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EMPIRICAL RESEARCH

Subjective Invulnerability, Optimism Bias and Adjustment in Emerging Adulthood

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Abstract The relationship between subjective invulnerability and optimism bias in risk appraisal, and their comparative association with indices of risk activity, substance use and college adjustment problems was assessed in a sample of 350 ($M_{age} = 20.17$; 73% female; 93% White/European American) emerging adults. Subjective invulnerability was measured with the newly devised adolescent invulnerability scale (AIS). Optimism bias in decision-making was assessed with a standard comparative-conditional risk appraisal task. Results showed that the danger- and psychological invulnerability subscales of the AIS demonstrated strong internal consistency and evidence of predictive validity. Subjective invulnerability and optimism bias were also shown to be empirically distinct constructs with differential ability to predict risk and adjustment. Danger invulnerability and psychological invulnerability were more pervasively associated with risk behavior than was optimism bias; and psychological invulnerability counter-indicated depression, self-esteem and interpersonal problems. Results support recent claims regarding the "two faces" of adolescent invulnerability. Implications for future research are drawn.

Keywords Invulnerability · Adolescence · Risk-taking · Adjustment · Optimism bias

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Introduction

It is believed widely that adolescents and emerging adults engage in risk behaviors partly because of their felt sense of invulnerability to injury, harm and danger. This view is so common that it seems to be a deeply entrenched part of our folk psychology of adolescence. Yet, in spite of its ubiquity as an explanation of adolescent behavior, there is no consensus on how invulnerability is to be understood, and, indeed, there is controversy about its role in adolescent development and its implications for adaptation (e.g., Elkind 1985; Lapsley and Murphy 1985).

At least two developmental approaches to invulnerability can be discerned in the literature. One approach argues that invulnerability is a problem of cognitive development. That is, invulnerability results from the cognitive egocentrism that attends the transition to formal operations (e.g., Elkind 1967). On this account adolescent egocentrism encourages an over-differentiation of feelings that contributes to the sense of uniqueness and "immortality" (Elkind 1967, p. 1,031). This sense of immortality, in turn, disposes adolescents to believe in a *personal fable* that harmful outcomes are more likely for others than for the self. For example, and as Elkind (1967, p. 1,032) put it, "…many young girls become pregnant because, in part at least, their personal fable convinces them that pregnancy will happen to others but never to them." A number of theorists have embraced cognitive egocentrism as the developmental basis for personal fable ideation and the "reckless" behavior" that it encourages (Arnett 1992, 1995; Greene et al. 2000).

A second developmental approach is friendly toward the notion of invulnerability but doubts its source in adolescent egocentrism on both theoretical (Lapsley and Murphy 1985) and empirical (Lapsley et al. 1986) grounds. Instead

this perspective views invulnerability (and personal fable ideation more generally) not as a differentiation error but as an adaptive, narcissistic response to the developmental challenge of separation-individuation (Hill and Lapsley 2009; Lapsley 1993; Lapsley and Rice 1988). It is a problem, therefore, not of cognitive but of ego development. Moreover, although both developmental models support the claim that invulnerability is an outcome of normative developmental processes, they differ on what it means for adaptive functioning. The traditional egocentrism account views fables of invulnerability as a lamentable feature of adolescent development insofar as it impairs judgment in critical situations. The alternative view holds out the possibility that invulnerability presents with "two faces," that is, predicts risk behavior certainly but also adaptation, coping and resilience (Hill and Lapsley 2009; Lapsley 2003).

For example, a measure of invulnerability could well fortify adolescents as they undertake the normative developmental challenges that attend the transition to adulthood. Exploring identity options, making a friend, learning a new skill, applying for employment or university admission, asking for dates, among other examples, all require taking chances when the outcome is not forgone; all require taking a risk when failure is an option and self-image is potentially at stake. Hence not all risk-taking is maladaptive. In many circumstances the invulnerable adolescent might be better equipped to take on the normative, age-appropriate challenges that are a hallmark of mature development.

There is a third approach to invulnerability that does not make developmental assumptions. This approach treats invulnerability as a pervasive cognitive bias that plagues decision-making and not just in adolescence (e.g., Jacobs-Quadrel et al. 1993; Millstein and Halpern-Felsher 2002b; Weinstein 1980). Invulnerability, on this account, is the result of an *optimism bias* that is endemic to risk appraisal. Optimism bias is evident when individuals assume more favorable outcomes for the self than for others (or, alternatively, when negative events are judged more likely to happen to others than to the self). Individuals tend to be optimistic about their chances of getting cancer if they smoke, of contracting an STD if they are sexually active, of surviving a natural disaster if one comes their way. As Weinstein (1980, p. 806) put it, "people tend to think they are invulnerable." Moreover, the implication for intervention is straightforward: induce a greater sense of vulnerability to the harmful consequences of this behavior.

