a comprehensive treatment of conditional adaptation, see West-Eberhard, 2003)

Conditional adaptations underpin development of contingent survival and reproductive strategies and thus enable individuals to function competently in a variety of environments. For example, according to life history (LH) theory, children's brains and bodies tend to respond to dangerous or unpredictable environments by growing up fast and living for the here and now (e.g., Belsky et al., 1991; Chisholm, 1999; Ellis et al., 2009; Nettle, 2010; Quinlan, 2007). Viewed from within this framework, the adolescent who responds to a dangerous environment by developing insecure attachments, adopting an opportunistic interpersonal orientation, engaging in a range of externalizing behaviors, and sustaining an early sexual debut is no less functional than the adolescent who responds to a well-resourced and supportive social environment by developing the opposing characteristics and orientations (see Belsky et al., 1991; Ellis et al., 2011).

In summary, the developmental psychopathology model is limited in its ability to explain patterns of risky adolescent behavior because it does not explicitly model evolutionary constraints—how natural selection shaped the adolescent brain to respond to environmental opportunities and challenges—and does not adequately address why adolescents engage in risk-taking behaviors in the first place. Explaining that some high-risk behavior is adaptive in an evolutionary sense does not justify it in a normative or ethical sense; however, by providing a unique vantage point on the functions of risky adolescent behavior, the evolutionary model can lead to practical solutions that have not been forthcoming from the developmental psychopathology perspective.

Risky Adolescent Behavior: Five Key Insights From an Evolutionary Perspective

The evolutionary model yields a number of insights into risky adolescent behavior. Five key insights and their implications for intervention are summarized in Table 1 and articulated below.

1. The Adolescent Transition Is an Inflection Point in Development of Social Status and Reproductive Trajectories

Spanning the years from the onset of puberty until the onset of adulthood, adolescence is fundamentally a transition from the pre-reproductive to the reproductive phase of the life span. The developing person reallocates energy and resources toward transforming into a reproductively competent individual. From an evolutionary perspective, a major function of adolescence is to attain reproductive status—to develop the physical and social competencies needed to gain access to a new and highly contested biological resource: sex and, ultimately, reproduction. Both sexual promiscuity and the intensity of sexual competition peak during adolescence and early adulthood (Weisfeld, 1999; Weisfeld & Coleman, 2005), when most people have not yet found a stable partner and the mating market is maximally open. This time of heightened promiscuity and competition may help young people determine their own status and desirability, refine their mate preferences, and practice mate-attraction tactics (Weisfeld & Coleman, 2005). Indeed, an important function of self-organized peer groups in adolescence may be to position oneself in a social context to be sexually active, pulling away from adult supervision and engaging in reinforcing activities with peers (Dishion, Ha, & Véronneau, 2012). Most critically, as articulated below, the adolescent transition is an inflection point (i.e., a sensitive period for change) in developmental trajectories of status, resource control, mating success, and other fitness-relevant outcomes.

To achieve success at the critical adolescent transition, natural selection has favored a coordinated suite of rapid, punctuated changes—puberty—across multiple developmental domains. Driven by maturational changes in secretion of growth hormones, adrenal androgens, and gonadal steroids, pubertal development includes maturation of primary and secondary sexual characteristics, rapid changes in metabolism and physical growth, activation of new drives and motivations, and a wide array of social, behavioral, and affective changes (see Table 2).

These puberty-specific processes function to build reproductive capacity and increase sociocompetitive competencies in boys and girls. Increases in height, weight, and muscularity; more prominent jaws and cheekbones; emergence of body and facial hair; greater cardiovascular capacity, upper body strength, and grip strength; and broader shoulders make the male body more hardy, formidable, and sexually attractive to females. Breast development, fuller lips, widening of the hips, fat accumulation, and attainment of adult height and weight signal fertility and make the female body more sexually attractive to males. Changes in metabolic rates, food consumption, and sleep patterns support this physical metamorphosis. The adolescent phase shift also increases nighttime activity (when most sexual and romantic behavior occurs). Heightened sexual desire increases motivation to pursue, attract, and maintain mating relationships. Increased sensation seeking and emotional responsivity promote novelty seeking and exploration and may increase pursuit of socially mediated rewards. Higher levels of aggression and social dominance both facilitate and reflect the higher stakes competition that is occurring in adolescence over sex, status, and social alliances. Delinquent and risky behaviors (e.g., crime, rule breaking, fighting, risky driving, drinking games) often have signaling functions that enhance reputations for bravery and toughness and can leverage position in dominance hierarchies, especially for males. Distancing of parent–child relationships increases autonomy and reorients the adolescent toward peer relationships and the mating arena. Increasing levels of anxiety and depression in girls may reflect heightened sensitivity to negative social evaluations at a critical time for alliance formation. Al-

Table 1
Five Evolutionary Insights Into Risky Adolescent Behavior

Domain of study	Sample insights	Sample implications for intervention
1. Adaptive significance of adolescence: *The adolescent transition is an inflection point in determining social and reproductive trajectories.*	• Puberty-specific maturational changes function to build reproductive capacity and increase sociocompetitive competencies (see Table 2). • Successes and failures in adolescence disproportionately influence fitness. • Risk taking in adolescence has important signaling functions for establishing social status, prestige, and dominance.	• Interventions that simply attempt to stop high-risk adolescent behavior may fail because they ignore the function of the behavior • Interventions should promote group structures and behavioral strategies that enable adolescents to earn status for prosocial behaviors and avoid dynamics that confer status and peer reward for antisocial behavior.
2. Functions of risky and aggressive behavior: *Interventions need to address "what's in it for the kids" who engage in bullying and antisocial behavior.*	• Both prosocial and antisocial behavioral strategies function to control resources. • Bullying is a common animal behavior that increases access to physical, social, and sexual resources. • Adolescents are adapted to engage in bullying when the conditions are right.	• Many antibullying interventions fail because they are based on false stereotypes about the social incompetence of bullies. • Interventions need to alter the cost–benefit ratio of bullying so that it is no longer an adaptive strategy in the school ecology • Interventions should try to substitute more prosocial strategies that yield outcomes that are comparable to those achieved through bullying.
3. Conditional adaptation to stressful environments: *Risky adolescent behavior adaptively calibrates over development to match both harsh and unpredictable environmental conditions.*	• Stressful experiences direct or regulate development toward strategies that are adaptive under stressful conditions. • Exposures to harsh (high mortality–morbidity) and unpredictable environments each uniquely increase risky adolescent behavior.	• Interventions should be careful of declawing the cat. • Band-Aid solutions that do not address causative environmental conditions will not effectively change high-risk behaviors. • Interventions need to alter social contexts in ways that—through changes in the experiences of at-risk youth—induce an understanding that they can lead longer, healthier, more predictable lives.
4. Sex differences: *Understanding evolved sex differences is critical for understanding risk psychology.*	• Males have more to gain and less to lose from engaging in high-risk behaviors. • Both risk taking and sex differences in risk taking peak in adolescence and early adulthood. • Boys are much more responsive than girls to social and contextual cues to mating and status.	• Interventions should consider how the sex ratio of groups (the relative proportion of males to females) influences both antisocial and prosocial behavior. • The effects of sex ratio and sex composition on intervention outcomes may depend on the relative status of group members.
5. Environmental mismatch and mixed-age groups: *Mismatches between current and ancestral environments can dysregulate adolescent development and behavior.*	• Risky adolescent behavior can occur in response to evolutionarily novel environments outside of the species-typical range. • Mixed-age settings, rather than age-segregated school and peer environments, are the natural context for child development. • Mixed-age settings reduce aggression and increase prosocial behavior in adolescents.	• Many adolescent behavior problems could be treated by restoring past environmental conditions or removing novel environmental conditions that are causing harm. • Interventions could promote age mixing in contexts where the parties know one another well, are part of the same family or community, and interact naturally and freely in the course of their everyday lives.

though any given puberty-specific change listed in Table 2 may be modest in size, taken together, the pubertal transformation is dramatic.

Puberty-specific neuromaturational changes, together with age- and experience-dependent changes in the adolescent brain, make human adolescence a period of major and dynamic synaptic reorganization, ranging from neurogenesis to programmed cell death, elaboration and pruning of dendrites and synapses, myelination, and sexual differentiation (Blakemore & Choudhury, 2006; Sato, Schulz, Sisk, & Wood, 2008). It has been hypothesized that this remodeling and refinement

Table 2
Puberty-Specific Morphological and Biobehavioral Changes (Independent of Age)

Puberty-specific change	Empirical research
1. Sexual development: Maturation of primary and secondary sexual characteristics; growth spurt in height and weight; each stage of pubertal development moves the adolescent toward greater physical reproductive capacity.	
2. Sleep: Circadian shift in sleep timing preference, with later onset of sleep and morning rise times, occurs in midpuberty; increased sleepiness, which may indicate increased need for sleep, is linked to more advanced pubertal development.	Carskadon, Harvey, Duke, Anders, & Dement (1980); Crowley, Acebo, & Carskadon (2007); Holm et al. (2009); Sadeh, Dahl, Shahar, & Rosenblat-Stein (2009); Wolfson & Carskadon (1998)
3. Appetite and eating: Total caloric intake increases over the stages of pubertal development, with approximately a 50% increase from prepuberty to late puberty; sharpest increases occur from pre- to midpuberty in girls and mid- to late puberty in boys, corresponding to the periods of most rapid growth in females and males, respectively.	Shomaker et al. (2010)
4. Sexual motivation: Each stage of pubertal development increases the probability of being romantically involved (e.g., dating), being sexually active, sexually harassing members of the other sex, and being "in love"; effects generally apply to both boys and girls.	McCabe (1984); McMaster, Connolly, Pepler, & Craig (2002); Richards, Crowe, Larson, & Swann (1998); Richards & Larson (1993); Smolak, Levine, & Gralen (1993); Udry (1990)
5. Sensation seeking (wanting or liking high-sensation, high-arousal experiences): Boys and girls with more advanced pubertal development display higher levels of sensation seeking and greater drug use.	Martin et al. (2002); Quevedo, Benning, Gunnar, & Dahl (2009); Steinberg et al. (2008)
6. Emotional reactivity: Boys and girls with more advanced pubertal development (pre- to early vs. mid- to late) display greater reactivity of neurobehavioral systems involved in emotional information processing.	Quevedo, Benning, Gunnar, & Dahl (2009); Silk et al. (2009); see also Graber, Brooks-Gunn, & Warren (2006)
7. Aggression/delinquency: Progression through each Tanner stage is associated with increasing levels of aggression and delinquency in both boys and girls.	Ge, Brody, Conger, Simons, & Murry (2002); Najman et al. (2009)
8. Social dominance: During pubertal maturation, higher levels of testosterone are associated with greater social dominance or potency in boys; this relation appears to be strongest in boys who affiliate with nondeviant peers.	Reynolds et al. (2007); Rowe, Maughan, Worthman, Costello, & Angold (2004); Schaal, Tremblay, Soussignan, & Susman (1996); Tremblay et al. (1998)
9. Parent–child conflict: Parent–child conflict/distance increases and parent–child warmth decreases over the course of pubertal maturation; some research suggests a curvilinear relation, with conflict/distance peaking at midpuberty; effects generally apply to both boys and girls.	Laursen, Coy, & Collins (1998); Paikoff & Brooks-Gunn (1991); Sagrestano, McCormick, Paikoff, & Holmbeck (1999); Steinberg (1987, 1988)
10. Depression and anxiety: More advanced pubertal maturation, as well as underlying changes in pubertal hormone levels, is associated with more symptoms of depression and anxiety and greater stress perception in girls.	Angold, Costello, Erkanli, & Worthman (1999); Angold, Costello, & Worthman (1998); Ge et al. (2003); Hayward et al. (1992); Huerta & Brizuela-Gamino (2002); Patton et al. (1996); Warren & Brooks-Gunn (1989)

