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The Relationship between Puberty and Risk Taking in the Real World and in the Laboratory

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Abstract

Adolescence is marked by the emergence and escalation of risk taking. Puberty has been long-implicated as constituting vulnerability for risk behavior during this developmental period. Sole reliance on self-reports of risk taking however poses limitations to understanding this complex relationship. There exist potential advantages of complementing self-reports by using the BART-Y laboratory task, a well-validated measure of adolescent risk taking. Toward this end, we examined the association between self-reported puberty and both self-reported and BART-Y risk taking in 231 adolescents. Results showed that pubertal status predicted risk taking using both methodologies above and beyond relevant demographic characteristics. Advantages of a multimodal assessment toward understanding the effects of puberty in adolescent risk taking are discussed and future research directions offered.

Adolescence is a developmental period marked by the emergence and escalation of risk behaviors (Chassin, Presson, Sherman & Edwards, 1990; Gullo & Dawe, 2008). There is a long line of research examining the biological, behavioral, and environmental determinants of risk taking in this age group. Puberty is one biological variable that has received attention as presenting vulnerability for numerous risk taking behaviors (see Dahl, 2004 review). Puberty is a normative period of physiological and psychosocial changes that culminates in sexual maturity and delineates the transition from childhood into adolescence. Findings generally suggest that advanced pubertal status is related to a higher likelihood of real-world risk behavior such as substance use, relative to adolescents in earlier stages of their pubertal development, irrespective of age (e.g., Costello, Sung, Worthman & Angold, 2007; Faden, Ruffin, Newes-Adeyi & Chen, 2010; Patton et al., 2004). Although findings indicate a basic relation between puberty and risk taking, the potential for understanding this complex association may be limited by the exclusive use of self-reports.

For example, numerous perspectives attempt to explain the association between puberty and risk taking. Biophysiological theories ascribe risk taking to developmentally-limited spikes

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in reward-related brain function (e.g., Cyders & Smith, 2008; Forbes et al., 2010). Psychosocial models on the other hand, posit that adolescents are risky as a result of peer socialization and approval-seeking (Caspi, Lynam, Moffitt, & Silva, 1993; Ge et al., 2003; Stattin & Magnusson, 1990). Reconciling what may be considered opposing theories, Steinberg (2008) argued that both biophysiological and psychosocial models play an important role in the increase of risk-taking that occurs around pubertal development. Research supporting Steinberg's integrated theory (e.g., Chein et al., 2011) highlights the importance of moving toward a comprehensive assessment of the relation between puberty and risk taking behavior; one that complements self-report data with laboratory paradigms of risk taking propensity.

In addition to the potential multidimensional association between puberty and risk taking, various challenges are posed by the sole implementation of paper-and-pencil assessments of risk behavior without considering a multi-method assessment of risk taking. Adolescents may be reluctant to provide truthful responses to self-report questionnaires due to perceived negative repercussions (Lejuez et al., 2002; Williams & Nowatzki, 2005). In addition, they may lack insight and other cognitive factors necessary to accurately self-report risk taking behavior (Ladouceur et al., 2000; Winters & Fahnhorst, 2005). This suggests that additional methods are necessary to capture risk taking in real-time. Therefore, the investigation of the role of puberty and risk taking behaviors under an integrated framework may be enhanced with performance-based, laboratory approaches in addition to the use of self-report methodologies (e.g., Lejuez et al., 2003).