The concept of optimism bias was first invoked to explain risk assessment in the field of health psychology. As a result it made few developmental assumptions. When researchers did address a developmental question it was to show that optimism bias is a general cognitive error and that adolescents were not uniquely disposed to optimism bias (or invulnerability) as one might have expected on the basis of, say, Elkind's (1967) theory of adolescent egocentrism. Indeed, research in the risk judgment literature showed that teenagers (at least after age 15) and adults do not appear to differ greatly in how they appraise risk, with both groups tending "to rely on similar, moderately biased psychological processes" that lead them to attribute more risky possibilities to target others rather than the self (Jacobs-Quadrel et al. 1993, p. 112; Furby and Beyth-Maron 1992; Lapsley 2003). These data would not support, then, a strong claim for the uniquely invulnerable adolescent and, indeed, would suggest that optimism bias is a pervasive characteristic of human decision-making.

Yet this conclusion must be tempered by studies that appear to show that optimism bias is indeed stronger in adolescents than in adults (Cohn et al. 1995; Arnett 2000); and by studies that show just the opposite (Millstein and Halpern-Felsher 2002a). In a comprehensive review of the literature Millstein and Halpern-Felsher (2002b) concluded that popular conceptions of the invulnerable adolescent are mythical. Indeed, if anything, young adolescents feel unreasonably vulnerable to a wide variety of hazards; and it is in early adulthood when perceptions of invulnerability are strongest.

Clearly, then, the invulnerability question is unsettled and in need of much additional research. One obstacle is the lack of well-attested assessments of invulnerability, at least as a developmental construct. Previous attempts to measure invulnerability have done so as part of a general project to assess personal fable ideation (e.g., Alberts et al. 2007; Aalsma et al. 2006; Lapsley et al. 1989). Recently, Duggan et al. (2000) reported on the development of an adolescent invulnerability scale (AIS) that aligns, in theory, with the "two faces" conceptualization of invulnerability (Lapsley 2003). The AIS has two subscales: danger invulnerability and psychological invulnerability. Danger invulnerability captures adolescents' sense of indestructibility and propensity to take physical risks. Psychological invulnerability measures one's felt invulnerability to personal or psychological distress (e.g., having one's feelings hurt). Duggan et al. (2000) reported strong internal consistency for both subscales, and both subscales positively predicted delinquent risk behavior, although danger invulnerability was the stronger predictor of risk behavior. That psychological invulnerability also correlated positively with delinquent risk behavior probably reflects the fact that, for most of us, exposure to threatening hazards normally invokes a measure of psychological distress to impending physical danger. Although this first evidence for construct validity is encouraging, additional research must address the claim that some aspects of invulnerability have adaptive implications. Moreover, it is unclear how subjective invulnerability and optimism bias are related, or

whether they are related differentially to risk behavior and adjustment.

The Current Study

The purpose of this study was to address these questions. First, we further assessed the reliability and predictive validity of the AIS. Following the "two faces" conception (Lapsley 2003), we expected danger invulnerability to correlate positively with delinquent risk-taking and substance use. Psychological invulnerability may also be related to risk behavior (as evidenced by Duggan et al. 2000), but it should also counterindicate a range of psychological problems, including self-esteem problems, interpersonal problems and depressive concerns.

Second, we evaluated the relationship between optimism bias and subjective invulnerability. It is often assumed in the invulnerability literature that optimism bias and invulnerability (and personal fables) are identical constructs, or point to the same mechanisms or have the same developmental implications. This is, at best, an untested assumption. To date not a single study has attempted to explore the interplay between subjective invulnerability as a dispositional or attitudinal construct and optimism bias as a defect in veridical risk appraisal. In the present study, we expected optimism bias to correlate positively with subjective invulnerability, yet not so strongly as to suggest that they are identical constructs. We also examined the differential relationship of subjective invulnerability and optimism bias to indices of risk behavior and adaptation. Taking up these questions goes to the heart of whether subjective invulnerability and optimism bias are coterminous constructs, as so often assumed in the literature, or whether they are distinct constructs with differential relationships with adaptational outcomes.

Optimism bias has been assessed in different ways, and how it is done is an important methodological issue. The most common way to assess optimism bias is to ask participants to make comparative risk judgments (e.g., "what are your chances *compared to the average person*"). Another option is to have participants make absolute judgments of risk. For example, participants might be asked to imagine a possible outcome for the self in a given situation (e.g., "Imagine that you are at a picnic when a lightning storm strikes. What is the chance that you will die in the lightning storm?"). Studies using absolute (vs. comparative) judgments tend to show that young adolescents feel unreasonably *vulnerable* to a wide variety of hazards, and that it is in *early adulthood*, not adolescence, when perceptions of invulnerability are the strongest (Millstein and Halpern-Felsher 2002a, b). Studies also differ to the extent they require *unconditional* ("What are your chances of getting lung cancer?") or *conditional* ("What are your chances of getting lung cancer *if you smoke*?") risk judgments. Millstein and Halpern-Felsher (2002b) argue in favor of using conditional risk judgments because it anchors risk assessment to specific situations or conditions and controls for behavioral experience. Consequently, in the present study we require participants to make comparative-conditional risk judgments using items derived from previous research.

