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**Environmental Unpredictability in Childhood is Associated with Anxious Romantic Attachment
and Intimate Partner Violence Perpetration**

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Abstract

Human life history theory describes how resources are allocated among conflicting life tasks, including tradeoffs concerning reproduction. The current research investigates the unique importance of environmental unpredictability in childhood in association with romantic attachment, and explores whether objective or subjective measures of environmental risk are more informative for testing life history hypotheses. We hypothesize that (1) unpredictability in childhood will be associated with greater anxious attachment, (2) anxious attachment will be associated with intimate partner violence (IPV) perpetration, and (3) anxious attachment will mediate the relationship between unpredictability in childhood and IPV perpetration. In two studies (total $n = 391$), participants in a heterosexual, romantic relationship completed self-report measures of childhood experiences, romantic attachment, and IPV perpetration. Study 1 provides support for Hypothesis 1. Hypothesis 1 is replicated only for men, but not women, in Study 2. Results of Study 2 provide support for Hypothesis 2 for men and women, whereas Hypothesis 3 was supported for men but not women. The findings contribute to the literature addressing the association of environmental risk in childhood on adult relationship outcomes.

Keywords: Life history theory; adult attachment; intimate partner violence; development; evolutionary psychology.

Environmental Unpredictability in Childhood is Associated with Anxious Romantic Attachment and Intimate Partner Violence Perpetration

Human life history theory describes how and why resources are allocated among conflicting life tasks (Sterns, 1992). Resources for life tasks are finite and can be allocated to somatic effort or reproductive effort, which include three fundamental life history trade-offs: *current versus future reproduction, mating effort versus parenting effort, and offspring quantity versus quality* (Kaplan & Gangestad, 2005). Life history theory describes the factors that affect resource allocation strategies and provides a framework for generating hypotheses about human sexual psychology and behavior, including conflict in romantic relationships. The current research aims to integrate life history theory and attachment theory to provide a developmental life history model of the proximate mechanisms underlying intimate partner violence perpetration.

The pattern of ways in which an individual allocates resources is described as his or her *life history strategy*, and can manifest in psychological and behavioral differences between individuals. Life history strategies fall along a continuum anchored by fast and slow (Griskevicius, Delton, et al., 2011; Promislow & Harvey, 1990) and each strategy is associated with distinct mating and parenting characteristics (Belsky, Steinberg, & Draper, 1991; Kaplan & Gangestad, 2005; Szepeswol, Simpson, Griskevicius, & Raby, 2015). Slower life history strategies reflect greater allocation of resources to parenting effort: reproduction occurs at a relatively later age and individuals have fewer, and more committed, romantic relationships. Faster life history strategies reflect greater allocation of resources to mating effort: reproduction occurs at a relatively earlier age and individuals have many, and unstable, romantic relationships (Egan et al., 2005).

Within-species variation in life history strategies are a product of interrelated processes of evolution and development (Ellis, Figueredo, Brumbach, & Scholmer, 2009). Over evolutionary history, selection favored phenotypes that successfully allocated resources and adjusted to environmental fluctuations (West-Eberhard, 2003). Organisms are responsive to local environmental conditions, which can result in developmental changes in psychology and behavior (West-Eberhard, 2003). For instance, in

unstable or harsh environments, a faster life history strategy marked by earlier reproduction might be more advantageous than a relatively slower life history strategy in which one delays reproduction because the probability of reproducing in the future is uncertain. In contrast, a stable and predictable environment might favor later reproduction, affording an individual more time to acquire resources to invest in future offspring. Recent evolutionary models of human life history (Ellis et al. 2009) focus on two features of environmental risk—harshness and unpredictability—that can produce phenotypic modifications associated with accelerated life history strategies.

Environmental harshness refers to morbidity-mortality rates in the local environment. In Western societies, environmental harshness can be indexed by socioeconomic status. Lower socioeconomic status is associated with higher rates of morbidity-mortality (Adler, Boyce, Chesney, Folkman, & Syme, 1993; Ellis et al., 2009). Higher mortality rates in the local environment, or correlates of higher mortality rates (i.e., lower socioeconomic status), are associated with accelerated life history strategies, as indicated by earlier age of reproduction (Low, Hazel, Parker, & Welch, 2008; Wilson & Daly, 1997), earlier sexual debut (Ellis et al., 2003), and lesser parental investment per child (Belsky, Schlomer, & Ellis, 2012).

