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Delay Discounting Mediates Parent-Adolescent Relationship Quality and Risky Sexual Behavior for Low Self-Control Adolescents

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Abstract

Parent-adolescent relationship quality and delay discounting may play important roles in adolescents' sexual decision making processes, and levels of self-control during adolescence could act as a buffer within these factors. This longitudinal study included 219 adolescent (55% male; mean age = 12.66 years at Wave 1; mean age = 15.10 years at Wave 2) and primary caregiver dyads. Structural equation modeling was utilized to determine whether delay discounting mediated the association between parent-adolescent relationship quality and adolescents' risky sexual behavior and how this mediated association may differ between those with high versus low self-control. The results revealed parent-adolescent relationship quality plays a role in the development of risky sexual behavior indirectly through levels of delay discounting, but only for adolescents with low self-control. These findings could inform sex education policies and health prevention programs that address adolescent risky sexual behavior.

Keywords

delay discounting; parent-adolescent relationship quality; risky sexual behavior; adolescence; self-control

Introduction

Risky sexual behaviors commonly emerge and peak during adolescence persisting into young adulthood (Fergus, Zimmerman, & Caldwell, 2007; Mahalik et al., 2013). These behaviors can include, but are not limited to, early sexual debut (Beadnell et al., 2005) or having sex without a condom (Levy, Sherritt, Gabrielli, Shrier, & Knight, 2009). Consequently, risky sexual behavior not only places adolescents at increased risk for

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Authors' Contributions

R.E.K conceived of the study, participated in its design and interpretation of the data, performed the statistical analysis, and drafted the manuscript. C.H. participated in the design and interpretation of the data. J.P.F participated in the coordination of the study and performed measurements. J. K. conceived of the study, participated in its design and coordination, supervised the statistical analysis, and helped to draft the manuscript. All authors approved the final version of the manuscript for submission.

Conflict of Interest

The authors declare that they have no conflict of interest.

negative outcomes such as sexually transmitted diseases (STDs), including HIV/AIDS (CDC, 2012a), but also leads to unplanned pregnancies (Bryan, Schmiede, & Magnan, 2012). For instance, analyses of national and international pregnancy and abortion rates from 2008 to 2011 revealed pregnancy rates among adolescent females ages 15–19 are higher in the U.S. (57 pregnancies per 1,000 females) compared to 20 other countries with 26% of these pregnancies ending in abortion (Sedgh, Finer, Bankole, Eilers, & Singh, 2015). Additionally, STDs (such as chlamydia, gonorrhea, and syphilis) and HIV acquired through risky sexual behaviors during adolescence and young adulthood, are a major public health concern in the United States. There are 19 million new infections every year with young people age 15 to 24 accounting for nearly half of new STDs even though they represent only a quarter of the sexually experienced population (Wilson, Wright, & Safrit, & Rudy, 2010). The serious health consequences associated with risky sexual behavior have prompted the need for more research that can enhance our ability to identify risk markers associated with these behaviors (Kohler, Manhart & Lafferty, 2008; Steinberg, 2008).

Although prior research has concentrated on identifying direct associations between the parent-adolescent relationship and risky sexual behavior (e.g., Parkes, Henderson, Wight, & Nixon, 2011; Price & Hyde, 2009), far less research has attempted to evaluate psychological processes, such as delay discounting, that explain why aspects of the parent-adolescent relationship may influence adolescent decision making involved in sexual behavior. The current study aims to fill this gap by examining whether delay discounting mediates the association between parent-adolescent relationship quality and risky sexual behavior. Further, given the increasing amount of research that suggests differences in child and adolescent self-control may greatly influence adult health and financial outcomes (e.g., Moffitt et al., 2011), we also sought to examine how this mediated association differs for individuals high and low self-control.

Parent-Adolescent Relationship Quality

The relationship between a parent and adolescent is crucial for healthy adolescent development (Simpson, 2001) and plays a key role in an adolescent's decision making process and subsequent choices in sexual behavior. Thus, several aspects of the parent-adolescent relationship are commonly studied in order to identify markers for risky sexual behaviors. The triad model of parenting is one way to conceptualize the core parenting practices and parent-child interactions that underlie the overarching system foundation of parent-adolescent relationship quality (Dishion & McMahon, 1998). Specifically, this model proposes that parent-adolescent relationship constructs such as parental monitoring and knowledge along with behavior management and motivation are “dynamically connected” and interact with but are hierarchically embedded under the foundation of parent-adolescent relationship quality. Given this conceptualization, increased relationship quality between the parent and adolescent can represent the product of interactions between connected parenting practices such as close monitoring of behavior and providing positive reinforcement in order to manage behavior.

Extant research suggests that the quality of the parent-adolescent relationship is an important determinant of risky sexual behavior (Markham et al., 2003; Miller, Benson, & Galbraith,

2001; Resnick et al., 1997). Indeed, increased parent-adolescent relationship quality, (i.e., closeness, trust, security, open communication), is linked to less overall risk taking behavior among adolescents even after controlling for parenting practices (e.g., Bronte-Tinkew, Moore, Capps, & Zaff, 2006). For instance, closeness, connectedness, and positive relationships with parents are associated with significant delaying effects (albeit small effects) for onset of sexual intercourse in adolescents (Parkes et al., 2011; Price & Hyde, 2009; Zimmer-Gembeck & Helfand, 2008) and more condom use over time by adolescents (Pingel et al., 2012). Additionally, adolescents' reports of relationship satisfaction with their parents are associated with lower probability of initiating sex and higher probability of using birth control (Dittus & Jaccard, 2001). Other dimensions of parenting that interact to influence the quality of the parent-adolescent relationship, such as increased parental monitoring or perceived parental disapproval of sex (i.e., communication about norms and values regarding sex), also show small but delaying effects for onset of sexual intercourse (Buhi & Goodson, 2007; Zimmer-Gembeck & Helfand, 2008). In contrast, there is very little support for the claim that indicators of parental control or coercion influence risky sexual behavior among adolescents (Buhi & Goodson, 2007; Zimmer-Gembeck & Helfand, 2008).