Measuring optimism bias can be nuanced further when researchers separate optimism with respect to the type of event examined. People could be optimistic that negative events *will not* happen to them, and/or optimistic that positive events *will* happen to them. This distinction between *negative optimism bias* and *positive optimism bias* appears to be particularly important when examining cultural differences in optimism bias (Chang et al. 2001; Heine and Lehman 1995). While one would expect optimism bias to influence risk-taking behavior, both *negative* and *positive* optimism bias appear to counter-indicate dysphoria, at least for European-Americans (e.g., Chang et al. 2001). Therefore, it is of interest to not only examine how these two optimism constructs relate to risk-taking but also how they predict adjustment. We take up both aspects in the current study, in examining how invulnerability and optimism bias relate to risk-taking and adjustment outcomes.

Method

Participants

Participants included 350 undergraduates ($M_{age} = 20.17$; 73% female) at a large, public Midwestern university. The age range of participants was 18–25, which is the period commonly denoted as "emerging adulthood" (Arnett 2000). The sample was predominantly White/European–American (93%).

Instruments

Subjective Invulnerability

Subjective invulnerability was assessed with the AIS (Duggan et al. 2000). The AIS assess felt invulnerability with respect to two factors: danger invulnerability (12 items) and psychological invulnerability (8 items). Items are rated on a five-step continuum ranging from (1) strongly disagree to (5) strongly agree. All items are presented in the Appendix. Both subscales demonstrated strong reliability in the current sample (danger invulnerability, $\alpha = 0.76$; psychological invulnerability, $\alpha = 0.73$).

Optimism Bias

A comparative-conditional risk assessment was used to measure optimism bias. Participants rated their chances of experiencing 22 conditional risks compared with "the average (university name) student." Response options were the following: "Much below average" (−3), "Below average" (−2), "Slightly below average" (−1), "Average for (university name) students" (0), "Slightly above average" (1), "Above average" (2), and "Much above average" (3). Items were chosen to reflect a broad range of situations typically assessed in this literature. Furthermore, we included both positive and negative risk items, although we focused on negatives because these are more typically assessed in the adolescent literature (e.g., Jacobs-Quadrel et al. 1993). Following the precedent of previous research (e.g., Chang et al. 2001; Klaczynski and Fauth 1996; Pyszczynski et al. 1987), we formed two optimism bias subscales. One subscale was the sum of negative items (19 items, $\alpha = 0.85$) and the second subscale was the sum of positive risk items (3 items, $\alpha = 0.76$). These subscale reliabilities are quite strong given the heterogeneous nature of the items and the few positive risks (for example, compared to Heine and Lehman 1995), suggesting that our measure did tap participants' general disposition towards optimistic biases. Note that optimism bias for negative items would be demonstrated by negative scores (below average risk of a negative event), while optimism bias for positive risks would be demonstrated by positive scores (above average chance of a positive event).

Risk Behavior

Risk behaviors were assessed by the self-report delinquency battery developed by Rowe (1985; $\alpha = 0.84$). Participants were asked to rate the extent to which they engaged in a list of 20 risk behaviors, including vandalism, fighting, using weapons, stealing, and fast driving (among others) on a four-point scale that ranged from No/Never (1) to Very Often (4). In spite of the heterogeneity of content the various delinquency items can be considered a single factor (Flannery et al. 1993; Rowe and Flannery 1994), and a total score is summed across the 20 items, with high scores representing a greater proclivity for risk behavior. In addition to these items participants were also asked "How many times have you ever" drank beer/alcohol, smoked cigarettes, used chewing tobacco/snuff, did cocaine, did speed, smoked marijuana, did acid, and used inhalants. The response scale for each substance was: "Never," "1–2 times," "3–9 times," "10–39 times" and "40 or more." These eight items were also summed across to form a drug use scale ($\alpha = 0.76$).

College Adjustment

The college adjustment scales (CAS; Anton and Reed 1991) were used to assess various dimensions of mental health and adjustment. The CAS can be used as a screen for common developmental and psychological problems faced by college students. It consists of nine subscales, only three of which were used in the present study. The interpersonal problems (12 items, $\alpha = 0.82$) scale measures the extent of problems in one's social relationships. The depression problems (12 items, $\alpha = 0.90$) scale is a measure of depressive symptoms. The esteem problems scale (11 items, $\alpha = 0.88$) is a measure of global self-esteem that taps negative self-evaluations and dissatisfaction with personal achievement.

Results

Sex Differences in Invulnerability and Optimism Bias

We first assessed whether there was evidence of sex differences in invulnerability and optimism bias. In line with previous research on sex differences in invulnerability (Alberts et al. 2007; Duggan et al. 2000), males scored higher on both danger invulnerability, $t(340) = 7.89$, $p < 0.001$, and psychological invulnerability, $t(339) = 8.30$, $p < 0.001$. No sex differences were evident in negative, $t(330) = -1.65$, $p > 0.05$, or positive optimism bias, $t(345) < 1$, a finding also reported by previous research (Klaczynski and Fauth 1996).