The Balloon Analogue Risk Task, Youth Version (BART-Y; Lejuez, et al. 2007) may complement and develop our understanding in this research area. The BART-Y is a well-validated laboratory paradigm that has been utilized widely in measuring adolescent risk taking. The task has shown to be associated, but not redundant, with self-reported risk behaviors, including alcohol use (MacPherson et al., 2010), substance use, gambling, delinquency, and risky sexual behavior (Aklin et al., 2005; Lejuez et al., 2005; Lejuez et al., 2007). Further, performance on the BART-Y accounts for unique variances in self-reported risk behaviors, above and beyond demographic variables and self-report measures of impulsivity, sensation seeking (Aklin et al., 2005; Lejuez et al., 2004) and conceptually-relevant personality variables (Skeel, Neudecker, Pilarski & Pytlak, 2007). Accordingly, and in line with broader perspectives of risk taking, the BART-Y operationalizes risk behavior as a continuum: possible negative consequences of a particular behavior are offset by possible rewards of the same behavior (Lejuez et al., 2002; Lejuez et al., 2005), which embraces strong parallels between the laboratory task and real-world risk behavior. Moreover, the BART-Y is able to measure young adolescents' propensity for future risks even if they have not yet started to engage in health-compromising activities.

A critical first step is to examine the relationship between pubertal status and the two distinct methods of assessing risk taking. The current study investigated the extent to which self-reported puberty related to both self-reported real-world risk taking and the BART-Y's measurement of risk-taking propensity. Although pubertal development is associated with increased real-world risk taking, no investigations to date have examined this relation using both modes of assessments. In the short term, this investigation will provide the opportunity

for a cross-modal replication of the findings between risk taking and pubertal development. In future work, the current investigation may establish a laboratory paradigm for studying the complex interplay of puberty and risk taking. We hypothesized that pubertal development would predict real-world risk behavior and BART-Y risk taking above and beyond demographic variables of relevance, including age.

Method

Participants

This study utilized data from an adolescent community sample participating in the third wave of a larger prospective study of behavioral, environmental, and genetic risk factors for HIV-related behaviors in youth. This wave of data was the first to include a pubertal development assessment. Participants in this study wave were between 11 to 15 years old, allowing for the examination of a wide range of risk behavior engagement across different gradations of pubertal development.

The original sample was comprised of 277 adolescents. Thirty eight participants did not attend their third wave appointment. Eight participants were excluded from the analyses because they did not complete one of the assessments administered due to 1) an error in administration and 2) late incorporation of the Pubertal Development Scale (please see *Measures*) into the study. The excluded participants did not differ on baseline demographic variables relative to the remaining sample.

The final study sample was comprised of 231 adolescents (44% girls) ages 11 to 15, with a mean age of 12.98 ($SD = 0.84$). Forty nine percent of the sample self-identified as White, 36% as Black, 3% as Latino/a, 1% as Asian, and 11% as “Other”. Annual household income was reported by the parent accompanying the adolescent and the mean was \$93, 969 ($SD = \$74,019$).

Measures

Balloon Analogue Risk Task-Youth (BART-Y; Lejuez et al., 2007)—The BART-Y is a well-validated and widely-used behavioral measure of risk taking propensity in which a computer-generated balloon is inflated by the adolescent, with each pump representing one point. If the balloon is pumped past its explosion point, all of the points accrued for that balloon are lost. Participants can stop pumping the balloon at any time prior to an explosion and allocate the accrued points to a permanent prize meter. After a balloon explodes or points are allocated to the permanent prize meter, a new balloon appears. After completing 30 balloon trials, the total points in the prize meter determines the participants’ final prize value, ranging from small (a prize valued at \$10) to bonus (a prize valued at \$35).

Pubertal Developmental Scale (PDS; Petersen, 1988)—The PDS is the most widely-used self-report instrument to assess pubertal development on a continuous scale in which youths self-report their pubertal status by rating their growth spurt and pubic hair growth, menarche and breast development for girls, and changes in voice and facial hair growth for boys. The scores on this measure range from 1 (have not begun) to 4 (completed).

Self-Reported Risk Behaviors—We used a modified version of the Youth Risk Behavior Surveillance System (YRBS; CDC, 2002) assessing past year engagement in the following behaviors: a) drank alcohol, b) gambled for money, c) rode a bicycle or motorcycle without a helmet, d) rode in a car without wearing a seatbelt, e) crossed the street recklessly, f) carried a weapon, g) stole from a store, h) stole from a person, i) rode in a car driven by someone who had been drinking, j) been in a physical fight, k) started a physical fight, and l) visited inappropriate web sites. Adolescents reported the frequency of past year engagement for these risk behaviors on a Likert-type scale with the following response options: a) zero, b) once, c) a few times, d) 1–3 times per month, e) 1–3 times per week, f) almost every day or more.