Environmental unpredictability refers to stochastic changes in morbidity-mortality rates during an individual's lifetime, which also accelerate life history strategies (Ellis et al., 2009). A generalist strategy is unlikely to be effective in frequently changing environments, given the variety of possible ecological conditions. Thus, life history strategies are accelerated because an accurate estimation of morbidity-mortality risk cannot be waged. Environmental unpredictability is typically indexed by the number of parental transitions experienced in childhood (e.g., Simpson, Giskevicius, I-Chun Kou, Sung, & Collins, 2012). Greater environmental unpredictability is associated with earlier sexual debut, greater number of sexual partners, more aggressive and delinquent behavior (Belsky et al., 2012; Simpson et al., 2012), and lesser parental investment per child (Ellis et al., 2009).

Both environmental harshness and environmental unpredictability are uniquely associated with acceleration of life history strategies (Brumbach, Figueredo, & Ellis, 2009; Ellis et al., 2009). Individual susceptibility to risky environments, however, should also be considered when investigating effects on

life history strategies. Differential susceptibility theory posits that individual differences can cause individuals to respond differently even if exposed to equally risky environments (Belsky & Pluess, 2011). For example, in a series of studies, *subjective* perceptions of environmental harshness (i.e., perceptions of socioeconomic status) was a more reliable predictor of the way adults interpret their social environments than was *objective* environmental harshness (i.e., family income; Kraus, Piff, & Keltner, 2009). Research conducted to test the dimensions of the environmental risk model directly, however, has not previously assessed subjective and objective measures of environmental risk simultaneously. In a longitudinal study, Simpson et al. (2012) examined environmental harshness and environmental unpredictability as simultaneous predictors of adult sexual behavioral outcomes. However, an objective measure of environmental harshness was utilized (i.e., family income), but a subjective measure of environmental unpredictability was utilized (i.e., stress associated with transitions). One aim of the current research is to explore the influence of objective and subjective measures of harshness and unpredictability.

In early development, parental investment is a cue from which children receive information regarding risk in the local environment (Belsky, 1999; Chisholm, 1993; Ellis et al., 2009; Simpson & Belsky, 2008). In less harsh and more stable environments, parents are better able to invest in offspring, whereas parents raising children in harsh and unstable environments are less able to invest in offspring. One measure of childhood environmental unpredictability is the number of parental transitions a child experiences, including parental divorce or separation, the presence of genetically-unrelated adult males in the household, and parental occupational transitions. Several studies have assessed environmental harshness and unpredictability simultaneously (Albrecht & Teachman, 2003; Belsky et al., 2012; Capaldi, Crosby, & Stoolmiller, 1996; Simpson et al., 2012; Szepsenwol et al., 2015; Woodward, Fergusson, & Horwood, 2001; Wu, 1996; Wu & Martinson, 1993), documenting an associations between environmental unpredictability and accelerated life history strategies.

Environmental unpredictability may be particularly informative for explaining acceleration of human life history strategies (Ellis et al., 2009). Environmental unpredictability in early childhood more strongly predicts number of sexual partners in adolescence than does environmental harshness (Belsky et

al., 2012). Longitudinal research investigating the associations of environmental harshness and unpredictability in early and later childhood documents that subjective unpredictability in early childhood—but not environmental harshness in early childhood—predicts the number of sexual partners and aggressive behavior at age 23 years (Simpson et al., 2012). The results of this research are consistent with previous theory suggesting that early experiences, particularly before the age of five years, are important indicators of adult outcomes, signifying a faster life history strategy (Belsky et al., 1991).