Predictive Validity of the AIS

Descriptive statistics for all variables are provided in Table 1. We first examined whether the AIS subscales were related to risk behavior. Partial correlations controlling for age are provided in Table 2. As can be seen in Table 2, danger invulnerability was positively correlated significantly with both risk behavior, $r(323) = 0.36$, $p < 0.001$, and drug use, $r(320) = 0.22$, $p < 0.001$. Psychological invulnerability was also significantly correlated with both risk behavior, $r(321) = 0.13$, $p < 0.05$, and drug use, $r(319) = 0.15$, $p < 0.01$. Hence the two subjective invulnerability factors appear to correlate significantly with risk behavior and substance use in the expected direction. This finding confirms the popular notion that risk behavior is associated with a felt sense of invulnerability, although danger invulnerability is generally the stronger correlate, as expected.

We next examined the relationship between subjective invulnerability and college adjustment problems. As can be seen in Table 2, danger invulnerability was unrelated to

Table 1 Descriptive statistics

Variable	Mean (SD)	Min	Max
Age	20.17 (1.45)	18	25
Danger invulnerability	25.89 (6.23)	12	44
Psychological invulnerability	19.66 (4.78)	8	35
Negative optimism bias	70.66 (12.84)	19	109
Positive optimism bias	14.11 (2.86)	3	21
Delinquency	27.37 (6.15)	20	51
Drug use	6.16 (5.09)	0	25
Interpersonal problems	19.07 (5.12)	12	37
Depression problems	17.61 (5.79)	12	45
Self-esteem problems	20.09 (5.74)	11	38

depressive problems, $r(326) = 0.11$, $p > 0.05$, and self-esteem problems, $r(334) = 0.03$, $p > 0.1$ but positively related to interpersonal problems, $r(327) = 0.17$, $p < 0.01$. In contrast, there was a significant negative correlation between psychological invulnerability and depressive problems, $r(324) = -0.23$, $p < 0.001$, self-esteem problems, $r(333) = -0.34$, $p < 0.001$, and interpersonal problems, $r(326) = -0.19$, $p < 0.001$. This supports the claim that some forms of subjective invulnerability may have adaptive implications (Lapsley 2003).

Invulnerability, Optimism Bias and Adjustment

We next considered the relationship between subjective invulnerability and optimism bias, and we examined their relationship with indices of risk behavior and with college adjustment problems. Our first analysis was to determine whether the participants in our study did, in fact, evince optimism bias with respect to the 22 risk scenarios presented in the comparative-conditional risk appraisal assessment. Recall that items were rated on a scale ranging from −3 to +3, with zero as the midpoint (indicating no optimism bias). For items that describe negative risky outcomes ("getting lung cancer"), optimism bias is indicated by scores ranging from −3 to −1. For items that describe positive risky outcomes ("making a new friend"), optimism bias is indicated by scores ranging from 1 to 3. We considered optimism bias to be evident if the mean rating for each item was significantly different from zero. Table 3 displays the items with their means and standard errors. All but three optimism bias items were significantly different from zero, indicating that the participants in this study showed pervasive optimism about their comparative chances with respect to numerous negative and positive risk situations.

We then evaluated the relationships between subjective invulnerability and optimism bias. As can be seen in Table 2, danger invulnerability was significantly related to negative optimism bias, $r(322) = -0.21$, $p < 0.001$, but unrelated to positive optimism bias, $r(336) = 0.02$, $p > 0.1$. Psychological invulnerability was significantly related to both negative optimism bias $r(322) = -0.21$, $p < 0.001$, and positive optimism bias, $r(335) = 0.16$, $p < 0.01$. Invulnerability and optimism bias thus were correlated in the expected direction, as more invulnerable participants scored lower on negative optimism bias (indicating less belief that negative events will happen to them), and higher on positive optimism bias (indicating greater belief that positive events will happen to them).

Table 2 also reports the differential (partial) correlation of subjective invulnerability and optimism bias with risk behavior, substance use and college adjustment problems. We noted earlier that danger invulnerability was significantly correlated with both delinquent risk behavior and substance use, accounting for 13 and 5% of the variance in these variables, respectively. Moreover, we noted that psychological invulnerability was also significantly correlated with risk behavior, and with substance use, accounting for 2% of the variances in both of these variables. In contrast, optimism bias for negative events was not significantly correlated with either delinquent risk behavior,

Table 2 Correlations between invulnerability, optimism bias, risk behavior and adjustment, partialled for age

	DI	PI	NO	PO	Del	DU	IPP	SEP	DP
Danger invulnerability	–	0.36**	−0.21**	0.02	0.36**	0.22**	0.17**	0.03	0.11^
Psych. invulnerability		–	−0.21**	0.16**	0.13*	0.15**	−0.19**	−0.34**	−0.23**
Neg. optimism bias			–	−0.21**	−0.05	0.02	0.12*	0.31**	0.19**
Pos. optimism bias				–	0.10^	0.07	−0.11*	−0.33**	−0.15**
Delinquency					–	0.57**	0.32**	0.10^	0.22**
Drug use						–	0.18**	0.05	0.22**
Interpersonal problems							–	0.61**	0.63**
Self-esteem problems								–	0.67**
Depressive problems									–