of behavioral circuits opens the brain to environmental input and thus creates a sensitive period for learning and developmental change (Blakemore & Choudhury, 2006; Sato et al., 2008). Adolescence may thus constitute a window of vulnerability and opportunity—an inflection point where experiences can disproportionately influence developmental trajectories.

Much is at stake at the adolescent transition, as rates of disability and death increase dramatically from such causes as depression, eating disorders, alcohol and other substance use, accidents, suicide, homicide, daredevilry, violence, and risky sexual behavior (IOM & NRC, 2011; Steinberg, 2008). The peak in these high-risk, high-stakes behaviors during adolescence suggests that this phase of the life span had substantial effects on fitness over evolutionary history and, therefore, underwent strong selection. We hypothesize that natural selection favored especially strong emotional and behavioral responses to social successes and failures during the adolescent transition, including heightened reactivity to peers. This hypothesis is consistent with fMRI data showing that in adolescents, but not adults, the presence of peers during a simulated driving task amplifies activity in reward-related brain regions, including the ventral striatum and orbitofrontal cortex (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011). This heightened brain activity then predicts subsequent risky decision making while driving. In total, there may be an evolved nexus between the adolescent brain's incentive processing system, peer contexts, and risky behavior.

Maturational changes and experiences in adolescence interact with social context to shape long-term social and reproductive trajectories. Among males, early maturing boys tend to be taller and stronger than their same-age peers and often attain high status within the peer group (reviewed in Weisfeld, 1999). Jones (1957) found that early maturing boys were more socially poised and less anxious in adolescence than later maturing boys. Although these boys only achieved about the same final height as their later maturing peers, longitudinal analyses demonstrated that they remained more self-assured in adulthood, scored higher on person-

ality characteristics associated with dominance, and were more likely to attain executive positions in their careers. In a more recent longitudinal study, height attained in adolescence, rather than final adult height, positively predicted adult income in males (Persico, Postlewaite, & Silverman, 2004), again suggesting long-term consequences of "stature" in adolescence. Finally, early maturing boys (but not early maturing girls) display a more unrestricted sociosexual orientation (i.e., greater willingness to engage in casual sex) and have a higher number of lifetime sexual partners through young adulthood than do later maturing boys (Ostovich & Sabini, 2005; see also Ellis, 2004). Interestingly, pubertal status is clearly linked to levels of aggressive/delinquent behavior in pubescent boys, but timing of puberty does not feed forward to predict aggressive/delinquent behavior in young men (Najman et al., 2009). It may be that status obtained in adolescence is long lasting and obviates the need for risky antisocial behavioral strategies in adulthood.

Extant research has also documented the long-term sequelae of early pubertal development in girls. Women who experienced early pubertal development, compared with their later maturing peers, tend to have higher levels of serum estradiol and lower sex hormone binding globulin concentrations that persist through 20–30 years of age; have shorter periods of adolescent subfertility (the time between menarche and attainment of fertile menstrual cycles); experience earlier ages at first sexual intercourse, first pregnancy, and first childbirth; display more negative implicit evaluations of men in early adulthood; attain lower educational outcomes and occupational status; engage in more aggressive/delinquent behavior as young adults; and are heavier, carry more body fat, and bear greater allostatic loads (cumulative biological "wear and tear") in adolescence and early adulthood (Allsworth, Weitzen, & Boardman, 2005; Belles, Kunde, & Neumann, 2010; Emaus et al., 2008; Najman et al., 2009; van Lenthe, Kemper, & van Mechelen, 1996; reviewed in Ellis, 2004; Weichold, Silbereisen, & Schmitt-Rodermund, 2003). These effects can be conceptualized as part of a developmental continuum in which familial and ecological stressors in childhood forecast earlier pubertal maturation in girls (Belsky et al., 1991; Ellis, 2004; Ellis & Essex, 2007; Ellis, McFadyen-Ketchum, Dodge, Pettit, & Bates, 1999), which in turn regulates important dimensions of social and reproductive development (Belsky, Steinberg, Houts, & Halpern-Felsher, 2010; James, Ellis, Schlomer, & Garber, 2012; Trickett, Noll, & Putnam, 2011).

Status and risk-taking are also linked in adolescence (see Key Insight 4). Among youth whose current condition or circumstances are predictive of future reproductive failure (e.g., unemployed, unmarried, marginalized young men with few resources or prospects), low-risk strategies that minimize variance in outcomes have limited utility. By contrast, high-risk activities (e.g., confrontational and dangerous competition with other males, gang membership, criminal activities), which by definition increase variance in outcomes, become more tolerable—even appealing—because success at these activities can yield otherwise unobtainable fitness benefits for disenfranchised individuals (Wilson & Daly, 1985). Along these lines, male–male homicide rates increase with income inequality (Daly, Wilson, & Vasdev, 2001), suggesting that young males who lack the resources to socially compete and reproduce may be willing to risk even their lives to alter the balance of power. Extensive data support these inferences, uniformly demonstrating markedly elevated rates of violence among young, poor, marginalized males (e.g., Archer, 2009)—a group that may largely account for the dramatic rise in serious violence and delinquency in adolescence. Furthermore, peer aggression and risk-taking behaviors among adolescents correlate reliably with greater mating opportunities (Gallup et al., 2011; Palmer & Tilley, 1995; Pellegrini & Long, 2003; Sylwester & Pawlowski, 2011).

Evidence suggests that threats to social status for aggressive children emerge quite early in development, such as the first years of school entry (Coie & Kupersmidt, 1983; Dodge, 1983). Children and young adolescents who tend to be rejected or ignored by peers are those most likely to form coalitions with other high-risk children and engage in "deviancy training" (i.e., giving attention and rewards for talk about engaging in deviant behavior) in the context of the playground (Snyder et al., 2005) as well as in their adolescent friendships (Dishion, Spracklen, Andrews, & Patterson, 1996). There is a clear process through which middle school children who are harassed by their peers into marginal positions in status hierarchies come to associate with deviant peers and engage in progressively higher levels of risky and antisocial behavior over time (Rusby, Forrester, Biglan, & Metzler, 2005). This competition for peer status and acceptance may be most intense and consequential in early adolescence. For example, in a study of 206 male youth (Dishion, Nelson, & Bullock, 2004), behavioral observations of deviancy training were collected at ages 13–14, 15–16, and 17–18. Most critically, observations at age 13–14 were the most prognostic of delinquent and antisocial behavior in young adulthood. These data further highlight puberty and early adolescence as an inflection point in trajectories of high-risk behavior in young men and underscore the importance of this developmental period for well-conceived interventions.

Implications for prevention and intervention. Intervening with children who are experiencing a turbulent adolescence raises complex issues because this turbulence itself may reflect adaptive responses to social challenge. Socially rejected or marginalized adolescents often become anxious, depressed, socially withdrawn, aggressive, and/or delinquent (Weisfeld, 1999). Although these responses cause impairment and distress in many domains of life, interfering with these responses (such as through pharmacological interventions or cognitive behavioral therapy) may undermine the ability of adolescents to develop and carry out strategies that effectively meet relevant social challenges (Andrews & Thompson, 2009). The quandary for formulating social policy is that adaptive responses to social adversity often shift adolescents toward high-risk behaviors (see especially Key Insight 3).

Because (a) adolescence is a critical time for establishing status and long-term trajectories, (b) "anything worth having is worth fighting for," and (c) position in social hierarchies is a zero-sum game with winners and losers, status, popularity, and social success are not easily attained or readily surrendered. According to the handicap principle (Zahavi & Zahavi, 1997), behaviors that confer status must be costly to produce (i.e., they must be valid and reliable signals of the individual's sociocompetitive competencies, or fitness, that cannot be faked; otherwise, everyone would engage in these behaviors). For this reason, risk-taking behaviors among adolescents often have an important signaling function; successful risk taking (e.g., fighting, stealing something valuable, daredevilry, substance use, risky sports), where real danger is involved, is often admired and confers status, especially to males (Daly &

Wilson, 1988; Weisfeld, 1999). Thus, reckless driving, substance abuse, and crime are all much more likely to occur among adolescents, but not among adults, in the presence of peers (Chassin, Hussong, & Beltran, 2009; Simons-Morton, Lerner, & Singer, 2005; Zimring, 1998). These realities constrain the options for intervention but also suggest possible ways forward.

From an evolutionary perspective, what current prevention and treatment programs are generally on target in terms of working with adolescent goals and motivation? Consistent with an evolutionary perspective, there is a growing consensus that interventions aimed at promoting more positive strategies for attaining social status seem to have long-lasting effects. For example, the Good Behavior Game was established as a strategy for reducing problem behavior in the classroom (Barrish, Saunders, & Wolf, 1969). The game is simple; all children in the classroom earn points for not engaging in a list of problem behaviors such as aggression. Thus, high-risk children who effectively "inhibit" problem behavior earn rewards for the group. This intervention is easy to implement and disseminate, addresses issues of social status, and not only effectively reduces aggressive behavior in the first grade but appears to alter the risk trajectory of youth through adolescence (Kellam et al., 2008; Petras et al., 2008; Poduska et al., 2008). This approach concurs with a substantial body of evidence showing that peer influences in adolescence can promote prosocial behavior (Eisenberg & Morris, 2004). In total, interventions that target and promote adaptive goals in the context of prosocial norms have shown promise, as long as such interventions do not "pull out" only high-risk children, which may inadvertently confer status and reinforcement for risky behavior (as described below).