These direct associations between parenting practices and adolescent sexual behaviors are well documented, but less is known about mediating processes through which parent-adolescent relationship quality may indirectly influence the decision making associated with risky sexual behavior. We propose that the association between the parent-adolescent relationship and risky sexual behavior may exist in part because the quality of the parent-adolescent relationship influences impulsive decision making in the form of delay discounting, a core component of the broader construct of trait impulsivity (de Wit, 2009).

Delay Discounting

Delay discounting occurs when an individual places less value on a reward due to a delay in receipt of the reward (Ainslie, 1975; Rachlin, Raineri, & Cross, 1991) and is believed to underlie impulsive decision making (Madden & Bickel, 2010). The delay discounting process typically presents a participant with two choices, a smaller immediate reward and a larger delayed reward. Unwillingness to forego small, short-term rewards in order to obtain larger delayed rewards is suggestive of higher levels of impulsive decision making and thus more maladaptive behavior. Indeed, prior research supports a link between delay discounting and various health risk behaviors, including risky sexual behaviors such as unsafe sexual activity or sexual infidelity (e.g., Daugherty & Brase, 2010; Reimers, Maylor, Stewart, & Chater, 2009) among both young adult and adult populations. However, only one study has examined the association between delay discounting and risky sexual behavior using a sample that included adolescents recruited from health clinics (Chesson et al., 2006). This study found no significant associations between discounting rates and risky sexual behavior when the adolescent sample was examined in isolation. However, the nature of this adolescent sample recruited from the health clinics is unclear; thus it is difficult to determine whether the findings can be generalized to community samples of adolescents.

While it is generally understood that delay discounting is an important predictor of risk taking behavior (Madden & Bickel, 2010), less is known about what contextual or interpersonal factors may influence or predict individual differences in delay discounting. Significant predictors of adolescent delay discounting identified in prior studies are limited to intraindividual factors such as working memory and religiousness (Bickel, Yi, Landes, Hill, & Baxter, 2011; Kim-Spoon, McCullough, Bickel, Farley, & Longo, 2015a). As such, environmental factors that could influence delay discounting are not well explored. Heritability research has demonstrated that genes cannot entirely explain delay discounting behavior (Anokhin, Golosheykin, Grant, & Heath, 2011), thus pointing towards environmental factors such as the parent-adolescent relationship that serves as a major influence during child and adolescent development (Euser, Evans, Greaves-Lord, Huizink, & Franken, 2013; Wolff & Crockett, 2011). This assertion is supported by a theoretical framework proposed by Bowlby (1969) that emphasizes the importance of the parent-adolescent relationship for optimal developmental outcomes including autonomy, successful social relationships, and impulse control (Erickson, Sroufe, & Egeland, 1985). One recent study conducted in a sample of adolescents found no evidence for an association between parental knowledge and delay discounting (Farley & Kim-Spoon, 2015). However, whether the broader construct of parent-adolescent relationship (that subsumes specific parenting practices such as parental knowledge) may affect risk-taking behavior indirectly through its influence on delay discounting (or impulsive decision-making processes) remains unclear.

It is evident from previous work in child populations that parenting constructs are linked to delay of gratification (Mischel & Ebbesen, 1970), which is a connected but distinct construct from delay discounting (Reynolds & Schiffbauer, 2005). Specifically, delay of gratification paradigms usually involve a single choice between an immediate and delayed reward, whereas delay discounting paradigms often involve multiple trials and vary the delay and reward amounts in order to determine an overall discount rate. Findings from this body of research provide support for the importance of parent-child interactions in toddlers' ability to delay gratification (e.g., Sethi, Mischel, Aber, Shoda, & Rodriguez, 2000). Specifically, longitudinal research on children followed from infancy to age 6 suggests attachment quality within the parent-child relationship helps to mold a child's decision-making process, including delay of rewards (Jacobsen, Huss, Fendrich, Kruesi, & Ziegenhain, 1997). Similarly, other prospective research indicates parenting dimensions such as maternal responsiveness and positive parent-child interactions at age 2 predicts increases in delay times at age 6 (Olson, Bates, & Bayles, 1990). In contrast, indicators of restrictive parenting strategies (e.g., limit setting or power-based styles) measured at age 3 are associated with below average delay times at age 6 (Houck & Lecuyer-Maus, 2004).

Taken together, prior heritability and developmental research provide a foundation for exploring how the parent-adolescent relationship may influence individual differences in impulsive decision making in the form of delay discounting. In turn, delay discounting may be one pathway that helps to explain how the parent-adolescent relationship influences risky sexual behavior. That is, impulsive decision making (delay discounting) may be one process through which parent-adolescent relationship quality impacts choices related to risky sexual behavior. To date, only one study has examined the mediating role of delay discounting between family environment and risk-taking behavior in a sample of undergraduate students

(Hill, Jenkins, & Farmer, 2008) and found no evidence for mediation of delay discounting. However, this study did not focus on the role of parenting or parent-adolescent relationship quality, and the findings have yet to be replicated in samples of adolescents.