^ $p < 0.1$; * $p < 0.05$; ** $p < 0.01$

Table 3 Optimism bias items with means (standard errors), with significance for one-sample *t*-tests against a value of 0

Negative items	
Getting a divorce if I were married	−1.00 (0.07)**
Giving up on a task after being criticized	−0.73 (0.07)**
Losing a friend because of something I did	−0.66 (0.06)**
Getting caught if I illegally downloaded materials	−0.64 (0.07)**
Getting a sexually transmitted disease if I have unprotected sex	−0.59 (0.08)**
Getting caught by authorities if I use illegal substances	−0.43 (0.08)**
Becoming an alcoholic if I drink regularly	−0.36 (0.09)**
Being injured in a tornado if one struck near a picnic I was attending	−0.35 (0.06)**
Getting dental problems if I don't floss regularly	−0.31 (0.07)**
Getting caught if I damage or destroy something that did not belong to me	−0.26 (0.07)**
Getting caught if I cheat on a test	−0.25 (0.07)**
Failing a class if I don't study regularly	−0.20 (0.07)**
Becoming depressed because of a disappointment	−0.19 (0.08)*
Getting caught if I take something from a store without paying for it	−0.16 (0.07)*
Being rejected if I ask someone for a date	−0.14 (0.07)*
Getting mugged if I go to a dangerous neighborhood	−0.05 (0.06)
Becoming injured in a car accident if I drive very fast	0.00 (0.05)
Being injured if I got into a fight	0.07 (0.07)
Developing lung cancer if I smoke regularly	0.20 (0.07)**
Positive items	
Getting a good grade if I study for an exam	0.83 (0.06)**
Getting an interview if I apply for a job	0.67 (0.06)**
Making a new friend if I make the first move	0.60 (0.06)**

* $p < 0.05$; ** $p < 0.01$

$r(313) = -0.05$, $p > 0.1$, or with substance use, $r(310) = 0.02$, $p > 0.1$. Optimism bias for positive events was also unrelated to delinquent risk behavior, $r(327) = 0.10$, $p > 0.05$, and substance use, $r(325) = 0.07$, $p > 0.1$. Therefore, invulnerability appears to clearly have a stronger relationship with risk-taking than does optimism bias.

With respect to college adjustment problems, we noted earlier that while danger invulnerability was positively correlated with interpersonal problems (accounting for approximately 3% of the variance), psychological invulnerability was negatively correlated with all three college adjustment problems ($M_r = -0.25$). Optimism bias for negative events was positively correlated with self-esteem problems, $r(325) = 0.31$, $p < 0.001$, interpersonal problems, $r(317) = 0.12$, $p < 0.05$, and depressive problems, $r(318) = 0.19$, $p < 0.001$. Note that the positive correlation here indicates that optimism bias counter-indicates self-esteem, interpersonal, and depressive problems, given that negative scores for optimism bias (for negative events) indicates greater optimism. Optimism bias for positive events demonstrated negative correlations with self-esteem problems, $r(339) = -0.33$, $p < 0.001$, interpersonal problems, $r(331) = -0.11$, $p < 0.05$, and with depressive problems, $r(330) = -0.15$, $p < 0.01$. Hence optimism bias (for either positive or negative events) appeared to be of some benefit with respect to these college adjustment problems.

To clarify the patterns of associations we ran simultaneous multiple regression analyses to predict the five outcome variables of interest (delinquent risk behavior, drug use, depressive problems, self-esteem problems, and interpersonal problems) from the invulnerability and optimism bias measures, controlling for sex and age. The question of interest here was whether subjective invulnerability would still significantly predict these adjustment outcomes when optimism bias (and gender) is included in the regression equation. If so this would demonstrate further evidence of their conceptual independence. Details of the regression analyses are provided in Table 4.

The results indicated that danger invulnerability was the only significant predictor of both delinquent risk behavior, $\beta = 0.26$, $t(294) = 4.48$, $p < 0.001$ and substance use, $\beta = 0.19$, $t(290) = 3.00$, $p < 0.01$. Again, this suggests that invulnerability, and specifically danger invulnerability, serves as the best predictor of risk-taking behavior.

Three variables emerged as significant predictors of depression problems: psychological invulnerability, $\beta = -0.27$, $t(298) = -4.35$, $p < 0.001$, danger invulnerability, $\beta = 0.26$, $t(298) = 4.19$, $p < 0.001$, and optimism bias for negative events, $\beta = 0.17$, $t(298) = 2.90$, $p < 0.01$. Note that psychological invulnerability was a negative predictor of depression problems, while danger invulnerability was a positive predictor. Optimism bias for negative events also counter-indicated depression.