Demographic Variables—To explore relevant demographic variables and their relationship with the outcomes variables (real-world risk behavior and risk taking as indexed by the BART-Y), we extracted items from a demographics questionnaire also used in previous studies (MacPherson et al., 2010; Reynolds et al., 2011).

Procedures

Recruitment was conducted in the Washington, D.C. metropolitan area via media outreach, mailings sent to local schools, Boys and Girls Clubs, and community libraries. Permission to conduct research was obtained from the [Academic Institution Omitted] Institutional Review Board. Informed consent and assent were obtained from the adolescent's parent/guardian and the adolescent, respectively.

Adolescent participants completed all questionnaires and the BART-Y alone, in a private room. According to participant confidentiality guidelines and IRB approval, parents did not have access to the responses provided by the participants. All measures were administered using standard instruction sets.

Statistical Analyses

To calculate the total PDS score, the total sum of the scores of the five indicators of pubertal development was divided by five to maintain the 1 to 4 scoring as suggested by the Scale developers. The item inquiring about menarche was dichotomized (as suggested by the developers of the measure) with “1” indicating premenarcheal and “4” postmenarcheal (Petersen et al., 1988). The social comparison question (which assesses perception of pubertal development as compared to peers) was omitted from the analyses. Internal consistency for the measure was $\alpha = 0.76$.

In creating a composite measure of risk behaviors, we used methods consistent with previous work conducted in youth utilizing a modified version of the YRBS (please see Aklin et al., 2005; Lejuez et al., 2007; MacPherson et al., 2010 for further details). We focused on the 12 risk behaviors mentioned above, of which at least 10% of our sample reported engaging in (see Lejuez et al., 2007). Behaviors were dichotomized (“present in the past year” or “not present in the past year”) to preserve an equal metric and allow for a single risk behavior composite score. The Cronbach's alpha for the composite scale was .77.

Demographic variables were selected given their empirical and/or theoretical rationale. Gender was examined because boys often engage in more risk behavior both in the real world and on the BART-Y (Dahne et al., 2013). Further, pubertal development in boys lags one to two years relative to girls (Graber, Petersen, & Brooks-Gunn, 1996). We also selected age, which has demonstrated close and significant associations with pubertal stage (Blakemore, Burnett & Dahl, 2010). In addition, we selected self-reported race as a variable of interest given consistent reports that relative to other adolescents in the US, Black boys and girls have been shown to engage in fewer risk taking behaviors (e.g., Flory et al., 2006) and may begin and complete their pubertal development at an earlier age (e.g., Kaplowitz et al., 2001; Sun et al., 2002). Finally, we chose to examine annual household income (e.g., Blum et al., 2000).

Given the positive skew of annual household income, we conducted a log transformation which fixed the skew to an acceptable range. Further, as a result of the sample's greater representation of Black and White adolescents (altogether 85%), we grouped adolescents as "Black," "White" and "Other". To examine differences across adolescents' racial groups and relevant variables we used one-way ANOVAs. For relationships between demographic variables other than race and variables of interest to this study, we examined zero-order correlations.

For our primary analyses, we only controlled for demographic variables that were associated with the dependent variables as suggested by Keppel (1991), Miller & Chapman (2011) and Tabachnick & Fidell (2007). Finally, interactions among our predictor and the selected demographic variables were examined in their relationship to each dependent variable.