Environmental unpredictability can affect parental investment which, in turn, may affect offspring functioning in childhood and perhaps into adulthood. Maternal care (Belsky et al., 2012) and paternal care (Szepeswol et al., 2015) is less supportive when raising children in unpredictable environments, specifically. Experimental research with bonnet macaque (*Mocaca radiate*) mothers demonstrates that environmental unpredictability (i.e., variation in food availability), but not environmental harshness (i.e., restricted food availability) predicts decreased maternal investment (Andrews & Rosenblum, 1994). The infants of mothers exposed to variable food availability received inconsistent parental investment and displayed more distress and less attachment security (i.e., greater anxiety) than infants in the other groups. Most telling, these infants continued to show anxious behavioral reactions four years after the initial resource availability experiment on their mothers (Andrews & Rosenblum, 1994). This research suggests that environmental unpredictability in early childhood may adversely affect the attachment system (i.e., hyperactivation), such that unpredictability is associated with anxious attachment and, in addition, may be associated with attachment insecurity in adult relationships.

Attachment researchers have suggested that the adult attachment system may have evolved from, or has been “co-opted” from the parent-infant attachment system (Hazan & Diamond, 2000; Hazan & Zeifman, 1994). The adult attachment system (Fraley & Shaver, 2000) functions to maintain the pair-bond between romantic partners (Hazan & Diamond, 2000; Hazan & Zeifman, 1999), may facilitate reproductive strategies (Del Giudice, 2009), and may regulate the ways in which individuals respond to distressing situations and episodes of interpersonal conflict (Bowlby, 1982; Simpson & Belsky, 2008).

Attachment bonds reflect developmental adjustments to local environmental risk (Belsky, 1999; Belsky et al., 1991; Chisholm, 1996; 1999). Young children may use parental investment and parental transitions as cues to local environmental risk, which affords conditional adjustments in life history strategies (Ellis et al., 2009). In unpredictable environments, the parental investment a child receives is sporadic and inconsistent, which in humans is correlated with unstable romantic relationships in adulthood characterized by anxious attachment (Ellis et al., 2009; Simpson et al., 2011).

Anxious romantic attachment is one dimension of attachment insecurity (Brennan, Clark & Shaver, 1998; Fraley & Shaver, 2000). Anxious attachment embodies an intense desire for intimacy, greater insecurity, persistent fear of rejection (Rholes & Simpson, 2004; Shaver & Mikulincer, 2008), and high sexual motivation (Davis, Shaver, & Vernon, 2004). Anxious attachment also is associated with affect escalation, impulsivity, anger and resentment, displaced aggression, and low self-control (Alexander & Anderson, 1994; Bartholomew, 1990; Gormley, 2005; Mikulincer, 1998). These characteristics may account for the partner-directed controlling and coercive behavior displayed by anxiously attached individuals (Mikulincer & Shaver, 2007).

Several features of anxious attachment are associated with intimate partner violence (IPV) perpetration. Mayseless (1991) argued that IPV is motivated by fear of abandonment, and violence is one strategy an anxiously attached individual deploys to preserve the relationship (Gormley, 2005). For men in particular, IPV also functions to guard sexual access to a romantic partner (Thornhill & Palmer, 2000). Anxious attachment may be associated with violent behavior because anxiously attached individuals have difficulty regulating emotional and behavioral responses produced by fear of rejection and abandonment (Dutton, 2007). Anxiously attached individuals are hypervigilant to rejection cues and have difficulty disengaging from these cues (Mikulincer, Gillath, & Shaver, 2002). Hypervigilance associated with anxious attachment also increases negative affect (Mikulincer & Shaver, 2007), such as feelings of frustration and anger.

Men and women perpetrate violence against their partners (Archer, 2000), and insecure romantic attachment is consistently associated with male and female IPV perpetration (Gormley, 2005). Anxious

attachment is associated with male-perpetrated physical and psychological IPV (Babcock, Jacobson, Gottman, & Yerington, 2000; Bookwala & Zdaniuk, 1998; Dutton, Saunders, Starzomki, & Bartholomew, 1994; Fournier, Brassard, & Shaver, 2010; Mauricio, 2002; Mauricio, Tein, & Lopez, 2007; Roberts & Noller, 1998), and female-perpetrated intimate partner physical violence (Bookwala & Zdaniuk, 1998; O'Hearn & Davis, 1997; Orcutt, Garcia, & Pickett, 2005; Roberts & Noller, 1998; Gromley & Lopez, 2003).