From an evolutionary perspective, what current prevention and treatment programs are probably misguided, or wiser not to conduct, in terms of adolescent goals and motivation? What is missing from almost all current intervention efforts is attention to motivation. Interventions that simply attempt to stop high-risk adolescent behaviors (e.g., zero tolerance, Abstinence Only, Just Say No) or encourage adolescents to substitute other activities that are arousing but not dangerous or illegal (e.g., activities that elicit high-intensity feelings in a safe way) may not be successful because they ignore the function(s) of the risky behavior. For example, efforts to reduce high-risk sexual behavior by encouraging abstinence in middle school students have inadvertently increased the frequency and riskiness of sexual behavior by the time these students are in high school (Moberg & Piper, 1998). Clearly, many young adolescents are interested in having sex, and discussions in the classroom have a disinhibiting effect on the desired behavior.

Furthermore, educational messages that emphasize the dangers of risky behavior—which almost all American adolescents are exposed to—appear to be much more successful in changing knowledge than behavior (Steinberg, 2008). Because these messages may actually increase the signaling value of risky behaviors by advertising their costs, they make these behaviors more appealing to some adolescents (i.e., those who are not cost sensitive and who are most likely to engage in dangerous behaviors to gain status and opportunities). Indeed, the National Cancer Institute's (2008) analysis of tobacco companies' marketing techniques concluded that emphasizing the harmful effects of smoking would have little impact on many at-risk adolescents. Accordingly, J. Gordon, Biglan, and Smolkowski (2008) redesigned antismoking interventions to minimize messages about the negative health effects of tobacco and instead marketed antitobacco norms by associating not smoking with fun, excitement, and social acceptance. In a randomized control trial, this proved to be an effective way to prevent smoking in adolescents. The key is that the intervention worked with, instead of against, adolescent goals and motivations by associating a nonsmoking lifestyle with "symbols, images, and activities that adolescents highly value" (J. Gordon et al., 2008, p. 84).

The other side of the coin is that interventions need to be careful not to provide a platform for reinforcing risky or deviant behavior. Aggregating high-risk youth into groups runs the risk of inadvertently conferring status on adolescents who engage in the most risky behavior. This process, known as "deviancy training," supports increases in problem behaviors that lead to negative life outcomes in adulthood (Dishion, McCord, & Poulin, 1999). This principle applies to interventions and policies affecting public schools (Reinke & Walker, 2006), community programs such as recreational centers (Lansford, 2006), and college roommate assignment (Duncan, Boisjoly, Kremer, Levy, & Eccles, 2005). Dodge, Dishion, and Lansford (2006) reviewed these findings and made recommendations for reducing potential iatrogenic effects (i.e., adverse effects caused by an intervention) on subsequent problem behavior associated with aggregating high-risk youth. These recommendations included carefully supervising the interventions, avoiding dynamics that confer social status and peer reward for engaging in problem behavior (i.e., deviancy training), and integrating youth as much as possible into settings that involve low-risk peers.

From an evolutionary perspective, what intervention strategies deserve special consideration? In many social contexts, adolescents can attain status without scenes of contest and braggadocio or engaging in antisocial behavior. This could include using prosocial strategies to control resources (such as building social value and alliances through cooperation and reciprocity; see Key Insight 2) or mastering important skills or knowledge that are valued by other group members. Social media also provide prosocial opportunities for children and adolescents to become part of a social network. Virtual groups, such as Facebook or interactive online video games, could act as a buffer against the lack of status or social acceptance at school. Interventions could guide adolescents toward these alternative means of gaining acceptance and respect. A related approach involves systematically promoting a group structure that confers status, especially among marginalized youth, for engaging in behaviors that promote reciprocally rewarding relationships and academic achievement. Bierman (2004) provided a wealth of insights on the strategies for effectively working with youth prone to peer rejection in ways that address issues of social status as well as skills development and reductions in problem behavior. One approach involves systematically pairing high-risk youth with those with high social status to develop skills in (pro)social competence. The next stage of research will involve testing these "peer-context" intervention strategies in random assignment studies.

Intervention efforts could also potentially benefit from considering proactively how to "engineer" social networks in early adolescence to minimize status attainment through increases in problem behavior. Innovative longitudinal research indicates that,

without intervention, salient antisocial behaviors such as carrying weapons or vandalism can result in increases in social status in some high-risk, urban environments (Dijkstra et al., 2010; Light & Dishion, 2007). An intriguing possibility is that it may be possible for adults to measure and attend to emerging social networks to prevent these dynamics from developing in high-risk community contexts. Teachers, school administrators, and parents are often aware and concerned about the early formation of deviant peer groups in early adolescence. Social network data could be used to design classroom assignments that mix high-risk and low-risk youth into learning environments. Extant research suggests that adults can be effective in engineering peer group environments that promote prosocial behavior and reduce antisocial behavior by attending to the supraordinate goal structure (e.g., the Good Behavior Game, described above).

In summary, adolescence is a critical time in the life span for attaining status and setting long-term social and reproductive trajectories. The adolescent transformation in brain, body, and behavior functions to increase sociocompetitive competencies and intensify motivation for peer status and acceptance and related mating opportunities. Intervention programs for high-risk youth need to work with, and not against, these powerful goals and motives. This means promoting group structures and behavioral strategies that enable adolescents to earn status for prosocial behaviors, on the one hand, and avoiding dynamics that confer social status and peer reward for antisocial behavior, on the other. Consideration of the functional role of status attainment in adolescent development is potentially useful in explaining the effectiveness and iatrogenic effects of past interventions, as well as suggesting novel, yet-to-be-tested approaches.

2. Interventions Need to Address the Adaptive Functions of Risky and Aggressive Behaviors Like Bullying

The evolutionary model emphasizes function over form. Function is what natural selection designed a behavior or characteristic to do; form addresses its phenomenological manifestation. Behaviors or signals that look very different (i.e., have different forms) may actually have the same adaptive function. Bowlby (1969) clearly understood this when he proposed that a cry and a coo (i.e., negative and positive affect, respectively), despite constituting different behaviors or affective states, both function to reduce distance to the caregiver.

The developmental psychopathology model tends to focus on the form of behavior over its functions. That is, such approaches rarely ask, What is the behavior for? Accordingly, the developmental psychopathology literature takes a form-focused approach to prosociality and antisociality, regarding or even defining these constructs as "opposites" (i.e., "pro" vs. "anti"), in a manner consistent with societal views of social desirability and undesirability (Hawley, 2002). This leads to the assumption that prosociality and antisociality correlate negatively. Prosociality is regarded as normative and "good" because it benefits others, and antisociality as disordered and "bad" because it harms others.

In contrast to this moralistic view, an evolutionary analysis focuses on the deeper roots of behavior and calls attention to the instrumentality of both prosocial and antisocial strategies; both function to control resources (i.e., getting what one wants, getting attention from others, wielding influence). Thus, social and material goals can be achieved in groups through means such as theft, bullying, trickery, or threatening harm or by participating in friendly relationship-building cooperation and reciprocation. Because prosocial and antisocial strategies for controlling resources share a common underlying function, the extent to which individuals employ these strategies should be independent or even positively related—a prediction that contrasts sharply with the developmental psychopathology model. This prediction has been supported in research with both young children and adolescents (Hawley, 2002, 2003; Hawley, Shorey, & Alderman, 2009). As a corollary to this novel proposition, one cannot assume a simple positive nexus among socially desirable characteristics (e.g., prosocial behavior, social competence, and positive peer regard) and straightforward positive correlations among socially undesirable characteristics (e.g., coercion, impulsivity, and social rejection; Hawley, 2002).

Derived from this logic, resource control theory (Hawley, 1999) posits two classes of resource control strategies, from which several distinct types of strategists can be derived (Hawley, 2003). *Prosocial controllers* mainly cooperate and work with the group to obtain resources. They are friendly, are socially skilled, value their friendships, and are very attractive social partners. As such, they embody social competence as construed by traditional perspectives. Moreover, they illustrate that power (i.e., resource control) does not require aggression. *Coercive controllers,* on the other hand, are by definition antagonistic in their resource control attempts; they tend to be unskilled, impulsive, rejected by the group, and they accordingly exemplify social incompetence, as per the developmental psychopathology model.

Bistrategic controllers, however, use both prosocial and coercive strategies to a high degree (Hawley, 2003). Partly because of their dual-strategy approach, bistrategics are by far the most successful at resource control. Like coercive controllers, bistrategics are aggressive and manipulative (Hawley, 2003; Hawley et al., 2009). At the same time, they appear to have many of the skills of prosocial controllers, such as a sophisticated understanding of others (Hawley, 2003). This combination of skills balanced with aggression—unexpected from a developmental psychopathology perspective—appears to capture an important dualism of human nature: the need to balance getting along and getting ahead.

Consistent with the dualistic approach, bullies are generally not socially incompetent. Bullying is a coercive strategy that can be defined as repeated, purposeful aggression directed toward a significantly weaker individual (Olweus, 1993). It peaks during adolescence, may directly affect 100–600 million adolescents worldwide each year, has been found in all cultures examined by modern researchers (though at widely varying rates), and is described in historical records as well (Volk, Camilleri, Dane, & Marini, in press; Volk, Craig, Boyce, & King, 2006). Contrary to popular stereotypes, pure bullies (i.e., excluding bully victims) often display average or above average mental health, peer popularity, and social skills (e.g., Berger, 2007; Faris & Felmlee, 2011; Ireland, 2005; Juvonen, Graham, & Schuster, 2003; Sutton, Smith, & Swettenham, 1999; Volk et al., 2006; Wolke, Woods, Bloomfield, & Karstadt, 2001).