Neurodevelopmental processes that underlie delay discounting also have implications for risk-taking behaviors, such as risky sexual behavior, in adolescence. In particular, neural correlates of control have been posited to interact with neural mechanisms of valuation (e.g., regions of the striatum) and to contribute to impulse control difficulties in adolescence (Casey, Getz, & Galvan, 2008). This control network includes regions of the prefrontal cortex that undergo maturation, including increased myelination and experience-dependent synaptogenesis and pruning, throughout adolescence and into early adulthood (Paus, 2005). Indeed, risk-taking in adolescence has been hypothesized to be derived in part from distinct developmental trajectories of two neural systems: a frontostriatal system underlying the assessment of value associated with rewarding stimuli, and a separate prefrontal system exerting control over the pursuit of rewards (Casey et al., 2008; Steinberg, 2010). This neurobiological model of adolescent development proposes that an imbalance in the development of these two neural systems is at the core of risky behaviors in adolescence. As such, dramatic and rapid increases in reward sensitivity during adolescence in conjunction with impaired development in control contribute to heightened rates of risk-taking (Steinberg, 2008; Wahlstrom, White, & Luciana, 2010). From this theoretical perspective, it is expected that adolescents with higher delay discounting (i.e., high impulsivity) are more vulnerable to sexual risk-taking compared to those with lower delay discounting. However, this vulnerability may be even more pronounced when combined with lower levels of self-control during adolescence, as adolescents may not be able to sufficiently regulate the prefrontal regions associated with control in order to inhibit impulsive reward drives such as sexual arousal.

Self-Control

Self-control can be defined as an individual's ability to change or inhibit dominant impulses that may be undesirable in order to refrain from acting on these impulses. Self-control regulates cognition, emotions, and behavior (Carver & Scheier, 1998; Tangney, Baumeister, & Boone, 2004) and is separate and only modestly related to measures of behavioral impulsivity (Reynolds, Penfold, & Patak, 2008). Research suggests that self-control may serve as a protective factor and is associated with better psychological adjustment and positive life outcomes, especially during adolescence (for review see de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). In contrast, adolescents with low levels of self-control show higher levels of risk-taking behavior and, as such, low self-control has been linked to later risky sexual behavior in adolescents and young adults (Gailliot & Baumeister, 2007; Quinn & Fromme, 2010; Raffaelli & Crockett, 2003).

Self-control theory (Gottfredson & Hirschi, 1990) emphasizes the importance of self-control as the root cause of delinquent and risk-taking behaviors; however, there is less emphasis in the literature on self-control as a moderating factor even though processes involved may buffer the impact of adverse experiences during development (Masten & Powell, 2003). Available research suggests that self-control may act as a buffering factor or moderate the

relationship between environmental or individual risk factors and risk-taking behaviors including substance use (Wills, Ainette, Stoolmiller, Gibbons, & Shinar, 2008) and antisocial behavior (Gardner, Dishion, & Connell, 2008). Neurobiological models of adolescent brain development are also consistent with self-control as a buffering factor in that the impaired development of self-control (i.e., cognitive control) is associated with heightened risk taking in the context of high reward sensitivity (see Kahn, King-Casas, Deater-Deckard, Chiu, & Kim-Spoon, 2015 for a review). Given that youth who have stronger self-control may be better able to resist or control their sexual behavior in the presence of other risk factors, we propose that self-control during adolescence will act as a buffer against the detrimental effects of risk factors such as poor parent-adolescent relationship quality or high impulsive decision making on risky sexual behavior among adolescents.

Current Study and Hypotheses

In the current study, we used a prospective longitudinal design to test whether early parent-adolescent relationship quality is related to later risky sexual behavior through delay discounting and how self-control may moderate this mediated association. We hypothesized that delay discounting would mediate the relationship between parent-adolescent relationship quality and risky sexual behavior; thus lower levels of parent-adolescent relationship quality at Wave 1 would predict higher levels of risky sexual behavior at Wave 2 indirectly through high rates of discounting at Wave 2. We also hypothesized that the mediated relations would differ for adolescents with low versus high self-control. In this case, the detrimental effects of low parent-adolescent relationship quality via high delay discounting would be amplified for those adolescents low on self-control compared to those high on self-control.

Method

Participants

Participants were part of a longitudinal study conducting research on youth's healthy development and were recruited from an understudied Appalachian population. At Wave 1, participants included 357 adolescents between 10 and 17 years ($M = 13.03$, $SD = 1.91$). Approximately two years later, 220 adolescents between the ages of 12 and 18 years participated at Wave 2. At Wave 1, 91.6% of the adolescents identified as Caucasian, 6.1% African American, 1.5% Hispanic, and 0.8% other. However, due to the small amount of non-Caucasian participants, race was dichotomized into Caucasian (91.6%) and non-Caucasian (8.4%). For Wave 2, those who had already attended their first year of college were aged out of the study and were not asked to complete the study a second time. There were 137 participants that did not return for Wave 2 for reasons including: child not invited back due to age or other issues ($n = 24$), too busy ($n = 8$), moved away ($n = 12$), unable to reach ($n = 86$), child not interested ($n = 6$), and child death ($n = 1$). For the current analyses, one additional participant was excluded due to missing data points on all outcome variables, leaving a final sample of 219 adolescents (55% male) ranging in age from 10 to 16 ($M = 12.66$, $SD = 1.51$) at Wave 1 and 12 to 18 years ($M = 15.10$, $SD = 1.51$) at Wave 2. The majority of the participants (87.2%) were 16 years of age and under.