Table 4 Regression analyses predicting outcome variables from invulnerability and optimism bias

Variable	*B*	SE *B*	β
Delinquency			
Sex	−4.32	0.81	−0.32**
Age	0.36	0.22	0.09
Danger invulnerability	0.25	0.06	0.26**
Psychological invulnerability	−0.15	0.08	−0.12^
Negative optimism bias	0.01	0.03	0.03
Positive optimism bias	0.22	0.12	0.10^
Drug use			
Sex	−1.72	0.72	−0.15*
Age	0.85	0.20	0.24**
Danger invulnerability	0.15	0.05	0.19**
Psychological invulnerability	0.02	0.07	0.02
Negative optimism bias	0.04	0.02	0.11^
Positive optimism bias	0.19	0.10	0.10^
Interpersonal problems			
Sex	−1.74	0.72	−0.15*
Age	−0.07	0.20	−0.02
Danger invulnerability	0.22	0.05	0.27**
Psychological invulnerability	−0.33	0.07	−0.30**
Negative optimism bias	0.04	0.02	0.10^
Positive optimism bias	−0.07	0.11	−0.04
Self-esteem problems			
Sex	−1.79	0.72	−0.14*
Age	−0.24	0.20	−0.06
Danger invulnerability	0.18	0.05	0.20**
Psychological invulnerability	−0.47	0.07	−0.38**
Negative optimism bias	0.11	0.02	0.24**
Positive optimism bias	−0.42	0.11	−0.20**
Depressive problems			
Sex	−0.51	0.81	−0.04
Age	0.04	0.23	0.01
Danger invulnerability	0.24	0.06	0.26**
Psychological invulnerability	−0.33	0.08	−0.27**
Negative optimism bias	0.08	0.03	0.17**
Positive optimism bias	−0.16	0.12	−0.07

^ $p < .01$; * $p < .05$; ** $p < .01$

With respect to interpersonal problems, only the two invulnerability subscales emerged as significant predictors: psychological invulnerability, $\beta = -0.30$, $t(298) = -4.82$, $p < 0.001$, and danger invulnerability, $\beta = 0.27$, $t(298) = 4.41$, $p < 0.001$. Once again, psychological invulnerability counter-indicated interpersonal problems, while danger invulnerability was positively associated with interpersonal problems.

Finally when predicting self-esteem problems, all four predictors were statistically significant: psychological invulnerability, $\beta = -0.38$, $t(311) = -6.71$, $p < 0.001$, danger invulnerability, $\beta = 0.20$, $t(311) = 3.54$, $p < 0.001$, negative optimism bias, $\beta = 0.24$, $t(311) = 4.57$, $p < 0.001$, and positive optimism bias, $\beta = -0.20$, $t(311) = 3.97$, $p < 0.001$. Psychological invulnerability and optimism bias counter-indicated self-esteem problems, while danger invulnerability was positively associated with self-esteem problems.

Discussion

This study attempted to bring some clarity to the notion of adolescent invulnerability and its relationship to various adaptational outcomes. Two research traditions have explored this question. One tradition suggests that the felt subjective invulnerability of adolescents is linked to their developmental status. A second tradition assumes that individuals are like intuitive statisticians who calculate probabilities, likelihoods and chances when weighing decisions, but who are prone to self-regarding cognitive biases that lead to unrealistic optimism about one's chances with respect to risk-laden situations. One tradition, then, sees invulnerability emerging as a result of cognitive or ego development. The second tradition views invulnerability in terms of an optimism bias that is endemic to risk appraisal. Both traditions invoke the term "invulnerability" although it is far from clear that the terms of reference are the same in both cases. Moreover, research on invulnerability is handicapped by a lack of assessment options, particularly with respect to subjective invulnerability, making it difficult to sort out the contributions of the two traditions to explaining risk and adjustment outcomes.

This study attempted to provide additional evidence of construct validity for a recently devised AIS. We also wanted to provide the first answers to two novel questions. First, what is the relationship between subjective invulnerability and optimism bias? For example, do they overlap substantially or are they distinguishable constructs? Second, what is their differential relationship to indices of risk behavior and adjustment? In theory we expected subjective invulnerability to present with "two faces", that is, to indeed predict risk behavior but also to counterindicate a range of adjustment problems. Moreover, we were interested in determining whether subjective invulnerability or optimism bias would emerge as stronger predictors of risk and adjustment.

The results showed encouraging evidence for the AIS. As in previous research (Duggan et al. 2000), the two factors of the AIS (danger invulnerability and psychological invulnerability) showed strong evidence of internal consistency. Moreover, the two invulnerability scales were positively correlated with risk behavior and substance use, particularly the danger invulnerability subscale. This finding corroborates similar findings reported by Aalsma et al. (2006), who

reported a pervasive pattern of association between invulnerability (measured by a personal fable scale) and both delinquent risk behavior and substance use in a large sample of early and middle adolescents. Similarly, Lapsley et al. (2005) report a pervasive pattern of significant associations between danger invulnerability and use of tobacco, marijuana and alcohol in a sample of young adolescents.

Hence there is mounting evidence to support one of the more prominent of the popular notions of adolescence, namely, that young people take greater risks because of their felt sense of invulnerability to danger. Note, however, that although the popular notion implies a causal line of effect—from danger and psychological invulnerability to risk behavior—the present findings can only support their bivariate association, though this is the one of the first studies to do so. Note also that in the present study danger invulnerability was positively related to interpersonal problems, which suggests that this form of invulnerability might have broader consequences for the adjustment of emerging adults in addition to risk exposure.