Results

Preliminary Analyses

Participants evidenced a mean of 39.25 ($SD = 13.88$) pumps on the BART-Y. Further, participants reported engaging in 0 to 12 risk behaviors, with an average of 5.07 ($SD=2.84$) real-world risk behaviors in the past year. Adolescents most commonly rode in a car without wearing a seatbelt (69%), rode a bicycle or motorcycle without a helmet (63%), crossed the street recklessly (61%), and drank alcohol (47%) (see Table 2). Further, participants obtained a total mean PDS score of 2.47 ($SD = 0.66$). Examined separately, females had a higher PDS score ($M = 2.84$; $SD = 0.57$) than males ($M = 2.18$; $SD = 0.58$; $p < 0.001$). Please see Table 3 for PDS scores. No significant differences were noted in adolescents' pubertal development according to race (all $ps > 0.08$). There were no significant interactions between puberty and the aforementioned demographic variables of interest ($ps > 0.10$).

In terms of the dependent variables (i.e., real-world risk behaviors and BART-Y risk taking), Black adolescents took less risks in the BART-Y than White adolescents ($p < 0.001$). Zero-order correlations (see Table 1) indicated BART-Y score was positively correlated with annual family income ($r = 0.15$; $p = 0.02$). Greater pubertal development scores were associated with older age ($r = 0.39$; $p < 0.005$) and females ($r = 0.16$; $p = 0.01$), whereas real-world risk behavior was associated with older age ($r = 0.18$; $p = 0.01$) and males ($r =$

0.31; $p < 0.001$). For the interrelationship of the primary variables, pubertal score was correlated with BART-Y score ($r = 0.18$; $p = 0.01$) and real-world risk behavior ($r = 0.14$; $p = 0.04$). Consistent with previous literature (Aklin et al., 2005; Lejuez et al., 2007), there was a positive association between the two measures of risk taking ($r = 0.13$; $p = 0.05$).

Primary Analyses

Two separate linear regression models were conducted to examine the relation between puberty and real-world risk behaviors and risk taking in the BART-Y, adjusting for covariates associated with the outcome of interest. In all regression analyses, covariates (i.e., demographic variables) were entered in the first block, and the independent variable in the second block. First, we estimated the association between puberty and real-world risk behaviors, adjusting for both gender and age. Results indicated that more advanced pubertal scores predicted engagement in a higher number of real-world risk taking behaviors above and beyond the influence of covariates ($B = 1.04$, $SE = 0.47$, $\beta = 0.15$, $p = 0.03$). Pubertal development significantly accounted for 1.8% of unique variance above and beyond covariates. The results also indicated that higher pubertal score significantly predicted higher risk taking scores in the BART-Y ($B = 7.16$, $SE = 2.26$, $\beta = 0.21$, $p = 0.002$) above and beyond the effect of race and annual household income, significantly accounting for 4.2% of unique variance in this model. See Tables 4 and 5 for each of these regression results.

Discussion

Consistent with our study hypotheses and existing literature, adolescents further along in their pubertal development engaged in a higher number of real-world risk taking behaviors. Further, adolescents more advanced in their pubertal development exhibited higher BART-Y risk taking. To our knowledge, this is the first published study to demonstrate the relationship of puberty and risk taking across two separate modes of assessment. This finding enhances our confidence about the link between puberty and risk taking phenomena in youths and highlights the promise of incorporating behavioral risk tasks in future research examining this association.

In addition to the intrinsic strengths of a laboratory paradigm in its ability to capture risk taking in real-time for youths undergoing puberty, the BART-Y is able to assess adolescents' risk taking propensity, even if the opportunities for risk taking have not yet presented themselves (Cauffman et al., 2010; MacPherson et al., 2010). The BART-Y may be useful in identifying a pubescent adolescent vulnerable to risk taking at an early age, which is an invaluable asset to prevention efforts aimed at decreasing the likelihood of adverse risk taking (e.g., Bornoalova et al., 2009). The BART-Y is also a parsimonious measure of risk taking in pubescent adolescents that does not require disclosure of the various risk behaviors in which an adolescent has or has not engaged.