We performed multivariate general linear modeling (GLM) analyses to determine if those 220 adolescents who participated in both waves differed from the 137 adolescents who did not participate in both waves of the study with regard to demographic variables at Wave 1. Results indicated that adolescents completing both waves of the study had a higher average family income ($p < .001$) and were younger ($p < .001$), but the two groups had similar race ($p = .11$) and gender compositions ($p = .92$). However, the effect sizes of the attrition effects were small ($\eta^2 = .04$ for income and $\eta^2 = .06$ for age). The greater likelihood of younger participants remaining in the sample is most likely due to the aging out of older participants that were intentionally excluded. Furthermore, the final sample still had the family income level that was representative of the Southwestern Virginia region in 2007 when the data were collected (U.S. Census Bureau, 2007).

Primary caregivers (parents, hereafter) also participated in the study at both waves. Parents self-selected their specific role as a caregiver from the following choices: “Mother”, “Father”, “Grandmother”, “Grandfather”, “Foster parent”, and “Other”. Parents were 81–84% mothers, 13–14% fathers, and 3–5% grandmothers at Wave 1 and Wave 2, respectively. Parent ages ranged from 28 to 71 years ($M = 45.92$, $SD = 6.47$) at Wave 2. Parents reported their race as 91% Caucasian with the remaining 9% reporting their race as African American, Hispanic, or other races. Family income ranged from no source of income to earning more than \$200,000 a year. The mean family income was between \$35,000 and \$49,000 a year in both waves.

Measures

Parent-Adolescent Relationship Quality at Wave 1—The Inventory of Parent and Peer Attachment 12-item short version (IPPA; Raja, McGee, & Stanton, 1992) was administered to adolescents to assess self-reported level of parent-adolescent attachment and perceived relationship quality with parents. The items are rated on a 5-point Likert scale ranging from 1 (*Almost never or never true*) to 5 (*Always or almost always true*). Higher scores indicate higher levels of relationship quality. The IPPA consists of three subscales (communication, trust, and alienation) and statements such as “I tell my parent about my problems and troubles” (communication), “My parent accepts me as I am” (trust), and “I don’t get much attention at home” (alienation). For the current sample, internal consistency was $\alpha = .69$, $.73$, and $.85$ for the communication, trust, and alienation scale respectively. Parent-adolescent relationship quality was included in the model as a latent variable comprised of the three subscales (the alienation subscale score was inverse coded; $r = .53$ to $.66$ among the three items, $p < .001$).

Delay Discounting at Wave 2—The Monetary Choice Questionnaire (MCQ; Kirby, Petry, & Bickel, 1999) was used to measure impulsive decision making in the form of delay discounting. Each question asked the respondent to choose between a smaller, sooner reward and a larger, delayed reward. From these responses, we calculated a discounting rate (k), a parameter that reflected the degree to which future rewards are diminished in value as a function of the delay. The choice of smaller, sooner monetary rewards over larger, delayed rewards implied varying degrees of delay discounting (e.g., “Would you prefer \$27 today, or \$50 in 21 days?”). Higher discounting rates reflect higher levels of impulsive decision

making. To make the tasks more realistic, all participants were given a 1-in-30 chance of receiving one of the rewards they chose over the 27 trials. Values for k , the hyperbolic control parameter, were log-transformed for small, medium, and large rewards due to the non-normal distribution (i.e., skewness values greater than 3 and kurtosis greater than 10, Kline, 2011). In the current analyses, delay discounting was a latent variable comprised of k values for small, medium, and large rewards ($r = .71$ to $.77$ among the three items, $p < .001$).

Self-Control at Wave 2—The Brief Self-Control Scale (BSCS; Tangney et al., 2004) was administered to both parents and adolescents. The BSCS is a 13-item scale that measures five domains of self-control: controlling thoughts, controlling emotions, controlling impulses, regulating behavior/performance, and habit-breaking (e.g., “Sometimes I can’t stop myself from doing something, even if I know it is wrong.”). Participants rated how typical each statement is for them (self-report) or their adolescent (parent report) with responses ranging from 1 (*Not at all*) to 5 (*Very Much*) in order to provide a multi-informant report. A composite score of self-control was generated by averaging parent and adolescent reports ($r = .34$, $p < .001$). For the current study internal consistency was $\alpha = .89$ and $.83$ for parent and adolescent report respectively.

Risky Sexual Behaviors at Wave 2—To assess HIV/STD-relevant risky sexual behaviors, adolescents completed questions adopted from the Youth Risk Behavior Survey (CDC, 2012a) regarding: condom use at last intercourse with response choices of 1 (*Never had sex*), 2 (*Yes*), 3 (*No*) and age of sexual debut or initiation with response choices of 1 (*8 years old or younger*), 2 (*9 to 10 years old*), 3 (*11 to 12 years old*), 4 (*13 to 14 years old*), 5 (*15 to 16 years old*), 6 (*17 years older or older*) and 7 (*I have never had sexual intercourse*). These specific items were chosen because they are widely used to assess key elements of sexual risk for exposure to HIV/STDs (CDC, 2012b; Saewyc et al., 2006). A latent variable of risky sexual behavior severity was created and comprised of standardized scores from condom use and age of sexual debut (inverse coded; $r = .83$, $p < .001$).

Procedures

For Wave 1 of the study, participants were recruited from small cities, towns, and rural areas in southwest Virginia via letters using address lists purchased from contact companies, email announcements, flyers, notices placed on the internet, or snowball sampling (word-of-mouth). For Wave 2, participants were contacted via letters in the mail and/or by phone using contact information gathered during the first wave of the study. At both waves, adolescents and their parents were interviewed privately and simultaneously, and both received monetary compensation. The current study was approved by the university’s Institutional Review Board.