Bullying, as a subtype of aggression, is relatively common among social animals, where its function may be to obtain physical, social, and sexual resources (e.g., Goodall, 1986; Masure &

Allee, 1934; Mech, 1970). These functions of bullying apply to humans as well (see Kolbert & Crothers, 2003; Volk et al., in press). For example, in cultures characterized by starvation-level competition, bullying can be an effective means of obtaining nutritional and economic resources (Turnbull, 1972). Bullying also appears to be effective in gaining popularity and/or social status, along with their attendant benefits (Faris & Felmlee, 2011; Juvonen et al., 2003; Sijtsema, Veenstra, Lindenberg, & Salmivalli, 2009). Notably, this is most pronounced with respect to members of the opposite sex, who are often impressed by bullies, while members of the same sex tend to view bullies negatively (Olthof & Goossens, 2008; Veenstra, Lindenberg, Munniksma, & Dijkstra, 2010). Bullying may thus be a form of intrasexual competition, similar to other forms of aggression (Leenaars, Dane, & Marini, 2008). Given the centrality of mating success to evolutionary fitness, vital evidence for the adaptive benefits of bullying is provided by data showing that bullies tend to date at younger ages and engage in more dating activities than do nonbullies (Connolly, Pepler, Craig, & Taradash, 2000; Faris & Felmlee, 2011; Gallup et al., 2011). Finally, akin to many evolved patterns of behavior, bullying appears to be a facultative adaptation; it is likely to develop and be expressed only under conditions in which bullying confers adaptive benefits (Volk et al., in press).

Implications for intervention. Although the following discussion focuses on bullying, the logic applies to prevention and treatment of antisocial behavior more generally. Many antibullying interventions are based on false stereotypes about the social incompetence or cognitive deficits of bullies (Rigby, 2010). It is not surprising, therefore, that early meta-analyses suggested that antibullying interventions were not very successful (e.g., Merrell, Gueldner, Ross, & Isava, 2008). More recent analyses, however, indicate that some antibullying interventions are reasonably effective (Rigby & Smith, 2011; Ttofi & Farrington, 2011). An evolutionary perspective helps explain why.

From an evolutionary perspective, what current antibullying interventions are generally on target? We believe that, at least in part, the success of some interventions derives from elements that converge with an evolutionary theory of bullying. Developed in Finland, the KiVa program (Kärnä et al., 2011; Salmivalli, Kärnä, & Poskiparta, 2010) recognizes the functionality of bullying as a means of obtaining status and dominance. Accordingly, the program alters reward structures for bullying. For example, KiVa empowers bystanders to intervene against bullying, either directly or indirectly. Moreover, KiVa explicitly recognizes that bullying is a function of norms involving the entire school ecology and that some ecologies confer more adaptive benefits to bullies than do others (e.g., through tolerance or resignation among people in and around the school). Accordingly, KiVa targets the attitudes and behaviors of principals, teachers, students, and parents (see also Olweus, 1993, as a predecessor in Norway). The success of both of these interventions lies in the fact that they recognize that bullying is functional and that it can be discouraged by altering the cost–benefit ratio so that it is no longer an adaptive strategy in the school ecology.

From an evolutionary perspective, what current antibullying interventions may be misguided or wiser not to conduct? In contrast, the widespread adoption of zero-tolerance policies requires that bullies stop their behavior without any consideration for why the bullies may engage in that behavior in the first place (for examples, visit http://www.bullypolice.org/). These policies are consistent with the Kandersteg Declaration Against Bullying in Children and Youth (2007), signed by many prominent bullying and aggression researchers, which simply demands, "Stop bullying now in all the places where children and youth live, work, and play." Even if one assumes that zero-tolerance policies have face validity (a currently tenuous assumption; American Psychological Association Zero Tolerance Task Force, 2008), can one realistically expect bullies to give up a successful social strategy simply because authorities have forbidden it? An evolutionary analysis posits that adolescents are adapted to engage in bullying when the conditions are right; thus, zero tolerance—without altering the larger ecology of bullying—may just lead bullies to conceal their behavior more carefully or to shift their methods from now-costly schoolyard bullying (due to interventions) to the "safe" anonymity of digital media via cyberbullying (see Rigby & Smith, 2011). Another example of misguided interventions is programs that promote working with peers to resolve bullying. A recent meta-analysis has shown that these programs increase the likelihood of victimization (Ttofi & Farrington, 2011). From an evolutionary perspective, such iatrogenic effects may occur because working with peers often involves having the victims (lambs) privately meet with the perpetrators (lions) within established adolescent dominance hierarchies. Peer interventions may also promote deviancy training (see Key Insight 1).

From an evolutionary perspective, what intervention strategies deserve special consideration? Interventions need to work within the goal structures of bullies to substitute effective, evolutionarily informed prosocial strategies that yield outcomes and incentives comparable to those achieved through bullying. Although encouraged by Olweus (1993), very few interventions actually focus on teaching, rewarding, and researching prosocial, alternative strategies for bullies that allow them to obtain the desired goals of resources, dating/sex, and dominance. For example, standing up for victims could be an alternative strategy that allows adolescents to assert their dominance against other adolescents (in this case, bullies instead of victims) in a prosocial manner (Dane, Marini, Book, & Volk, in press). As in the Good Behavior Game (discussed above), interventions should strive to teach and reward effective, goal-directed prosocial behaviors to at least the same degree that they seek to punish effective, goal-directed antisocial behaviors (i.e., bullying). Furthermore, antibullying efforts must be sustained and flexibly responsive to bullies' efforts to obtain their goals using new, less observable methods of bullying.

In summary, an evolutionary theory of bullying gives researchers something that is currently lacking—a cohesive, comprehensive explanation of the functions of bullying. More than any other current perspective, it explains why bullies do what they do. This in turn should help to design better interventions that work with, instead of against, adolescent goals and motivations.

3. Risky Adolescent Behavior Adaptively Calibrates Over Development to Match Both Harsh and Unpredictable Environmental Conditions

The adolescent transition is a sensitive period for change in developmental pathways—pathways that have already been influenced by earlier life experiences. As articulated above, an evolutionary perspective ineluctably implies that natural selection

shaped child and adolescent development to be responsive to rearing conditions. A key issue, therefore, involves identifying the experiences and environmental conditions that guide this process. Following Bronfenbrenner's (1979) multilayered ecology of human development, the developmental psychopathology model has called attention to the extent to which rearing environments are generally stressful or supportive, thus highlighting such factors as parental sensitivity and harshness, marital quality, parental mental health, and socioeconomic status (SES). Although such research has uncovered a variety of developmentally significant environmental influences, it has not been explicitly informed by evolutionary theory and, consequently, has not focused on or delineated basic dimensions of environmental stress and support that guide conditional adaptation (see discussion in Belsky, Schlomer, & Ellis, 2012). Without a model of the content of environmental factors, a common practice has been to aggregate multiple sources of stress in family environments, or to examine the additive effects of multiple stressors, to test a key hypothesis from the developmental psychopathology model: that the more stressors children are exposed to, the more their developmental competencies will be compromised (e.g., Evans & English, 2002; Fergusson & Woodward, 2000; Gutman, Sameroff, & Eccles, 2002; Scaramella, Conger, Simons, & Whitbeck, 1998). Although these methods for assessing cumulative contextual risk are empirically productive (accounting for substantial variance in adolescent behavior), they do not address why different types of childhood experiences matter.

Recently, Ellis and associates (2009) identified, via a within- and between-species analysis, distinct contextual dimensions that account for much of the variation in patterns of development both across and within species. LH theory, a branch of evolutionary biology addressing how organisms allocate time and energy to various activities over their life cycle, guided this analysis (e.g., Ellis et al., 2009; Roff, 2002; Stearns, 1992). Due to structural and resource limitations, organisms cannot simultaneously maximize the major life functions of bodily maintenance (e.g., immune function, predator defenses), growth (acquisition of physical, social, and cognitive competencies), and reproduction (mating and parenting). Instead, individuals make tradeoffs that prioritize resource and energy expenditures, so that greater investment in one domain occurs at the expense of investment in other domains. According to LH theory, natural selection favors individuals that schedule development and activities (i.e., allocate energy and resources) in a manner that optimizes tradeoffs over the life course and across varying ecological conditions. LH strategies[3] are adaptive solutions to a number of simultaneous fitness tradeoffs.

Both within and across species, developmental patterns that arise from different tradeoffs vary on a slow–fast continuum. Humans, of course, are not immune to these processes. As depicted in Figure 1, some people adopt slower strategies characterized by later reproductive development and behavior, a preference toward relatively stable pair bonds, an orientation toward longer term investments and outcomes, and allocation of resources toward enhancing the growth and long-term survival of both oneself and offspring, whereas others display faster strategies characterized by the opposite pattern (Ellis et al., 2009; Figueredo et al., 2006; Kaplan & Gangestad, 2005). Slow LH strategies, therefore, are inherently low risk (i.e., low variance), focusing on producing relatively few high-quality offspring that are likely to survive and reproduce. By contrast, fast LH strategies are comparatively high risk (i.e., high variance), focusing on mating opportunities, reproducing at younger ages (e.g., teen pregnancy), and producing a greater number of offspring with more variable outcomes. In total, the fast LH strategist is a short-term planner, taking benefits opportunistically with little regard for long-term consequences, whereas the slow LH strategist is a long-term planner, delaying immediate gratification in the service of future eventualities.

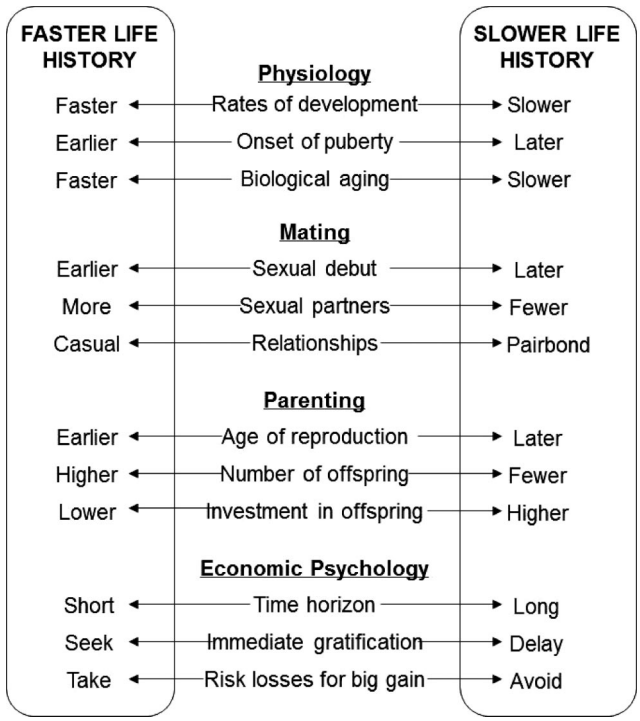

Figure 1. Faster versus slower life history strategies.