The Current Research

The aims of the current research are three-fold. First, we aim to investigate the unique importance of environmental unpredictability in early childhood in association with romantic relationships in adulthood. Second, we explore whether objective or subjective measures of environmental risk are more informative when testing the fundamental dimensions of risk model. And last, we aim to integrate life history theory and attachment theory to provide initial empirical support for a developmental life history model of the proximate mechanisms underlying IPV perpetration. It is important to distinguish between different types of IPV, however, to explore whether anxious attachment is predictive of different partner-violence behaviors. Thus, we explore the relationships between anxious attachment and three domains of IPV, including psychological aggression, physical assault, and sexual coercion

Two independent studies were conducted to test three hypotheses:

Hypothesis 1: Greater environmental unpredictability in early childhood will be associated with anxious romantic attachment (Study 1 & 2).

Hypothesis 2: Anxious romantic attachment will be associated with intimate partner violence perpetrated by both sexes across three domains (Study 2).

Hypothesis 3: Anxious romantic attachment will mediate the relationship between environmental unpredictability in early childhood and perpetration of intimate partner violence across the domains of psychological aggression, physical assault, and sexual coercion (Study 2).

The current research secured retrospective reports from adult participants regarding early childhood environments. Previous research has relied on retrospective reports of childhood experiences to

test life history hypotheses (see Szepeswol et al., 2015). To ensure the data collected are as accurate as possible, all life history measures used in the current research were derived from previous empirical studies testing life history hypotheses (see Measures).

Study 1

Study 1 sought to secure preliminary evidence for the relationship between environmental unpredictability in early childhood and anxious romantic attachment in adulthood (Hypothesis 1).

Method

Participants. We secured data from 128 participants (50% women, 73% White) via Amazon's Mechanical Turk (MTurk). MTurk is a crowdsourcing website increasingly used by psychological researchers. Researchers can collect survey data in exchange for monetary compensation (see Procedure). Participants recruited via MTurk are more socioeconomically and ethnically diverse than traditional internet or college samples (Casler, Bickel, & Hacklett, 2013). Data collected via MTurk is of equal quality to data collected by other internet methods and from college undergraduates (Buhrmester, Kwang, & Gosling, 2011; Casler et al., 2013).

Participants in the current study were required to be in a heterosexual, romantic relationship. The mean age of participants was 35.1 years ($SD = 11.68$), and the mean relationship length was 73.75 months ($SD = 103.5$). The mean household income reported by participants in early childhood was \$35,001-\$55,000.

Procedure. Eligible prospective participants viewed an advertisement for the study on MTurk's job listings. Those interested in and eligible to participate were provided a link to an informed consent about the study. Those who agreed to participate could access and complete the survey, and those who did not agree to participate were exited from the study. We implemented recommended MTurk filters (Peer, Vosgerau, & Acquisti, 2013), such that individuals could only participate if they had successfully completed 95% of at least 500 previously accessed MTurk jobs. Participants were compensated \$0.50 for completing the study.

Measures.

Romantic attachment. Participants completed the Experiences in Close Relationships Scale-Revised (ECR; Fraley, Waller, & Brennan, 2000), a 36-item measure assessing attachment bonds along the dimensions of anxiety and avoidance. Participants were instructed to respond to statements as they relate to their current romantic partner on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Statements included in the ECR were modified to be partner-specific, rather than partner-general. For example, the statement, “When I show my feelings for *romantic partners*, I’m afraid they will not feel the same about me” was modified to, “When I show my feelings for *my romantic partner*, I’m afraid my partner will not feel the same about me” (emphasis added). Composite scores were calculated for each participant by averaging their responses to the 18 anxiety items ($\alpha = .96$) and the 18 avoidance items ($\alpha = .95$).

Environmental harshness. Environmental harshness in early childhood was measured in two ways to secure objective and subjective measures. Participants were asked to respond to the questions as they relate to their childhood environment from birth to five years of age. Participants reported their household income with response categories ranging from “less than \$15,000” to “more than \$155,000” (Griskevicius et al., 2013; Kraus et al., 2009; Simpson et al., 2012). Responses to this question were re-coded such that higher scores indicate harsher environments, and we labeled this variable *objective harshness*.