Analytic Strategy

For all study variables, descriptive analyses were conducted to determine normality of distributions and univariate and multivariate outliers. Skewness and kurtosis were examined for all variable distributions with acceptable levels of skewness to be less than 3 and acceptable levels of kurtosis less than 10 (Kline, 2011). In addition, GLM was used to identify any multivariate predictors of the endogenous variables among the demographic

variables and any variables with significant Wilk's Lambda coefficients were used as covariates. A two group mediation model was estimated and analyzed with structural equation modeling (SEM) and was conducted in AMOS version 22. Overall model fit indices were determined by χ^2 value, degrees of freedom, corresponding p -value, Root Mean Square Error of Approximation (RMSEA), and Confirmatory Fit Index (CFI). An RMSEA value less than .06 and a CFI value equal to or greater than .95 were considered a good fit (Hu & Bentler, 1999). A series of models were tested comparing low and high self-control groups to determine the moderating effects of self-control in the link between parent-adolescent relationship quality and adolescent risky sexual behaviors. Based on computational instruments designed by Preacher and Coffman (2006), our sample size allowed for sufficient power (.80) to test a covariance structure using RMSEA (MacCallum, Browne, & Sugawara, 1996).

We formed low self-control (below median of the self-control scores, $n = 109$) versus high self-control (above median, $n = 110$) groups based on each individual's self-control composites averaged between adolescent self-reported and parent-reported scores. The low/high self-control groups were formed for testing moderating effects of *quantitative* differences in self-control using a multiple group SEM; they may not represent clinically meaningful or *qualitatively* different sub-groups. These two groups did not differ significantly on either the outcome or the mediator: sexual risk variables [age of sexual debut: $t(217) = 1.01, p = .31$; condom use: $t(217) = 1.40, p = .16$]; delay discounting variables [small: $t(217) = 0.48, p = .63$; medium: $t(217) = 1.77, p = .08$; large: $t(217) = 1.78, p = .08$]. A configural invariance model was fit first in which all parameters were freely estimated across the two groups (configural invariance model) and used in comparisons to the subsequent models. In subsequent models, we imposed equality constraints hierarchically to test numeric invariance between the low and high self-control groups with respect to the direct effect of parent-adolescent relationship quality on risky sexual behaviors (equal direct effect model), the effects of parent-adolescent relationship quality on adolescent delay discounting (equal parent-adolescent relationship effect model), and the effects of adolescent delay discounting on risky sexual behaviors (equal delay discounting effect model). An α level of .05 was used for all statistical tests and significance of direct and indirect effects was tested using bias-corrected bootstrap confidence intervals (Cheung & Lau, 2007; Preacher & Hayes, 2008) which has been shown to have more power than the often-used Delta method in smaller sample sizes (Preacher & Hayes, 2008).

Results

Descriptive statistics and correlations for all study variables appear in Table 1. By Wave 2, 17% of adolescents reported to have engaged in sexual intercourse. This level of sexual initiation is comparable to rates reported by Liu and colleagues (2015) from the National Health and Nutrition Examination Surveys (NHANES). For the participants who had engaged in sexual activity, age of initiation began at 11 to 12 years old, and while most sexual encounters were reported to be protected, 14% indicated having sex without a condom. This is consistent with data from the Youth Risk Behavior Survey indicating 14.1% of 10th graders (approximately 15–16 years of age) did not use any preventative methods during sexual intercourse to protect against pregnancy (CDC, 2014). Five cases were

identified as multivariate outliers due to significant Mahalanobis Distances ($p < .001$); however, the pattern of results did not change when testing the model with and without the identified cases. Therefore, these outliers were not excluded from the analyses. Multivariate general linear modeling analyses with potential demographic covariates at Wave 2 (age, gender, income, and race) predicting the risky sex outcome variable revealed age at Wave 2 was consistently associated with both sexual risk-taking variables ($p < .001$). Thus age at Wave 2 was included in the path analysis as a covariate.

In order to test the two group mediation model, a series of models were tested and model fit comparisons are presented in Table 2. For the first model (configural invariance model) including the direct effect of parent-adolescent relationship quality on risky sexual behavior, model fit was good $\chi^2(48) = 53.32, p = .28$; CFI = .99; RMSEA = .02. Then, we imposed an equality constraint between the low and high self-control groups with respect to the direct effect of parent-adolescent relationship quality on risky sexual behavior (the equal direct effect model). Model fit was good, $\chi^2(49) = 54.57, p = .27$; CFI = .99; RMSEA = .02 and imposing the equality constraint between high and low self-control groups did not significantly degrade model fit ($\chi^2 = 1.25, df = 1, p = .26$), indicating that the direct effects of parent-adolescent relationship quality were comparable between the high vs. low self-control groups.

Next, for the second model, we imposed an equality constraint between the low and high self-control groups with respect to the effects of parent-adolescent relationship quality on adolescent delay discounting (the equal parent-adolescent relationship effect model). Model fit was good, $\chi^2(50) = 54.60, p = .30$; CFI = 1.0; RMSEA = .02 and imposing the equality constraint between high and low self-control groups for this path did not significantly degrade model fit ($\chi^2 = 0.03, df = 1, p = .87$). Thus the finding indicated that the association between parent-adolescent relationship quality and delay discounting were comparable between the high vs. low self-control groups.