Development of fast LH strategies depends on adequate bioenergetic resources to support growth and development. Once this energetic threshold is crossed, other environmental conditions become salient determinants of LH strategy (Ellis et al., 2009). A fundamental influence on LH strategy is *extrinsic morbidity–mortality*: external sources of disability and death that are relatively insensitive to the adaptive decisions of the organism. When environmental factors cause high levels of extrinsic morbidity–mortality, even prime-age adults suffer relatively high levels of disability and death; thus, the probability of a child, or her parents and grandparents, surviving able bodied until the child reaches adulthood is greatly reduced. Accordingly, LH theory posits that our brains and bodies have been shaped by natural selection to respond to cues to extrinsic morbidity–mortality by developing faster LH strategies (Belsky et al., 1991; Chisholm, 1993, 1999;

[3] In evolutionary biology, the term *strategy* denotes an organism's realized phenotype among a set of possible alternatives. The term does not imply conscious planning, deliberation, or even awareness; low-level physiological mechanisms such as hormonal switches or modifications of genetic expression can implement a choice between phenotypic strategies (even behavioral ones).

Ellis et al., 2009; Quinlan, 2007). Relevant environmental cues include such life experiences as growing up in poverty, exposures to violence, harsh childrearing practices, attending the funerals of several peers during adolescence, and rarely seeing old people in one's local environment.

In addition to extrinsic morbidity–mortality, environmental unpredictability—variation over time and space in the fitness costs and benefits afforded by childhood environments—-also regulates development of LH strategies (Ellis et al., 2009). In environments that fluctuate unpredictably (e.g., changing randomly between Conditions A and B, so that exposure by parents or their young offspring to Condition A does not reliably forecast whether offspring will mature into Condition A or B), long-term investment in a development of a slow LH strategy does not optimize fitness; all of the energy invested in the future is wasted if the individual matures into an environment where life expectancy is short. Instead, people should detect and respond to signals of environmental unpredictability (e.g., erratic neighborhood conditions, frequent residential changes, fluctuating economic conditions, changes in family composition, stochastic parental behavior) by adopting faster LH strategies. Because extrinsic morbidity–mortality and unpredictability are distinct, developmental exposures to each of these environmental factors should uniquely contribute to variation in LH strategy (Ellis et al., 2009). Recent longitudinal analyses of the National Longitudinal Study of Adolescent Health, the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development, and the Minnesota Longitudinal Study of Risk and Adaptation support this prediction (Belsky et al., 2012; Brumbach, Figueredo, & Ellis, 2009; Simpson, Griskevicius, Kuo, Sung, & Collins, 2012).

This evolutionary analysis of key environmental influences on LH development differs in basic ways from the developmental psychopathology perspective, which emphasizes the harmful effects of cumulative stress. Whereas the developmental psychopathology model advances the hypothesis that the more stressors children are exposed to, the more their developmental competencies will be compromised, resulting in emotionally and behaviorally dysregulated functioning in adolescence, the evolutionary model clearly implies that biobehavioral development adjusts in different ways to different kinds of environmental stress (Ellis et al., 2009) and that these responses are often adaptive in context.

Implications for intervention. From an evolutionary perspective, fast LH strategies—having a child as a teenager, engaging in high-risk behaviors associated with immediate rewards, discounting the future—constitute reliable developmental responses to environmental cues indicating that life is short and future outcomes cannot be controlled or predicted. Because these are powerful evolved responses that promoted lineage survival during our natural selective history, Band-Aid interventions (e.g., sex education, birth control, promoting self-esteem, training coping skills, teaching problem-solving strategies) are unlikely to effect change at a foundational level (see Johns, Dickins, & Clegg, 2011). Prevention and treatment programs instead need to address causative environmental conditions. This means altering the social contexts of disadvantaged children and adolescents in ways that, through changes in their experiences, induce an understanding that they can lead longer, healthier, more predictable lives.

From an evolutionary perspective, what current prevention and treatment programs are generally on target in terms of altering the environments of adolescent development? Consistent with an evolutionary perspective, some interventions attempt to produce basic change in environmental conditions. For example, Moving to Opportunity is a randomized housing voucher experiment that relocates minority families living in public housing to lower poverty, lower crime neighborhoods (though only minimal improvements in school quality were achieved; Sanbonmatsu, Kling, Duncan, & Brooks-Gunn, 2006). This change in ecological conditions has resulted in better educational outcomes and lower rates of risky adolescent behavior (i.e., drug and alcohol use, teen pregnancy, arrests for violent and property crimes) in female youth; however, these gains were mostly offset by iatrogenic effects in male youth (Kling, Liebman, & Katz, 2007; Kling, Ludwig, & Katz, 2005). Moving to Opportunity was limited, however, because it did not change the economic status or self-sufficiency of the target families (Kling et al., 2007). This may have been especially problematic for male youth in the program, who ended up in schools with higher academically achieving peers from more advantaged families with different cultural norms and language. These youth did not integrate well into the mainstream groups and instead came to affiliate with more antisocial peers (Kling et al., 2005, 2007), a pattern that ultimately supports more risky and delinquent behavior.

Perhaps a deeper level of ecological change could be achieved through improving the SES of disadvantaged children. In Western societies, lower SES is linearly related to higher levels of virtually all forms of morbidity and mortality (e.g., Adler, Boyce, Chesney, Folkman, & Syme, 1993; Chen, Matthews, & Boyce, 2002). Even small changes in SES, therefore, would change exposure to morbidity–mortality cues—one of the key environmental determinants of fast and risky LHs. This logic has been supported by quasi-experimental data showing that income supplements that moved rural Native American families from below to above the federal poverty line reduced levels of conduct disorder and oppositional defiant disorder in children (Costello, Compton, Keeler, & Angold, 2003).

Another critical component of the child's environment is the family. Evolutionary-developmental models view quality of parenting as a central mechanism through which children receive information about levels of stress and support in their local environments, including levels of extrinsic morbidity–mortality (e.g., Belsky et al., 1991; Chisholm, 1999). Consistent with this logic, randomized intervention studies reveal that several family-based interventions delivered during childhood or early adolescence, focused on improving the quality of parental investment and supervision, are effective in reducing current levels of problem behavior and preventing problem behaviors in the future (e.g., Dishion, Connell, et al., 2008; Dishion et al., 2003; Forgatch & Patterson, 2010; Mason, Kosterman, Hawkins, Haggerty, & Spoth, 2003; Spoth, Redmond, & Shin, 2001). Interventions for adolescents engaged in high levels of problem behavior suggest that focusing on parenting practices is effective in most contexts (Henggeler & Schaeffer, 2010; Liddle, 2010; Waldron & Brody, 2010). However, as adolescents become more engaged in deviant peer groups and problem behavior, the strategies to reverse those risk processes require therapeutic skills and specialized knowledge.

Finally, exposure to unpredictable, changing environments is another critical factor shifting adolescents toward fast LH strate-

gies. Interventions could thus focus on creating maximally structured and predictable environments, where fair and consistent limits and predictable consequences for rule breaking exist. Indeed, this is exactly the approach taken in an ongoing randomized control trial that intervenes to reduce levels of unpredictability in the lives of high-risk adolescents: girls in the juvenile justice system assigned to out-of-home care (Chamberlain, Leve, & DeGarmo, 2007; Leve, Chamberlain, & Reid, 2005). Initial results indicate a reduction in teenage pregnancy rates by about 50% over a 2-year period for those enrolled in this highly structured intervention, implemented through foster care (Kerr, Leve, & Chamberlain, 2009).

From an evolutionary perspective, what current prevention and treatment programs are probably misguided, or wiser not to conduct, in terms of altering the environments of adolescent development? From a conditional adaptation perspective, the first question to ask is whether intervention is appropriate. Seemingly harmful risk-taking behaviors may be adaptive in the context of competitive or dangerous environments; therefore, preventing or changing these behaviors could be equivalent to declawing the cat—removing the psychological and behavioral weaponry necessary to survive and control resources in one's local ecology. Of particular relevance is experimental research in rats showing that stressful rearing experiences (i.e., low levels of maternal licking and grooming) actually enhance learning and memory processes under stressful conditions (Bagot et al., 2009; Champagne et al., 2008). On the other hand, even though successful interventions may create mismatches between the developing person and his or her local environment (see Frankenhuis & Del Giudice, 2012), such programs could still help adolescents function more successfully in educational institutions and the larger society. The resulting tension between intervention costs and benefits—including possible side effects of programs aimed at reducing risky behavior—should always be considered.

One form of environmental manipulation that is often used to control dangerous or illegal adolescent behavior is punishment (e.g., school expulsion, incarceration). Some research suggests that such punitive reactions to child and adolescent problem behaviors actually make the behaviors worse (Atkins et al., 2002; Gatti, Tremblay, & Vitaro, 2009). This iatrogenic process can be understood at both evolutionary and proximate levels. In terms of evolutionary causation, LH theory posits that ongoing exposure to morbidity–mortality cues results in the anticipation of early death, shifting individuals toward a fast LH strategy that includes discounting the future, hopelessness, and fatalism. In this context, the tendency to pursue high-risk behaviors associated with immediate rewards, including crime and violence, with little regard for future consequences, could be a normal, adaptive response (Brezina, Tekin, & Topalli, 2009; Wilson & Daly, 1997). Consequently, attempts to curtail these behaviors by increasing their future costs (e.g., increased criminal penalties) are unlikely to deter high-risk youth on the fast track (Brezina et al., 2009). In terms of proximal causation, expulsion and incarceration lead to increases in problem behavior because such interventions inadvertently increase self-organization into deviant peer clusters. This in turn supports new and novel forms of deviance through peer contagion. Systematic analysis of adolescents in juvenile corrections reveals social learning of new criminal behaviors during incarceration (Bayer, Pintoff, & Pozen, 2003). Youth reoffend with behavior learned from former roommates.

Another form of environmental manipulation used to influence adolescents is media messaging. Consistent with LH theory, extensive experimental research has demonstrated that exposures to messages emphasizing the dangers and uncertainty of the world around them causes adolescents from disadvantaged backgrounds to become more risk seeking, more impatient, and more motivated to have children sooner, even if it means forgoing education; the opposite is true of adolescents from privileged backgrounds (Griskevicius, Delton, Robertson, & Tybur, 2011; Griskevicius, Tybur, Delton, & Robertson, 2011). Thus, public service announcements warning about the dangers of child abduction, headline news reports of horrific homicides, and doom-and-gloom economic forecasts may all escalate risky behavior specifically among those youth whom the legal system and policymakers are most concerned about.

From an evolutionary perspective, what intervention strategies deserve special consideration? Given the central role of futurelessness and unpredictability in promoting fast LH strategies, an important goal for interventions should be to induce in adolescents a stronger future orientation and sense that they can control their own destiny—even though their developmental experiences indicate otherwise. One step in this direction is the innovative possible selves intervention (Oyserman, Bybee, & Terry, 2006), which focuses on cultivating a future orientation and planning skills for youth living in urban and poor neighborhoods. This randomized trial resulted in improved behavior and academic skills.