While danger invulnerability and, to a lesser extent, psychological invulnerability are both correlated with risk behavior and substance use, psychological invulnerability was also negatively correlated with self-esteem problems, interpersonal problems and depression problems (whereas danger invulnerability was not). This corroborates findings reported elsewhere (Duggan et al. 2000), and supports the contention that invulnerability has adaptive qualities and is not invariably a menace to adolescents and emerging adults. Lapsley (2003) argued, for example, that invulnerability has "two faces," one that looks towards potentially dangerous risk behavior ("danger invulnerability") and another that protects against internalizing, relational and self-esteem problems ("psychological invulnerability"). This differentiated view of invulnerability should caution against an overbroad claim that subjective invulnerability is invariably a lamentable feature of the adolescent experience, or that it should be the target of intervention to reduce risk-exposure, given that at least one form of invulnerability appears to serve an important adaptational purpose. Future research will need to investigate whether and to what extent invulnerability serves a protective function. But the present data suggests minimally that invulnerability is not a unidimensional construct, and that it does not have uniform implications for health promotion.

The present study also examined the relationship between subjective invulnerability and optimism bias. These constructs have often been conflated in the literature. Indeed, findings in the health decision-making literature that document widespread optimism bias in risk appraisal are often used to cast doubt on "invulnerability" as a dispositional, attitudinal or developmental construct. However, subjective invulnerability and optimism bias turn out to be correlated constructs, but the association is not very strong. For example, danger invulnerability accounted for about 4% of the variance in optimism bias for negative events, and was virtually uncorrelated with optimism bias for positive events ($r = 0.02$). Psychological invulnerability was correlated with both negative and positive optimism bias, but accounts for less than 5% of the variance in these constructs. Clearly, then, while subjective invulnerability and optimism bias share some elements in common, perhaps an element of self-assertion or agency, they nonetheless are tapping somewhat different psychological mechanisms.

One lesson of these data, then, is that optimism bias and subjective invulnerability are not identical constructs and should not be conflated. The conceptual independence of these constructs is underscored by analyses that attempted to document their comparative association with risk behavior, substance use and college adjustment problems. For example, whereas danger invulnerability accounted for 4 to 13% of the variance in risk behavior, and psychological invulnerability accounted for 1 to 2% of the variance in these constructs, optimism bias, in contrast, was not significantly correlated at all with risk activity or with substance use. When it comes to fighting, stealing or vandalism or driving fast and recklessly, or using drugs and alcohol, it was the subjective sense of danger and psychological invulnerability that was the more robust predictor and not the optimism-bias decision-making construct. As evidenced further in the multiple regression analyses, subjective invulnerability, and particularly danger invulnerability, serve to better predict risk-taking than does optimism bias. These data seem to underscore Steinberg's (2003) doubts on whether decision-making is the right framework for understanding adolescent risk behavior.

Accordingly, these results have certain implications for future interventions and efforts to prevent adolescent risk-taking. Efforts to "correct" adolescents by demonstrating probabilistic outcomes may prove less fruitful, as our results suggest that adolescents are not calculating these probabilities prior to risk-taking. This is not to say though that programs should focus on eliminating adolescents' perceptions of personal invulnerability. Instead, we suggest the need for increased nuance in these programs. Any efforts to decrease risk-taking must also consider the benefits of invulnerability, in order to avoid diminishing the adolescent's self-esteem in the process.

Although optimism bias was not associated with risk behavior, it did counterindicate depression and self-esteem problems. This association is not unanticipated. As Carroll et al. (2006, p. 56) observed, "Overwhelmingly, evidence shows that an optimistic outlook in its various incarnations provides a variety of emotional, social and health benefits." For example, dispositional optimism (generalized positive expectancy) and comparative optimism (one's risk relative

to others) are often associated with a wide range of adaptive outcomes, including indices of psychological and health-related well-being (e.g., Radcliffe and Klein 2002; Scheier and Carver 1982, 1992). Optimism biases are considered part of the complex of positive illusions that moderate stress and contribute to adaptive coping (e.g., Mazur et al. 1999; Taylor and Brown 1988; Radcliffe and Klein 2002; Weinstein and Klein 1996). Hence the comparative-conditional risk judgment task used in the present study appears to tap a form of adaptive optimism that ameliorates internalizing concerns, an outcome it shares with psychological invulnerability.

Finally, our results suggest clear sex differences with respect to felt invulnerability, but not optimism bias. In line with previous research (Alberts et al. 2007; Duggan et al. 2000), males scored higher than females on both measures of (danger and psychological) invulnerability. However, males and females did not differ on optimism bias, a finding also reported elsewhere (Klaczynski and Fauth 1996). That gender differences emerge for subjective invulnerability but not optimism bias is perhaps additional evidence that we are dealing with constructs that are conceptually distinct and should not be conflated. Hill and Lapsley (2009) argue that subjective invulnerability may be a form of adolescent narcissism that plays an adaptive role in helping young people manage important social and psychological transitions. If true then males may find the externalizing elements of invulnerability particularly suitable for their gender-linked preference for coping with transition stress. Further assessment of these sex differences is one intriguing avenue for future research.