For the third model (equal delay discounting effect model), we imposed an additional equality constraint between the low and high self-control groups with respect to the effects of adolescent delay discounting on risky sexual behaviors. Model fit was good, $\chi^2(51) = 59.92, p = .18$; CFI = .99; RMSEA = .03, however, imposing this equality constraint for the effects of adolescent delay discounting on risky sexual behaviors significantly degraded model fit ($\chi^2 = 5.32, df = 1, p = .02$). This outcome suggests that the magnitude of the association between delay discounting and risky sexual behavior differed significantly between the high vs. low self-control groups. Thus, the equal parent-adolescent relationship effect model was chosen as the best-fitting model.

Figure 1 shows standardized estimates for the final (best-fitting) model. For both high and low self-control groups, lower parent-adolescent relationship quality was associated with higher delay discounting ($b = -.48, SE = .23, p = .04$). For the low self-control group, higher delay discounting was related to higher levels of risky sexual behavior ($b = .20, SE = .08, p = .01$), whereas for the high self-control group, there was no association between delay discounting and risky sexual behavior ($b = -.01, SE = .05, p = .88$). The direct effects of parent-adolescent relationship quality on risky sexual behavior were not significant ($b = -$

09, $SE = .14$, $p = .54$) in both high and low self-control groups. Mediation effect test using Bias Corrected Bootstrapping indicated that the estimated indirect effect of parent-adolescent relationship quality on risky sexual behavior via the intermediate effect on delay discounting was significant (95% CI = $-.317$ to $-.008$) for the low self-control group, whereas the indirect effect was not significant (95% CI = $-.056$ to $.063$) for the high self-control group.

Discussion

Adolescence is a time that affords plasticity and can lead to positive outcomes, but it is also a time when behavioral patterns become more entrenched and can contribute to the development of harmful lifestyle patterns (Crockett & Crouter, 2014). This vulnerable period of adolescence is also understood to have a more protracted course than in past generations and highly relevant for determining health outcomes (Steinberg, 2014). Indeed, risky sexual behaviors such as early sexual debut or having sex without a condom often emerge during adolescence (Fergus, Zimmerman, & Caldwell, 2007), and the consequences of this behavior, such as STDs and HIV, represent a major public health concern in the United States. Extant research indicates the quality of the parent-adolescent relationship is an important determinant of risky sexual behavior (Markham et al., 2003; Miller et al., 2001; Resnick et al., 1997). Although these direct associations are well documented, less is known about the mediating processes, such as delay discounting, that explain how parent-adolescent relationship quality may influence the decision making processes associated with risky sexual behavior. Such mediating processes could be treated as the proximal process at which prevention/intervention efforts can be targeted. Additionally, research suggests that self-control may serve as a protective factor against high levels of risk-taking behavior (de Ridder et al., 2012). The current longitudinal study examined whether levels of delay discounting mediate the association between parent-adolescent relationship quality and adolescents' risky sexual behavior and how this mediated association may differ depending on levels of adolescents' self-control.

Our findings revealed that delay discounting serves as a mediator in the association between parent-adolescent relationship quality and later risky sexual behavior but only for those adolescents who demonstrated low levels of self-control. In other words, the quality of the parent-adolescent relationship does not act as a direct influence, but instead works indirectly through impulsive decision making processes to impact choices related to risky sexual behavior for adolescents with low self-control. Importantly, nested model comparisons revealed that the effect of parent-adolescent relationship quality on delay discounting did not differ between the low and high self-control groups; however, the effect of delay discounting on risky sexual behavior was significant only for the low self-control group.

Our results suggest that, regardless of the level of self-control, parent-adolescent relationship quality is predictive of impulsive decision making in the form of delay discounting. More specifically, we found that lower levels of relationship quality between parents and adolescents were associated with higher levels of delay discounting among adolescents two years later. In line with these results, a recent review by Odum (2011) proposes that delay discounting can be considered a personality trait and is thus influenced by both heredity and

environment. Our findings present the first evidence suggesting that the quality of the parent-adolescent relationship may be one influential environmental factor involved in the development of delay discounting. These results contrast to a degree with findings by Farley and Kim-Spoon (2015) who did not find an association between parental knowledge (as a measure of parental monitoring) and delay discounting among adolescents, thus begging the question – what is it specifically about parent-adolescent relationship quality that influences delay discounting? The triad model of parenting would suggest that parent-adolescent relationship quality represents the foundation of a system of parenting practices that includes parental knowledge (Dishion & McMahon, 1998). That is, parental knowledge or monitoring is one parenting construct (along with behavior management and motivation) hierarchically embedded within the parent-adolescent relationship and is seen to interact with the foundational component of relationship quality. Therefore, although these parenting constructs are dynamically connected and are thus highly correlated with one another (Patterson et al., 1992), parental knowledge is seen as a subordinate process to the hierarchical superior construct of relationship quality. Based on this theory, we speculate that parent-adolescent relationship quality serves as a more robust predictor of delay discounting because it represents a higher-order system encompassing multiple interactions within the process of parenting, whereas parental knowledge represents just one process within the complex system of parenting practices.

To our knowledge, this study is also the first to provide evidence for a link between delay discounting and risky sexual behavior among an adolescent population. To date, only one published study has examined the association between delay discounting and risky sexual behavior in a sample that included adolescents (Chesson et al., 2006), and the results were non-significant when the adolescent sample was examined separately from adult populations. The discrepancy between our findings and the findings by Chesson and colleagues may be, in part, due to a number of differences in participant characteristics (clinic vs. community) and methodological approaches (chi-square tests based on a categorical variable of delay discounting groups vs. structural equation modeling using a continuous latent variable of delay discounting). But more importantly, our findings emphasize that the effects of delay discounting on risky sexual behaviors are contingent upon the individual's self-control ability. That is, bivariate associations between delay discounting on risky sexual behaviors may not be significant, but it is when one's delay discounting cannot be regulated by self-control that delay discounting matters for risky sexual behaviors. Considering the pernicious effects of these types of behaviors and the potential for adolescents to disproportionately contribute to the increasing rates of sexually transmitted infections (CDC, 2011), there is a continued need for research in this area in order to gain further insight into risky sexual behavior. The current results add uniquely to the literature by providing evidence that delay discounting may be an important construct that predicts later risky sexual behavior among adolescents, particularly in those with low levels of self-control.