Another effective intervention has been contingency manipulation: paying substance abusers to not use drugs, with incentives increasing as the number of consecutive drug-free urine samples increased (Dutra et al., 2008). Belsky (2009) proposed such an intervention for at-risk high school students, using delayed monetary rewards (quarterly payments plus compounding escrow the student collects at graduation) for not getting pregnant and not dropping out of school. Such a system could induce an understanding in adolescents that they can make long-term investments with their resources that have large payoffs in the future.

In summary, LH theory provides a conceptual framework for analyzing adaptive variation in risky adolescent behavior in relation to different types of environmental stress. Intervention programs need to seriously address causative environmental conditions and life experiences that lead some adolescents to perceive (consciously or unconsciously) that they have little chance of leading a long and healthy life and that their own actions cannot control or prevent hazards in the world around them.

4. Understanding Evolved Sex Differences Is Critical for Understanding the Psychology of Risky Adolescent Behavior

The fact that young males are more likely than young females to engage in hazardous risk taking is well known in the social sciences (e.g., Byrnes, Miller, & Schafer, 1999); however, it takes an evolutionary perspective to understand and appreciate more fully the meaning of sex differences in the psychology of risk. A recent major report by the IOM and NRC (2011) on the "science of adolescent risk taking," which contained almost no discussion of sex differences, exemplifies the current lack of appreciation.

Risk taking and mating are connected at a fundamental level. Because of sex differences in minimum levels of parental investment (Trivers, 1972), variation in reproductive success has been substantially greater among men than among women during human evolution (Hammer, Mendez, Cox, Woerner, & Wall, 2008). That is, over the course of human natural selective history, men have been overrepresented at both the bottom (no offspring) and top (large numbers of offspring) of individual reproductive success. This pattern of differential variation is nearly universal[4] and means that males, more than females, have been selected to engage in high-risk, high-stakes behavior. Moreover, females are consistently more selective than males in choosing sexual partners (Buss, 1989; Kenrick, Sadalla, Groth, & Trost, 1990; Schmitt, Shackelford, & Buss, 2001); thus, the resulting threshold of attractiveness that excludes people from the mating market is set higher for males than for females.

Because male reproductive success is ultimately constrained by the ability to access, attract, and retain females, the reproductive strategies of teenage boys and men should be especially attuned to the demands and desires of the other sex and their ability to successfully engage in intrasexual competition (e.g., Gangestad & Simpson, 2000). Teenage boys and men (compared with teenage girls and women) have more to gain, and less to lose, from engaging in high-risk behaviors when a successful outcome can improve attractiveness or social status—and therefore potential reproductive success (Kruger & Nesse, 2006; Wilson, Daly, & Pound, 2002). Here, safe is not better than sorry. In evolutionary terms, it is of no use being healthy and long-lived if this means exclusion from the mating game and, ultimately, the genetic future of the species. Risk taking can be especially favored both at the bottom and at the top of the status hierarchy (Nettle, 2009), where competition is most intense and the costs and benefits are more dramatic.

From an evolutionary perspective, therefore, sex differences in risk taking should peak in adolescence and early adulthood, a prediction consistently supported by the evidence (e.g., Kruger & Nesse, 2006; Wilson et al., 2002). Indeed, males are everywhere more violent, homicidal, and risk prone than are females, especially when such risks involve physical hazards; they are also more present oriented, more sensation seeking, and less sensitive to punishment (e.g., Byrnes et al., 1999; Cross, Copping, & Campbell, 2011; Kirby & Maraković, 1996; Kruger, Reischl, & Zimmerman, 2008; Read & Read, 2004; Zuckerman, 1994). Although such sex differences are substantial, they do not imply that girls are not competing with other girls for status, dominance, and valued mates (Hawley, Little, & Card, 2008). Female competition can be intense, though it is generally less risky, confrontational, and physically dangerous than male competition (Archer, 2009; Campbell, 2004; Cashdan, 1998; Griskevicius et al., 2009).

Overall sex differences in risky behavior are only part of the story, however; contextual factors that guide risk taking in sex-specific ways moderate such differences. Adolescent males, but not adolescent females, tend to become especially risk prone and aggressive when being watched by same-sex individuals of similar status, compared with higher or lower ranking individuals (Ermer, Cosmides, & Tooby, 2008; see also Daly & Wilson, 2001; Griskevicius et al., 2009). In addition, exposures to attractive opposite-sex photographs or sexual or romantic scenarios cause adolescent and young adult males, but not adolescent and young adult females, to engage in not only more risky and aggressive behavior (e.g., playing riskier blackjack hands, spending money conspicuously, discounting the future, behaving aggressively toward same-sex rivals, and endorsing warfare; Baker & Maner, 2008; Chang, Lu, Li, & Li, 2011; Griskevicius et al., 2007, 2009; Mussweiler & Förster, 2000; Wilson & Daly, 2004) but also more altruistic behavior (e.g., donating money generously, displaying heroic altruism; Griskevicius et al., 2007; Iredale, Van Vugt, & Dunbar, 2008). In total, males seem to automatically (but flexibly) adjust levels of risky and aggressive behavior—and even public displays of altruism—to match the anticipated intensity of status and mating competition, which are highest when attractive potential partners are around and when the competitors are level with each other.

Implications for intervention. It was not until the end of the 20th century that the social policy literature came to recognize that the ratio of deviant to nondeviant youth in intervention programs is consequential and that clustering deviant youth may have sizeable iatrogenic effects (see Key Insight 1). To this day, however, the social policy literature remains opaque regarding possible influences of biological sex. There has been virtually no research conducted on the impact of either sex composition (male groups vs. female groups vs. mixed-sex groups) or sex ratio (the relative number of males vs. females in groups) on intervention outcomes. Thus, researchers have almost no knowledge of how gender dynamics, either as main effects or in interaction with other variables such as the deviancy or status of group members, enhance or undermine prevention and treatment. Given the well-documented effects of biological sex on risky behavior reviewed above, research on this topic is sorely needed.

From an evolutionary perspective, what intervention strategies deserve special consideration? Sex differences in levels and contexts of risky adolescent behavior have pervasive implications for intervention and policy. Recognizing that much of boys' risk taking is ultimately motivated by a struggle for status and mating opportunities is likely to help in designing successful interventions (see Key Insight 1). For both boys and girls, the effects of exposure to same-sex versus opposite-sex peers in amplifying or dampening both risky and prosocial behavior should not be underestimated. In some contexts, focusing an intervention on girls may be the most effective way to influence boys' behavior. Because male social strategies—from risk taking to altruism—are particularly sensitive to the immediate social contexts of status and mating, even minor changes to the social environment might achieve large results if made strategically.

Another contribution of evolutionary theory to policy and interventions is increased consideration of the sex ratio, that is, the ratio of males to females in a given social context or group. The sex ratio is a powerful moderator of human mating competition and a strong predictor of violence, risk taking, teenage pregnancy, and related outcomes (see Barber, 2001; Messner & Sampson, 1990; Pedersen, 1991). When the sex ratio is skewed toward males, competition among men for status and resources increases, leading young males to become impatient and seek immediate rewards (Griskevicius, Tybur, Ackerman, et al., 2011). In this context,

[4] For a discussion of the few exceptions, see Brown, Laland, and Borgerhoff Mulder (2009).

more competitively successful men, who are able to obtain mates despite the shortage of females, tend to pursue stable, committed mating relationships and engage in high levels of parental investment (see Kruger & Schlemmer, 2009; Pedersen, 1991; Pollet & Nettle, 2008); women compete to form long-term relationships with these successful males. At the same time, male-skewed sex ratios can increase social unrest because many (competitively disadvantaged) males are excluded from the mating market. This appears to be an especially critical problem in China, where tens of millions of low-status, unmarried male youth threaten domestic stability (Hesketh & Xing, 2006; Hudson & Den Boer, 2004). The other side of the coin is that young Chinese men and their families apparently respond to male-biased sex ratios by increasing their entrepreneurial activity and wealth accumulation (Wei & Zhang, 2011), thus improving competitive position on the marriage market. By contrast, when the sex ratio is skewed toward females, men compete for access to higher numbers of short-term sexual partners, while women compete to have sex with the most attractive males. Under these conditions, risky behaviors—especially risky sexual behavior—tend to increase in men as well as in women (Barber, 2001, 2011; Messner & Sampson, 1990; see also Schmitt, 2005).

Adjusting the sex ratio of adolescent groups, at least in social contexts where adults have some control over group composition, may alter various facets of adolescent behavior. These processes deserve systematic consideration in future research, as sex ratios and related mating contexts may influence not only risky and aggressive behavior but also altruism, entrepreneurship, and the motivation to work hard to get ahead. Consideration of sex ratios may also alert interventionists to possible side effects of prevention and treatment programs. Such side effects are likely, given the well-documented effects of the sex composition on dominant, competitive, aggressive, and exploitive behavior in small groups (reviewed in Colarelli, Spranger, & Hechanova, 2006). All of these effects may be amplified among low-status, disenfranchised males or when group members are comparable in status.

In summary, an evolutionary approach offers a deep, principled understanding of sex differences in risky behavior. Due to fundamental reproductive asymmetries, boys (especially those at the bottom and the top of status hierarchies) are much more likely than girls to engage in physically risky activities. Boys are also much more responsive than girls to social and contextual cues to mating and status; exposures to such cues can move male behavior in both prosocial and antisocial directions. These sex differences call attention to potentially useful, yet understudied, targets for prevention and treatment of risky and aggressive behavior.

5. Environmental Mismatches Can Dysregulate Adolescent Development and Behavior: The Case of Age Segregation

Because evolutionary processes have no foresight and can only adapt organisms to existing environments, natural selection shaped our brains and bodies to function optimally in conditions that were present during long stretches of human history. Natural selection generally operates too slowly to keep pace with the accelerating rate of cultural change that began with the advent of agriculture, roughly 10,000 years ago, and increased dramatically with industrialization. Humans are a remarkably flexible species, able to adapt ontogenetically to a wide range of conditions, but are by no means infinitely flexible. Many general problems facing society today, including problems involving adolescents, have to do with mismatches between present conditions and conditions that were extant during human history.