Beyond the practical contributions of this work, there are several aspects that bear upon current integrated theories to explain the link between puberty and risk behavior. Current theories suggest that the association between puberty and risk taking cannot be properly understood without considering the effects of context. Self-report assessments require

participants to call on their memory of the circumstances that led to risk engagement, whereas the BART-Y isolates this effect. This advantage is especially relevant given recent studies highlighting the impact of in-vivo peer influence on adolescents' BART-Y responses (Cavalca et al., 2013; Reynolds et al., in press). As a result, a combined, multi-method assessment consisting of self-report methodologies and the BART-Y laboratory task provide further insight regarding the emotional, environmental, and proximal factors associated with risk taking during puberty.

BART-Y may also provide useful opportunities to explore neural functions and their relation to youth risk behavior during puberty. For example, a modified BART task created for functional magnetic resonance imaging (Rao et al., 2008) may be useful to gauge changes in brain networks associated with socioemotional processing and cognitive control that occur during puberty and believed to be associated with risk taking among adolescents (e.g., Cyders & Smith, 2008; Forbes et al., 2010; Steinberg et al., 2006).

The findings of this study should be interpreted in light of its limitations. First, this is a convenience sample, which has implications for the representativeness of the sample. Furthermore, the annual household income of the participants was higher than the national average and there were no significant differences in pubertal development among female and male and Black and White adolescents, despite that other studies have found such differences. This latter inconsistency may raise some concerns about generalizability or power. Second, the PDS was selected as the measure of pubertal development given its non-invasive nature, ease of administration, and adequate validity and reliability of the measure (Brooks-Gunn et al., 1987). Nevertheless, this self-report tool is subjective and may lead to potential reporting bias or inaccuracies. Lastly, although the relationships between BART-Y scores, pubertal status, and real-world risk behavior were all significant, these were small. It is possible that the effects may be more accentuated among a more representative sample of adolescents.

Despite the abovementioned limitations, the current study highlights possible advantages and future directions of using a laboratory setting when measuring risk taking. Given the significant relationships among the variables of interest, puberty-risk taking literature could greatly benefit from the implementation of BART-Y, or a similar behavioral task to assess risk taking. Of note, the correlation between the BART-Y and real-world risk behaviors was significant, yet small. This is consistent with previous research and suggests that the BART-Y and risk behavior self-reports may tap into different aspects of risk taking. For example, self-reports of risk taking may measure adolescents' perceived engagement in health-compromising behaviors, whereas the BART-Y identifies a propensity for risk taking.

In sum, the current study highlights the importance of examining the relationship between puberty and risk taking using both a self-report measure of engagement in risk taking behavior and a controlled, laboratory setting analogue. Both methods demonstrated a significant relationship to pubertal status. As a result of the challenges of measuring real-world risk taking in isolation of proximal contextual factors (e.g., peers), the BART-Y is capable of providing a non-circumstantial, real-time measurement of risk taking as a

function of puberty, complementing information collected using paper and pencil methodologies.

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Highlights

- Risk taking multimodal assessments may clarify adolescent risk taking during puberty
- Self-reported and behavioral risk taking was assessed during pubertal development.
- Puberty predicted risk taking using both methodologies above and beyond demographics.
- Advantages of a multimodal assessment during puberty are discussed.

Table 1

Key Descriptive Variables and Intercorrelations (N=231)

	1	2	3	4	5	6	7	8	9
1. Modified YRBS	--	0.14*	0.13*	0.18**	0.31**	0.05	-0.01	0.02	-0.01
2. PDS			0.18**	0.39**	-0.16*	-0.12	0.07	-0.12	0.07
3. BART-Y				0.13*	0.02	0.15*	-0.21**	0.26***	-0.07
4. Age					0.09	-0.02	0.00	-0.03	0.02
5. Gender						0.31***	-0.05	0.04	0.01
6. Annual Family Income							0.01	0.37***	0.04
7. Black Race									
8. White Race									
9. Other Race									

Note. Pubertal Development Scale (PDS; Petersen et al., 1988); Balloon Analogue Risk Task-Youth Version; BART-Y, Lejuez et al., 2003); Real-World Risk Behavior (Modified YRBS; Centers for Disease Control and Prevention, 2002); Gender is scored as females=0 and males=1; Race categories were dummy coded as yes=1, no=0