The moderating role of self-control on the association between delay discounting and risky sexual behavior found in the current study is consistent with human neuroimaging studies implying that a cognitive control network interacts with the valuation of rewards to determine risky behaviors during adolescence (Bickel et al., 2007; Casey et al., 2008; Kahn

et al., 2015). Recent empirical work demonstrates support for this interaction by showing a significant moderating effect of cognitive control on the link between reward and risk processing and health risk behaviors in adolescents at both the behavioral and neural levels (Kim-Spoon, Holmes, & Deater-Deckard, 2015; Kim-Spoon et al., 2015b). Our findings add to this literature by illustrating a statistical interaction between self-control and impulsive decision making in the prediction of adolescent risky sexual behavior suggesting a protective role of self-control against the development of risk-taking behavior. It is widely believed that the product of the imbalance between two neural networks involved in reward processing vs. control may be at the root of risk-taking behavior in adolescence (Somerville, Jones, & Casey, 2010); therefore, it is critical for the development of effective intervention and prevention programs that future research continue to explore the developmental trajectory of self-control and how this network interacts with the reward and risk system to contribute to risk-taking behavior in adolescence.

While research suggests that self-control is a highly heritable factor that is relatively stable across childhood (e.g., Coyne & Wright, 2014), there is evidence that levels of self-control can improve across the lifespan (Moffitt et al., 2011). In fact, self-control is thought to resemble a muscle in that it is dependent on limited energy resources and will thus weaken through repeated use during a specific time period (Baumeister, Heatherton, & Tice, 1994). However, at the same time, self-control can improve and be strengthened over extended periods of time through regular exercise or practice (Baumeister, Gailliot, DeWall, & Oaten, 2006). Programs aimed at improving self-control during childhood and adolescence have been developed and show promising results (e.g., Berkman, Graham, & Fisher, 2012; Greenberg, 2006); understanding the buffering role of self-control in the development of risky sexual behavior may serve to enhance the utility of these intervention and prevention efforts. These efforts are especially relevant during adolescence given this period of development is often seen as a “window of opportunity” for intervention and prevention programs (Crockett & Crouter, 2014).

The indirect role of the parent-adolescent relationship on later sexual risk-taking behavior found in low self-control adolescents is also particularly important to take into account given that low self-control during adolescence can lead to poor lifestyle outcomes in adulthood. Notably, recent research demonstrated that adolescents with low self-control were more likely to be caught in “snares” that resulted in a greater likelihood they would be trapped in a harmful lifestyle during adulthood (Moffitt et al., 2011). In particular, adolescents with low self-control were more likely to become unplanned teenage parents, begin smoking at an early age, and even dropout of school. More interesting, however, was that these particularly poor outcomes during adolescence ultimately affected important lifestyle outcomes in adulthood in an additive way (i.e., snares) such as physical health, wealth, and adult criminal convictions (Moffitt et al., 2011). Such additive effects of risky behaviors are in line with research showing risky behaviors undertaken during adolescence tend to co-occur with one another. For example, both cross-sectional (Neal & Fromme, 2007) and prospective research (Shorey et al., 2015) have demonstrated that risky sexual behavior is associated with other harmful risk-taking behaviors such as substance use. Risky sexual behavior has also been linked to later delinquency (Armour & Haynie, 2007). Also illustrating the importance of self-control, it is believed that most adolescents have the capacity to understand the risks or

negative consequences associated with sexual activity; however, their lack of experience in cognitive regulation specific to sexual behavior may be limited and affect their decision making process in negative ways (Dahl, 2004). Taken together, these findings imply that self-control is an important individual characteristic that can have enduring effects on developmental outcomes through adolescence into adulthood and developing programs to enhance self-control may have considerable impacts across several domains of life.

The current findings should be interpreted in the context of study limitations. First, some of the measures relied solely on single informants and self-report, thus increasing the possibility of method bias inflating relations found among variables. Future studies could benefit from involving multiple informants and methods to reduce potential method bias. Relatedly, the primary caregivers in our sample were primarily mothers. It is worth mentioning that the quality of the parent-adolescent relationship may differ between maternal and paternal caregivers for an adolescent, and ultimately these potentially unique relationships may have differential impacts on delay discounting and risky sexual behavior in adolescents. As such, our findings should be considered within the limited context of primarily maternal caregivers, and future research warrants testing whether these effects would replicate for paternal caregivers. In addition, future work should continue to explore whether maternal and paternal relationships may differ between male and female adolescents and differentially influence their involvement in risky sexual behavior. Second, although the prospective nature of the current study helps to aid in our interpretation of mediation effects, our longitudinal design was limited by using only two-wave data, which could contribute to bias in estimating mediation effects (Cole & Maxwell, 2003). It is also important to note that causality in relations could not be verified based on our correlational data. The mediation effects found in this study warrant further replications using multiple-wave data. Third, although there was attrition over the course of the study, the attrition analyses demonstrated small effect sizes of variables that differed between participants included in the analyses and those who were excluded; thus it does not appear to compromise the integrity of the results. Fourth, the relative homogeneity of our sample with regards to race should also be taken into consideration. While the population in the present study was not highly diverse, the sample composition is typical for the Appalachian area in which it was collected (U.S. Census Bureau, 2011). Additionally, this rural area is understudied and may be considered a unique contribution in the adolescent literature on sexual risk taking behavior within this population. Nevertheless, future studies may benefit from examining the links between parent-adolescent relationship quality and sexual risk-taking behavior among more racially diverse populations to broaden generalizability of the findings. Finally, the current study utilized a community sample where mean levels of sexual risk-taking were likely lower than those potentially found in high-risk or clinical samples. Although this may limit the generalizability of our findings to typically developing populations, understanding the links between these constructs in a normative population is important and may contribute to wide-ranging public policy standards and interventions to combat risky sexual behavior among adolescents.