Participants responded to three statements about their family’s socioeconomic status during the participant’s childhood on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*): “I grew up in a relatively wealthy neighborhood,” “My family usually had enough money for things when I was growing up,” and “I felt relatively wealthy compared to other kids in my school” (Griskevicius, Delton, et al., 2011; Griskevicius, Tybur, et al., 2011). Participant’s responses were re-coded such that higher scores indicate harsher environments. Composite scores were calculated for each participant by averaging their recoded responses ($\alpha = .87$), and we labeled this variable *subjective harshness*.

Environmental unpredictability. We again secured objective and subjective assessments of environmental unpredictability in early childhood. Following Szepeswol et al. (2015; see also, Simpson

et al., 2012), unpredictability of participant's childhood environment was measured by four questions concerning their home environment from birth to five years of age. Participants indicated the number of times each life event occurred by reporting a whole number in response to: "How many times did your mother change employment?" "How many times did your father change employment?" "How many times did you change residence?" and "How many different adult men, besides your biological father, resided in your primary residence for a period of time?" Composite scores were calculated by summing each participant's responses to the four questions, and we labeled this variable *objective unpredictability*. Higher scores indicate greater unpredictability in the participant's early childhood environment.

Participants indicated the extent to which each of the four life events (see above) disrupted their home life (Simpson et al., 2012) on a 4-point scale ranging from 1 (*no disruption*) to 4 (*severe disruption*). Composite scores were calculated for each participant by averaging their responses to the life event disruption questions ($\alpha = .67$). Higher scores indicate greater subjective environmental unpredictability in early childhood, and we labeled this variable *subjective unpredictability*.

Results

Zero-order correlations and descriptive statistics for the study variables are displayed in Table 1. A multiple regression analysis was conducted to test Hypothesis 1. Because the dimensions of anxious and avoidant attachment are significantly correlated, avoidant attachment was included in the regression analysis to afford the investigation of the unique effect of environmental risk on anxious attachment. The variables avoidant romantic attachment, objective harshness, subjective harshness, objective unpredictability, and subjective unpredictability were simultaneously entered into the regression analysis as predictor variables, with anxious romantic attachment as the dependent variable (Table 2). Supporting Hypothesis 1, subjective unpredictability was associated with anxious romantic attachment. Objective unpredictability, objective harshness, and subjective harshness were not associated with anxious romantic attachment.

Because the dimensions of anxious and avoidant attachment are significantly correlated (see Table 1), we conducted another multiple regression analysis to confirm that unpredictability in childhood

is uniquely associated with anxious, but not avoidant, romantic attachment. The variables anxious romantic attachment, objective harshness, subjective harshness, objective unpredictability, and subjective unpredictability were simultaneously entered into the regression analysis as predictor variables, with avoidant romantic attachment as the dependent variable (Table 2). Objective harshness, subjective harshness, objective unpredictability, and subjective unpredictability were not associated with avoidant romantic attachment.

Discussion

The results of Study 1 support Hypothesis 1 in that subjective unpredictability in early childhood is associated with anxious romantic attachment, but not with avoidant romantic attachment. The results are consistent with theory regarding the unique relationship of environmental unpredictability in childhood with adult romantic attachment (Simpson et al., 2011).

Study 2

Study 2 sought to replicate the results of Study 1 in an independent sample (Hypothesis 1). Also, extending these findings, Study 2 investigates the relationship between anxious romantic attachment and reports of intimate partner violence perpetration across three domains (Hypothesis 2). Finally, an aim of this study was to take an initial step toward integrating these findings into a developmental model of the proximate pathways explaining intimate partner violence (Hypothesis 3).

Method

Participants. We secured data from 263 participants (57% men, 46% White, 37% Asian) in a committed, heterosexual, romantic relationship via MTurk (see Study 1). Participants' mean age was 32.2 years ($SD = 9.3$), and the mean relationship length was 59.2 months ($SD = 71.9$). The mean household income reported by participants in early childhood was \$35,001-\$55,000.

Procedure. Eligible prospective participants viewed an advertisement for the study on MTurk's job listings. Those interested in and eligible to participate were provided a link to an informed consent about the study. Those who agreed to participate could access and complete the survey, and those who did not agree to participate were exited from the study. We implemented recommended MTurk filters (Peer,

Vosgerau, & Acquisti, 2013) whereby individuals could only participate if they had successfully completed 95% of at least 500 accessed MTurk jobs. Participants were compensated \$0.50 if they completed the study.