Some of the best documented examples of such mismatches have to do with nutrition and physical exercise. Cow's milk and formula, available to infants today, were unavailable to ancestral infants; well-controlled experiments have shown that these alternatives to breast milk interfere with optimal cognitive development (Kramer et al., 2008). Today's environment, unlike human ancestral environments, includes easy availability of high-calorie foods and relatively little requirement for physical exercise, with the result that tens of millions of teenagers worldwide suffer the physical and psychological consequences of obesity (Eaton & Eaton, 2003; Hill, 2006; Konner & Eaton, 2010). Humans are well adapted for putting on weight, not for taking it off, because the latter problem rarely occurred in ancestral environments. The absence of vigorous physical activity may also contribute to the current epidemic of attention-deficit/hyperactivity disorder, which itself can be a direct or indirect cause of risky behavior among adolescents (Panksepp, 2007; Panksepp, Burgdorf, Turner, & Gordon, 2003). Here, however, we focus on a less obvious and much less discussed mismatch between present and past environments—that resulting from segregation of adolescents from younger children and adults.

In hunter-gatherer bands and traditional post-hunter-gatherer societies, people of all ages interact regularly across large age spans in play and work (Konner, 1975, 2010; Whiting & Whiting, 1975). In Western and Westernized cultures, however, young people generally grow up with little opportunity to know and interact with others much younger or older than themselves. Factors such as age-graded schooling, age-segregated out-of-school activities, a decline in family size, weakened extended-family ties, and the removal of adult work from areas where children and adolescents are welcome have driven this change. Indeed, the peer group today typically consists of children or adolescents whose ages are no more than a year or two apart. In contrast, a typical group of young people playing or exploring with one another at any given time in a hunter-gatherer band consisted of a mix of children and adolescents anywhere from about 4 to about 17 years of age (Konner, 1975, 2010). From an evolutionary perspective, the modern age-segregated environment is a clear departure from the human norm.

Social scientists have largely neglected age mixing as a topic of study, but the research that has occurred suggests that the presence of younger children and infants reduces aggression and promotes nurturance and compassion in young people (Gray, 2011b). Researchers observing hunter-gatherer cultures often comment on the lack of aggression among children and adolescents (Gray, 2009; Hewlett & Lamb, 2005; Thomas, 2006). A possible explanation for this is the continuous age mixing that occurs in such bands (Gray, 2009; Konner, 1975). A cross-cultural study of children in a variety of post-hunter-gatherer societies revealed that boys and girls in middle childhood behaved in helpful, prosocial ways much more frequently toward children 3 or more years younger than themselves than toward age-mates or older children (Whiting, 1983). A quasi-experimental study in a village in Kenya revealed

that boys ages 8 through 16 who were assigned by their mothers to help with infant care at home (because of the absence of a sister of suitable age for this traditionally feminine task) behaved less aggressively and more prosocially toward their peers than did boys not required to care for infants (Ember, 1973).

A quantitative field study at an unusual modern-day alternative school, where continuous age mixing among students from age 4 through high school age occurs, revealed that students regularly, on their own initiatives, interacted across wide age ranges (Gray & Feldman, 1997). Students in the age range of 12 to 15, of both sexes, were especially likely to interact with much younger children. A subsequent qualitative study showed that adolescents provided a great deal of implicit help and nurturing to younger children in the course of their naturally occurring interactions (Gray & Feldman, 2004). Adolescents read to younger children, rough-and-tumbled with them, taught them games, helped them solve practical problems (such as finding lost items or resolving conflicts), and regularly provided boosts and hints when playing games together. All such interactions were voluntary on the part of the adolescents; they had no official responsibility to care for younger children. Such observations suggest that the presence of younger children elicits nurturance in adolescents of both sexes and provides them with opportunities to practice mature leadership and responsible care for others. They may also be practicing parental skills and demonstrating to others that they would be caring, dependable future mates for reproduction.

In all hunter-gatherer cultures that have been studied, fathers play at least some role in the care and education of children (Konner, 2005); accordingly, natural selection likely shaped fathering skills and motivation to develop those skills (Gray & Anderson, 2010). Because cultures vary in the degree of childcare that fathers provide, the sight of men and older boys playing with and caring for young children may be an evolved signal that helps direct adolescent males toward displays of nurturance and away from violence. Consistent with this hypothesis is the negative correlation, documented across traditional human societies, between the violent aggressiveness of men and the degree to which men help care for infants and young children (Marlowe, 2000).

In addition to interacting with infants and young children, adolescents in hunter-gatherer and other traditional societies also interact regularly with adults of all ages. By their mid-teenage years, boys in hunter-gatherer cultures join men on hunting expeditions, and girls join women at gathering (Hewlett & Lamb, 2005). Successful participation in adult subsistence activities enables adolescents to demonstrate their value and to gain status without social confrontation. Moreover, the continuous presence of both older and younger people in the lives of adolescents provides a natural hierarchy, based on age, experience, and wisdom, which may mitigate tendencies to compete aggressively for dominance and status.

Implications for intervention. At a superficial level, the implications of this analysis for effective social change are obvious. To the degree that people, as a culture, can reverse the trend of age segregation, they may reduce aggression and increase prosocial behaviors of all sorts among adolescents. Such changes, however, are not easy to implement, and there is reason to think that some forms of age mixing are not beneficial. The contexts in which benefits of age mixing have been clearly demonstrated are those in which the interacting parties know one another well, are part of the same family or community, and interact naturally and freely in the course of their everyday lives. Forced interactions may not be beneficial, and interactions in which the older participants are motivated to exploit the younger ones, as in age-mixed street gangs, may be harmful.

From an evolutionary perspective, what current age-mixing interventions are generally on target? The most prevalent and systematic current programs to bring teenagers into contact with people older or younger than themselves are mentoring programs, which connect teenagers with adult mentors, and cross-age peer tutoring programs, which bring teenage tutors into contact with younger students.

The most extensive mentoring program in the United States is Big Brother Big Sister (BBBS), which operates through more than 500 agencies nationwide (DuBois, Holloway, Valentine, & Cooper, 2002). This program matches young people, usually age 10 to 16, with mentors, who are usually young adults. The mentors and mentees typically meet three or four times a month, with the goal of becoming friends and confidants. Controlled outcome studies of such programs have shown, overall, modest but statistically significant gains in prosocial attitudes and behavior and declines in risky and illegal activities for the mentees compared to youth in the control groups (DuBois et al., 2002; Grossman & Tierney, 1998). A meta-analysis of such studies indicated that such programs are particularly effective when (a) the mentees are from deprived, high-risk environments; (b) care is taken to make appropriate mentor–mentee matches; (c) training of mentors continues even after the mentoring has begun; and (d) mentors and mentees meet frequently and develop close personal relationships (DuBois et al., 2002).

Case studies indicate that adult mentoring can sometimes dramatically turn a young person's life around. For example, de Anda (2001) described a case in which "Gina," an 18-year-old Latina member of a violent male street gang who was regularly absent from school and was known for her anger and violence, was paired with a tough African American woman firefighter mentor. By the end of a year of mentoring, Gina had dropped out of the gang and completed high school, had enrolled full time in junior college, and was doing volunteer work as a youth health educator for an AIDS prevention program. The same researcher described several other, equally dramatic cases, all showing that positive connections to the legitimate adult world, by way of an adult whom the young person could admire and identify with, made a real difference for young people who previously had no such connections.

Cross-age tutoring programs provide teenagers with opportunities to interact with children younger than themselves. Most studies of such programs have focused on the academic gains, which can be considerable for both the tutors and the tutees (e.g., Cohen, Kulik, & Kulik, 1982; Galbraith & Winterbottom, 2011). A few studies have focused on the quality of the relationships developed and on changes in tutors' social attitudes and behavior. In one study, conducted in a laboratory school, eighth graders tutored first graders three times per week for 20-min sessions (Gorrell & Keel, 1986). At first, the tutors spent most of their tutoring time trying to keep their tutees on task, but by the end of the first month, the relationships became more playful and affectionate. The first graders began sitting on their tutors' laps, and there was a marked increase in such signs of affection as handholding, kissing, head patting, and good-

natured banter. According to the researchers, the relationships that best satisfied the affective needs and desires of the first graders were also the most successful in meeting the cognitive goals of the tutoring program. Several other studies of cross-age tutoring have revealed increases in measures of responsibility, empathy, and altruism in the tutors (Dearden, 1998; Spencer, 2006; Yogev & Ronen, 1982).

A more recent in-school intervention is that promoted by the Roots of Empathy program, founded in Canada by M. Gordon (2005), in which mothers and young infants make regular visits to elementary and middle school classrooms, so that students can observe and talk about the infant and the infant's behavior. The original purpose of the program was to help students learn, from an early age, what it means to be a parent. An additional effect of the program, documented by research, is significantly reduced aggression and increased prosocial behavior among students (Schonert-Reichl & Scott, 2009; Schonert-Reichl, Smith, Zaidman-Zait, & Hertzman, 2011). Apparently, repeated exposure to an infant, in a context in which students notice and talk about the infant's behavior and see it change from one visit to the next, promotes nurturing tendencies in those students.

From an evolutionary perspective, what current age-mixing interventions may be misguided or wiser not to conduct? For convenience and as part of an attempt to address the ever-growing concern to raise students' scores on standardized tests, BBBS programs have become increasingly school-based rather than community-based. In school-based programs, the mentor meets the mentee at some designated time during the school week within the school building. A recent study comparing over 500 school-mentored students (ages 9 to 16) with a similar number of control students revealed no significant effects on substance use, stealing, fighting, or any other measures of risky behaviors (Herrera, Grossman, Kauh, & McMaken, 2011). There was a temporary small increase in academic performance for the mentored group, but even this washed out over the course of the 1.5 years of the program. These results contrast with the positive effects, especially the decreases in risky behaviors, found in similar studies of community-based BBBS programs (DuBois et al., 2002; Grossman & Tierney, 1998). Thus, the research suggests that school-based programs should be discontinued or redesigned so that they contain more of the elements that have proven effective in community-based programs. It is even possible that the school setting itself tends to prevent the kinds of cordial, trusting, nonauthoritarian interactions that seem to be essential to a good mentoring relationship. Gina may not have trusted her firefighter mentor if all of their meetings had taken place at school. Community-based programs come closer than do school-based programs to replicating the kinds of adult–adolescent contacts that would have occurred naturally in hunter-gatherer cultures.

Over the past two or three decades, as schools have become increasingly focused on high-stakes testing, they have also become less tolerant of playful interactions or of interactions that could be construed (or misconstrued) as sexual. This, quite likely, has had a negative effect on the emotionally nurturing qualities of cross-age tutoring. The lap sitting, handholding, and kissing between eighth graders and first graders that seemed to be so beneficial in the tutoring program assessed by Gorrell and Keel (1986) would probably not be tolerated in most schools today.