Conclusion

The results from the current study contribute to a growing body of research on the development of risky sexual behavior among adolescents by examining mediating and moderating processes that could play a role in informing sex education policies and health prevention programs. Results from the current study build upon previous research by providing evidence to suggest that delay discounting serves as a mediator in the association between parent-adolescent relationship quality and later risky sexual behavior, particularly for those adolescents who demonstrated poor self-control. Specifically, our findings suggest that regardless of the level of self-control, parent-adolescent relationship quality predicts impulsive decision making in the form of delay discounting. However, only for low self-control adolescents did delay discounting influence engagement of risky sexual behavior. These findings highlight the importance of both contextual and personal characteristics for understanding risky sexual behavior and logically lead to applied implications. For instance, our results suggest that family or parent based interventions with a focus on improving parent-adolescent relationship quality may be useful for reducing risky sexual behavior among adolescents, especially among those with low self-control. Indeed, a recent finding suggests that engagement in the Family Check-Up (FCU) intervention indirectly influenced high risk sexual behavior through improved family relationship quality (Caruthers, Van Ryzin, & Dishion, 2014). However, incorporating proximal causes of risk taking behavior, such as delay discounting or self-control (Moffitt et al., 2011), may prove to be even more useful for intervention/prevention programs that serve to prevent or reduce risky sexual behavior. Finally, current evaluations also suggest the need for more sexual education programs to incorporate neuroscience research into existing curriculum, especially as it relates to brain regions responsible for impulsivity and self-control (Suleiman & Brindis, 2014). Clearly, there are already several promising avenues for reduction of risky sexual behavior among adolescents; the current study helps inform these avenues by highlighting how the parent-adolescent relationship, delay discounting, and self-control processes interface with one another to impact risky sexual behavior among adolescents.

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Figure 1.

Two group model of indirect effect of parent-adolescent relationship quality on risky sexual behavior through delay discounting moderated by self-control.

Note. Standardized parameter estimates are presented; estimates listed first are for the low self-control group; second for high self-control group. For clarity of presentation, coefficients related to the age covariate are not shown: age $\leftrightarrow$ parent-adolescent relationship quality: $r = -.14$ (.08), $p = .055$ / $r = -.18$ (.07), $p = .013$; age $\rightarrow$ risky sexual behavior: $b^* = .25$, $b = .15$ (.06), $p = .007$ / $b^* = .27$, $b = .13$ (.05), $p = .005$. Residual variance of condom use was fixed to 0 and delay discounting variables are log transformed. Comm = Communication, W1 = Wave 1, W2 = Wave 2. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 1

Descriptive Statistics and Correlations for All Study Variables

	1	2	3	4	5	6	7	8	<i>M</i> (<i>SD</i>)	Range
1. IPPA Communication									4.05 (0.71)	1.25 – 5.00
2. IPPA Trust	.66***								4.59 (0.56)	1.50 – 5.00
3. IPPA Alienation	.53***	.53***							4.06 (0.71)	2.25 – 5.00
4. DD (Small)	-.13*	-.05	.02						-4.41 (1.42)	-8.75 – -1.40
5. DD (Med)	-.18**	-.11	.01	.72***					-4.73 (1.56)	-8.75 – -1.39
6. DD (Large)	-.17**	-.14*	.00	.71***	.77***				-5.30 (1.54)	-8.75 – -1.39
7. BSCS: Self Control	.25***	.22***	.17*	-.05	-.14*	-.13			3.61 (0.55)	2.12 – 4.85
8. Age of Sexual Debut	-.14*	.16*	-.06	.16*	.15*	.12	-.07		6.63 (0.89)	3.00 – 7.00
9. Condom Use	-.13	.12	-.03	.17*	.15*	.14*	-.11	.83***	1.19 (0.45)	1.00 – 3.00

Note. DD = Delay Discounting; Med = Medium; BSCS = Brief Self Control Scale. Delay discounting variables are log transformed.

* *p* .05,

** *p* .01,

*** *p* .001.

Table 2

Model Fit Comparisons for SEM Analyses

Model Label	χ^2	df	p(exact)	CFI	RMSEA	p(close)	χ^2	df	p(d)
1. Configural invariance model	53.32	48	.277	.99	.02	.94			
2. Equal direct effect model	54.57	49	.271	.99	.02	.94	1.25	1	.263
3. Equal parent-adolescent relationship effect model	54.60	50	.304	1.0	.02	.95	0.03	1	.870
4. Equal delay discounting effect model	59.92	51	.184	.99	.03	.91	5.32	1	.021

Note. p(exact) = probability of an exact fit to the data; CFI = comparative -fit index; RMSEA = root mean square error of approximation; p(close) = probability of a close fit to the data; χ^2 = difference in likelihood ratio tests; df = difference in df; p(d) = probability of the difference tests. The best-fitting model is in bold face.