Measures. Measures of anxious romantic attachment ($\alpha = .95$), avoidant romantic attachment ($\alpha = .92$), objective environmental harshness, subjective environmental harshness ($\alpha s = .80$) objective environmental unpredictability, and subjective environmental unpredictability ($\alpha s = .80$) were identical to the measures used in Study 1. All variables are labeled in accordance with Study 1.

Intimate Partner Violence. Frequency of intimate partner violence (IPV) perpetration was measured with the Revised Conflict Tactics Scale (CTS2; Straus, Hamby, Boney-McCoy, & Sugarman, 1996). The CTS2 includes 38 statements regarding perpetration of IPV. Participants were instructed to read each statement, which describes a violent or coercive act, and then indicate the number of times they perpetrated this act against their partner in the past year on the following 8-point scale: 1 (*this has never happened*), 2 (*once in the past year*), 3 (*twice in the past year*), 4 (*3-5 times in the past year*), 5 (*6-10 times in the past year*), 6 (*11-20 times in the past year*), 7 (*20+ times in the past year*), and 8 (*not in the past year, but it has happened before.*)

The CTS2 contains five subscales: *psychological aggression*, *physical assault*, *sexual coercion*, *negotiation*, and *sustained injury*. The focus of the current research is on perpetration of IPV and, therefore, subsequent analyses focus on the three perpetration domains—psychological aggression (e.g., “Shouted or yelled at my partner”), physical assault (e.g., “Slammed my partner against a wall”), and sexual coercion (e.g., “Used [physical] force to make my partner have sex”). Following Straus et al. (1996), responses to each statement were re-coded as the midpoint of the response category the participant reported. For example, if the participant reported an act occurring “3-5 times in the past year,” the response was recoded as occurring 4 times in the past year. We used the recommended midpoint of 25 for the response category of “20+ times in the past year” (Straus et al., 1996). If participants reported that the act “has not occurred in the past year, but has happened before,” the response was re-coded as “0.” Composite scores for each violence domain—psychological aggression, physical assault, and sexual

coercion—were calculated by summing the recoded response category midpoints. Higher composite scores in each domain indicate greater frequency of IPV perpetration.

Results

Although both men and women perpetrate violence against their partners (Archer, 2000), female-perpetrated IPV is less researched and less understood than male-perpetrated violence (Gormley, 2005). We conducted independent-samples *t*-tests to identify sex differences in perpetration frequency of IPV. Men more frequently perpetrated IPV than did women. Men ($M = 31.26, SD = 39.04$) more than women ($M = 20.62, SD = 34.16$) more frequently perpetrated psychological aggression (Welch's $t(257.85) = 2.36, p < .05$). Men ($M = 43.41, SD = 62.85$) more than women ($M = 25.77, SD = 54.29$) more frequently perpetrated physical assault (Welch's $t(258.65) = 2.44, p < .05$). And men ($M = 28.34, SD = 35.29$) more than women ($M = 17.67, SD = 30.04$) more frequently perpetrated sexual coercion (Welch's $t(259.46) = 2.65, p < .05$). Because of the sex differences in violence perpetration, all subsequent analyses testing the three study hypotheses are conducted separately for men and women.

Men. Zero-order correlations and descriptive statistics for the study variables are displayed in Table 3. As in Study 1, avoidant attachment was included in the regression analysis to afford the investigation of the unique effect of environmental risk on anxious attachment. A multiple regression analysis was conducted to test Hypothesis 1. The variables avoidant romantic attachment, objective harshness, subjective harshness, objective unpredictability, and subjective unpredictability were simultaneously entered into the regression analysis as predictor variables, with anxious romantic attachment as the dependent variable (Table 4). Consistent with Study 1, subjective unpredictability was associated with anxious romantic attachment. Objective unpredictability and objective harshness were not associated with anxious romantic attachment; however, subjective harshness was negatively associated with anxious romantic attachment.