* p< .05,

** p< .01,

*** p< .005.

Table 2

Frequency of Engagement in Risk Taking Behaviors Over the Past Year (N=231)

Risk Behavior	% Endorsed
1. Rode in a car without wearing a seatbelt	68.6%
2. Rode a bicycle or motorcycle without a helmet	63.2%
3. Crossed the street recklessly	60.6%
4. Drank alcohol	47.1 %
5. Gambled for money	42.1%
6. Visited inappropriate web sites	39.1%
7. Been in a physical fight	36.5%
8. Stolen from a person	33.9%
9. Started a physical fight	20.9%
10. Rode in a car driven by someone who had been drinking	16.2%
11. Carried a weapon	14.4%
12. Stolen from a store	14.4%

Table 3

Means and Standard Deviations of Individual Items of the Pubertal Development Scale (N = 231)

Index	Mean	Standard Deviation	Score Ranges
Sample Total PDS	2.47	0.66	1.00 – 4.00
Boys			
Total PDS	2.18	0.58	1.00 – 4.00
Body Hair	2.48	0.75	1.00 – 4.00
Voice Change	2.15	0.80	1.00 – 4.00
Skin Change	2.33	0.82	1.00 – 4.00
Growth Spurt	2.22	0.77	1.00 – 4.00
Facial Hair	1.72	0.71	1.00 – 4.00
Girls			
Total PDS	2.84	0.57	1.20 – 4.00
Body Hair	3.07	0.74	1.00 – 4.00
Breast Change	2.71	0.68	1.00 – 4.00
Skin Change	2.57	0.71	1.00 – 4.00
Growth Spurt	2.54	0.93	1.00 – 4.00
Menarche	3.23	1.32	1.00 (26%) 4.00 (74%)

Note. Pubertal Development Scale (PDS; Petersen et al., 1988); Consistent with scoring guidelines, for each index, 1 represents “have not begun” and 4 represents “completed.” For the menarche index, 1 represents “premenarcheal” and 4 represents “postmenarcheal.”

Table 4

The Association between Puberty with Real-World Risk Behavior

	<i>R</i> ²	<i>t</i>	β	<i>SE</i>	<i>sr</i> ²	<i>p</i>
Criterion Variable: Modified YRBS						
<i>Step 1</i>	0.128					
Gender		5.07	0.31	1.76	0.35	0.10
Age		2.53	0.15	0.52	0.20	0.02
<i>Step 2</i>	0.146					
Gender		5.45	0.34	1.92	0.35	0.11
Age		1.38	0.09	0.31	0.22	0.01
PDS		2.20	0.15	1.04	0.47	0.02

Note. Pubertal Development Scale (PDS; Petersen et al., 1988); Real-World Risk Behavior (Modified YRBS; Centers for Disease Control and Prevention, 2002). Gender is scored as females=0 and males=1;

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$.

Table 5

The Association between Puberty with BART-Y Performance

	R^2	t	β	B	SE	s^2	p
Criterion Variable: BART-Y							
Step 1	0.086 ***						
Age		2.26	0.15	2.43	2.39	0.02	0.025
Annual Household Income		0.68	0.49	2.05	3.01	0.01	0.044
Black Race		-0.87	-0.09	-2.49	2.88	0.00	0.388
White Race		1.64	0.16	4.40	2.68	0.01	0.102
Step 2	0.111 **						
Age		1.13	0.08	1.29	1.14	0.01	0.259
Annual Household Income		0.90	0.07	2.71	2.99	0.00	0.367
Black Race		0.78	-0.08	-2.21	2.85	0.00	0.438
White Race		1.90	0.18	5.05	2.66	0.01	0.059
PDS		2.48	0.18	6.07	2.45	0.03	0.014

Note. Pubertal Development Scale (PDS; Petersen et al., 1988); Balloon Analogue Risk Task-Youth Version; BART-Y; Lejuez et al., 2003); Race categories were dummy coded as yes=1, no=0;

* $p < 0.05$,

** $p < 0.01$;

*** $p < 0.001$.