From an evolutionary perspective, what intervention strategies deserve special consideration? Unfortunately, in recent times, the cultural trend has been toward more age segregation, not less. Informal neighborhood play has declined sharply in recent years, with the result that opportunities for age-mixed interactions have also declined (Gray, 2011a). Parents have become increasingly fearful of employing teenage babysitters, especially if they are male. At the same time, opportunities for adolescents to have part-time or summer jobs that bring them into natural contact with adults have declined. These changes are all part of cultural and economic trends that are not easily reversed.

A first step toward reversal would be increased awareness of the value of natural age mixing. At present, perhaps partly because of the general lack of an evolutionary perspective, there is very little discussion of age segregation as a problem or age mixing as a benefit. If there were more awareness, communities might be more interested in developing safe parks and recreation areas to attract children and adolescents together for informal play and relatively less interested in promoting age-segregated competitive sports.

In summary, an evolutionary analysis affords a novel vantage point for understanding the nature of the problems caused by environmental mismatches and establishes parameters for designing appropriate interventions. Such interventions involve some form of either restoring the critical ancestral environmental condition (or a facsimile thereof) or removing or altering the novel environmental condition that is causing harm. These principles apply not only to the problem of age segregation but also to other mismatches that potentially threaten the physical, behavioral, and social well-being of adolescents (e.g., abnormally long periods between sexual maturation and adulthood that leave youth without meaningful social roles; reduced contact with immediate and extended family; increasing influence of peers, social networking, and media in defining normative behavior; disrupted sleep cycles associated with artificial light exposure and electronic media; see Hawley, 2011, for extended discussion).

Conclusion

The issue of risky adolescent behavior is remarkably complex, and any intervention aimed at reducing it (or ameliorating its consequences) faces formidable obstacles and complications. For this very reason, we believe that risk taking in adolescence provides an excellent testing ground for evaluating the potential of an evolutionary approach to human development. The evolutionary model supplements, extends, and amends the standard developmental psychopathology approach in two interconnected ways. First, the evolutionary model delivers a deep and sophisticated theoretical foundation for understanding the meaning and manifestations of risky behavior. Second, equally important, it can inform prevention and treatment programs by highlighting key variables, indicating ways to maximize program effectiveness, revealing potential pitfalls and tradeoffs, increasing the realism of the intervention goals, and in some cases suggesting truly novel approaches and solutions.

A guiding assumption of the evolutionary model is that understanding the functions of adolescence is essential to explaining why adolescents engage in risky behavior and that successful

intervention depends on working with, instead of against, adolescent goals and motivations. From an evolutionary perspective, a major function of adolescence is to attain reproductive status—to develop the physical and social competencies needed to gain access to a new and highly contested biological resource: sex and, ultimately, reproduction. This functional analysis has numerous implications for science, policy, and practice that we summarize below:

• *An evolutionary analysis explains the functional significance of puberty-specific changes.* The adolescent transition is an inflection point (i.e., a sensitive period for change) in developmental trajectories of status, resource control, mating success, and other fitness-relevant outcomes. Puberty-specific developmental changes function to build reproductive capacity and increase sociocompetitive competencies at this critical juncture.

• *The evolutionary model explains why there is a marked increase in risky behavior in adolescence*. Because adolescence is an inflection point, much is at stake at the adolescent transition. Indeed, adolescence may be a phase of the life span that historically had great influence on fitness and was thus under intense selection pressure. The legendary self-absorption of adolescents may reflect an evolved motivation to look out for number one at a time of life, evolutionarily speaking, that matters so much. We hypothesize that natural selection favored especially strong emotional and behavioral responses to social successes and failures during the adolescent transition, when social and reproductive trajectories are inflecting, for better and for worse. Risk taking increases because high-risk behaviors can alter these trajectories. By definition, risky behavior increases variance in outcomes. As argued in this article, high-risk behaviors can result in net harm in terms of a person's own phenomenology and well-being, the welfare of others around the person, or the society as a whole but still be adaptive in an evolutionary sense. Risky behaviors that expose adolescents to danger and/or inflict harm on others but increase dominance in social hierarchies and leverage access to mates are prototypical examples.

• *The central focus of the evolutionary model on "what's in it for the kids" who engage in high-risk behavior has important implications for intervention*. Risk-taking behaviors among adolescents have an important signaling function. Successful risk taking, where real danger is involved, is often admired and confers status, especially to males. Accordingly, drinking games, social drug use, daredevilry, fighting, and other risky displays play an important role in adolescent life. Interventions that simply attempt to stop such behaviors are unlikely to be successful because they ignore motivation and function. This leads to misguided interventions, such as zero tolerance or "Just Say No," that ask adolescents to give up successful social strategies without anything in return. For example, the widespread adoption of zero-tolerance policies demands that bullies stop their behavior without any consideration for why the bullies may engage in that behavior in the first place.

Instead, interventions need to work within the goal structures of adolescents to substitute effective, evolutionarily informed prosocial strategies that yield outcomes and incentives that are comparable to those achieved through risk taking, delinquency, or antisocial behaviors. There is a growing consensus that interventions aimed at promoting more positive strategies for attaining social status have long-lasting effects, as long as such interventions do not pull out only high-risk children, which may inadvertently confer status on adolescents who engage in the most risky behavior. In many social contexts, adolescents can attain status without scenes of contest and braggadocio or engaging in antisocial behavior; interventions could guide adolescents toward these alternative means of gaining social acceptance and respect. Finally, acknowledging that risk taking has important functions (and does not merely reflect pathology or dysfunction) alerts people to the possibility that, at least in some contexts, eliminating risky behaviors will not be possible or desirable. In those cases, policies aimed at damage reduction may prove more effective, as well as more in line with the needs of adolescents.

• *The evolutionary model specifies critical ecological contexts that regulate risky adolescent behavior and provide targets for intervention*. LH theory provides a conceptual framework for analyzing adaptive variation in risky adolescent behavior in relation to different types of environmental stress. Because different risk-taking strategies are potentially adaptive or maladaptive, depending on context, natural selection favors strategies that are contingent upon reliable and valid cues to environmental conditions. A critically important context that shifts adolescents toward faster (high-risk) strategies is the perception (conscious or unconscious) that life is short, the future is unknown, and one's own actions cannot control or prevent hazards in the world around you. Exposure to unpredictable, changing environments is another key factor shifting adolescents toward high-risk behaviors. These different forms of environmental stress do not so much disturb development as direct or regulate it toward strategies that are adaptive under various stressful conditions. Prevention and treatment programs need to address these causative environmental conditions. This means altering the social contexts of disadvantaged children and adolescents in ways that—through changes in their experiences—induce an understanding that they can lead longer, healthier, more predictable lives.

Bullying and other forms of antisocial behavior are also sensitive to context. Akin to many evolved patterns of behavior, bullying appears to be a facultative adaptation; it is most likely to develop and be expressed under conditions in which bullying confers adaptive benefits. Successful antibullying interventions recognize that bullying is functional and that it can be discouraged by altering the cost–benefit ratio so that bullying is no longer an adaptive strategy in a given ecology. This further stresses the need to move beyond Band-Aid solutions, which attempt to stop problem behavior without addressing underlying causal conditions, toward ecological solutions. The latter could involve changing ecological contexts (e.g., moving families out of poverty), creating more structured and predictable environments for at-risk youth, increasing the quality of parental investment and supervision, or altering the reward structures of home and school environments to reduce the adaptive benefits of risky and aggressive behavior.

• *The evolutionary model posits that biological sex, mating contexts, social status, ratio of deviant to nondeviant youth, and sex ratios all regulate risky adolescent behavior and thus need to be addressed in interventions.* Males, more than females, have been selected to engage in high-risk, high-stakes competitive be-

havior. As specified by the evolutionary model, sex differences in risk taking peak in adolescence and early adulthood. Because male social strategies are particularly sensitive to the immediate social contexts of status and mating, even minor changes to the social environment can have large effects. Males seem to automatically (but flexibly) adjust levels of risky and aggressive behavior to match the intensity of status and mating competition, which are highest when attractive partners are around and when competitors are level with each other. Risky adolescent behavior is also amplified by social processes and interventions that aggregate high-risk youth; higher ratios of deviant to nondeviant youth increase self-organization into deviant peer clusters, which supports new and novel forms of risky and delinquent behavior through peer contagion.

Over developmental time, levels of risky and aggressive behavior in males are influenced by sex ratios (relative numbers of males vs. females) and social status. Risky behavioral strategies are likely to develop when females are scarce or when individuals inhabit the bottom or top of status hierarchies, where the competition is most intense and costs and benefits are more dramatic. Among low-status youth whose current circumstances are predictive of future reproductive failure, low-risk strategies that minimize variance in outcomes have limited utility. In contrast, high-risk activities become more tolerable—even appealing—because success at these activities can yield fitness benefits for disenfranchised individuals that are otherwise unobtainable. Taken together, these complex status and gender dynamics, either as main effects or in interaction with other variables such as the deviancy of group members, are likely to moderate the effectiveness of almost any intervention.

• *Mismatches between present and past environments have numerous implications for designing interventions*. Because human brains and bodies have been shaped by natural selection to solve recurrent problems faced by ancestors, adaptations can misfire when the developing person experiences environments outside of the species-typical range. Many adolescent behavioral problems may be caused or exacerbated by environmental mismatch. In the present article, we have focused on extensive age segregation, which has no precedent in the human evolutionary past, clearly amplifies competition among adolescents, and appears to increase aggression and reduce prosocial behavior. Such pervasive changes in the social contexts of adolescence may have increased the intensity and ramifications of the adolescent transition in Western and Westernized cultures, with substantial implications for risky adolescent behavior. Some of these implications have been recognized in the literature. For example, the concept of environmental mismatch has been invoked to explain adolescent obesity and depression; thus, some evolutionarily guided treatment programs focus on restoring ancient patterns of diet, sleep, exercise, natural light exposure, and social connectedness (Ilardi, 2009). Interventions that attempt to restore more natural relationships between adolescents and both adults and younger children may have powerful effects on social development.

For all these reasons, we believe that the evolutionary model has much to contribute to the field of adolescent risk taking. It provides a framework for interpreting what is known about risky adolescent behavior, while also generating novel hypotheses, suggesting new lines of research that are not forthcoming from other perspectives, and informing present and future intervention efforts. In presenting this perspective, it is our hope that new knowledge concerning the causes of risky adolescent behavior will be uncovered and that developmentally appropriate programs and niches can be fostered that work with adolescent goals and motivations to more effectively address the problems associated with risky behavior in the second decade of life.

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