The present study is not without limitations, which should be addressed in future research. One limitation of the present study is that we were unable to sort out claims regarding the developmental source of adolescent invulnerability. There are at least two developmental accounts of invulnerability in the literature but the present study was not designed to test them. Additional research is required to track the longitudinal trajectory of subjective vulnerability during adolescence and to test theoretical claims about its association with concurrent developmental challenges, such as separation-individuation or identity exploration.

Another primary limitation is our inability to use this sample to test differences with respect to environmental context, ethnicity, and socioeconomic status. For example, adolescents raised in a more turbulent environment context are likely to perceive less subjective invulnerability because they may witness more human "vulnerability" in their daily lives. Therefore, invulnerability may prove a less fruitful predictor of risk-taking behavior for these samples. The current study is unable to examine these effects given our largely homogenous sample, but it proves another question for future research.

Future research should also examine whether subjective invulnerability or optimism bias varies with respect to whether adolescents or emergent adults are "engagers" or "non-engagers" in target risk behaviors. An adolescent who habitually drinks-and-drives without incident, for example, might have a basis for his or her optimism or felt sense of invulnerability that is different from one who does not engage in this risk behavior. In this case we can ask whether invulnerability or optimism is the cause or the effect of engaging in risk behavior. Sorting out the temporal precedence of this relationship is a crucial line of research for the future.

Research should also explore the association between subjective invulnerability and the various kinds of optimism evident in the literature. As noted above distinctions are drawn between dispositional, comparative and unrealistic optimism (e.g., Radcliffe and Klein 2002) and between different forms of dispositional optimism (Schweizer and Koch 2001). We have shown here that subjective invulnerability is a construct largely distinct from comparative optimism bias, although how it fares with respect to other forms of optimism remains to be seen.

Yet another research direction would be to examine further the differential prediction of adjustment outcomes by positive and negative optimism bias. Although the adolescent literature has largely focused on negative optimism bias (e.g., Jacobs-Quadrel et al. 1993), our results suggest that positive optimism bias is at least equally as informative. Indeed, positive optimism bias was related to all three adjustment variables. Relatively little research has compared the effects of positive versus negative optimism bias among adolescents and emerging adults; thus, investigations of how optimism bias for positive events contributes to successful adaptation to the normative challenges and transitions of adolescence would be profitable line of research for the future.

Finally, future research should better examine sex differences with respect to adolescent invulnerability. Males scored higher on both measures of adolescent invulnerability in the current study. However, it would be of interest to further examine how invulnerability differentially influences males and females. For example, Schonert-Reichl (1994) found that invulnerability had a stronger negative correlation with depressive symptoms for females than males, using a scale in line with a personal fable conception of invulnerability (Lapsley et al. 1989). This might suggest that psychological invulnerability is more beneficial for females than males, or that the processes underlying the buffering effect of invulnerability on mental health may differ between the sexes.

In sum, the present study makes several important contributions to the invulnerability literature. First, it documents the popular notion that felt invulnerability is

correlated with risk behavior. Second, it shows that invulnerability, as a subjective, dispositional or attitudinal construct, is distinct from optimism bias, which is a decision-making construct. Third, it shows that invulnerability itself is not a unidimensional construct but takes at least two forms: danger invulnerability and psychological invulnerability. Fourth, it shows that while danger invulnerability is a stronger predictor of risk behavior and has few other redeeming features, psychological invulnerability is associated with adaptive outcomes, although it predicts risk behavior as well. Finally, the present study invites further research on possible moderators of the invulnerability–adaptation relationship and its implications for intervention.

Appendix: Adolescent Invulnerability Scale

How well do the following statements describe you? Rate each statement using the following scale.

	Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly agree 5

1. I'm unlikely to be injured in an accident
2. My feelings don't get hurt
3. Nothing bad will happen to me when I go to a place by myself
4. Nothing seems to bother me
5. There are times when I think I am indestructible
6. I could probably drink and drive without getting into an accident
7. My feelings are easily hurt
8. I'm unlikely to get hurt if I did a dangerous thing
9. I'm a fragile person
10. Special problems, like getting an illness or disease, are not likely to happen to me
11. Nothing can harm me
12. The problems that happen to people my age are unlikely to happen to me
13. The opinions of other people just don't bother me
14. What people say about me has no effect on me at all
15. Driving very fast wouldn't be dangerous if I were driving
16. I feel very badly when I know there is gossip about me
17. Taking safety precautions is far more important for other people than it is for me
18. Safety rules do not apply to me
19. It is just impossible for people to hurt my feelings
20. It is not necessary for me to worry about being injured or harmed

AIS scoring

Reverse score: # 7, 9, and 16

Danger invulnerability: 1, 3, 5, 6, 8, 10, 11, 12, 15, 17, 18, 20

Psychological invulnerability: 2, 4, 7, 9, 13, 14, 16, 19

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