Because the dimensions of anxious and avoidant attachment are significantly correlated (see Table 3), we conducted another multiple regression analysis to confirm that unpredictability in childhood is associated with anxious, but not avoidant, romantic attachment. The variables anxious romantic

attachment, objective harshness, subjective harshness, objective unpredictability, and subjective unpredictability were simultaneously entered into the regression analysis as predictor variables, with avoidant romantic attachment as the dependent variable (Table 4). Objective harshness, subjective harshness, objective unpredictability, and subjective unpredictability were not associated with avoidant romantic attachment.

We conducted three multiple regression analyses to test Hypothesis 2, which stated that anxious romantic attachment will be associated with intimate partner violence perpetration across the domains of psychological aggression, physical assault, and sexual coercion (Table 5). In each regression analysis, we simultaneously entered the variables objective harshness, subjective harshness, objective unpredictability, and subjective unpredictability, avoidant romantic attachment, and anxious romantic attachment as predictor variables to assess the predictive utility of anxious romantic attachment on IPV perpetration. Each domain of IPV was entered separately as the dependent variable. As hypothesized, anxious romantic attachment was associated with more frequent perpetration of psychological aggression. Anxious romantic attachment was associated with more frequent perpetration of physical assault. Lastly, anxious romantic attachment was associated with more frequent perpetration of sexual coercion. The direct relationship between subjective unpredictability and perpetration of intimate partner violence across the three domains remained significant in each model. Avoidant romantic attachment was not associated with any of the three IPV domains.

Hypothesis 3 states that anxious romantic attachment mediates the relationship between environmental unpredictability in early childhood and IPV perpetration across the three domains. Based on the results of Hypothesis 1, mediational analyses focus on the subjective unpredictability variable. We employed the distribution of the product of coefficients method (Tofighi & MacKinnon, 2011) to confirm mediation. This method affords greater statistical power and more accurate Type 1 error rates than the traditional Baron and Kenny (1986) causal steps method (see also MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). The distribution of the products of coefficients method is recommended over traditional bootstrapping methods for smaller samples because traditional bootstrapping methods can

result in under-coverage of the 95% confidence interval (Tofighi & McKinnon, 2011; see also Good, 2006; MacKinnon, Lockwood, & Williams, 2004). The unstandardized regression coefficients and standard error estimates for the relationships between subjective unpredictability and anxious romantic attachment (path *a*; tests of Hypothesis 1; Table 4) and between anxious romantic attachment and each of the three domains of IPV (paths *b*; tests of Hypothesis 2; Table 5) were used to calculate the indirect effect estimate. The distribution of the products of coefficients method confirms that anxious romantic attachment mediates the relationship between subjective environmental unpredictability in early childhood and psychological aggression (indirect effect estimate $M_{ab} = 3.68$, $SE_{ab} = 2.04$; 95% CI [.11, 8.11]); the relationship between subjective environmental unpredictability in early childhood and physical assault (indirect effect estimate $M_{ab} = 5.49$, $SE_{ab} = 3.06$; 95% CI [.17, .12.15]); and the relationship between subjective environmental unpredictability in early childhood and sexual coercion (indirect effect estimate $M_{ab} = 3.22$, $SE_{ab} = 1.79$; 95% CI [.10, 7.10]), supporting Hypothesis 3.

We conducted a final multiple regression analysis to rule out an alternative explanation of IPV perpetration as a mediating variable—such that IPV may mediate the relationship between subjective unpredictability and anxious romantic attachment. Objective harshness, subjective harshness, objective unpredictability, subjective unpredictability, avoidant romantic attachment, psychological aggression, physical assault, and sexual coercion were entered as predictor variables, with anxious romantic attachment as the dependent variable. IPV perpetration across the domains of psychological aggression ($\beta = .12$, $t = .90$, $p = .37$), physical assault ($\beta = .07$, $t = .43$, $p = .67$), and sexual coercion ($\beta = .12$, $t = .67$, $p = .50$) was not associated with anxious romantic attachment when controlling for environmental harshness and environmental unpredictability measures.

Women. Zero-order correlations and descriptive statistics for the study variables are displayed in Table 6. Avoidant attachment was included in the regression analysis to afford the investigation of the unique effect of environmental risk on anxious attachment. We conducted a multiple regression analysis to test Hypothesis 1, which stated that greater environmental unpredictability in early childhood is associated with anxious romantic attachment. The variables avoidant romantic attachment, objective

harshness, subjective harshness, objective unpredictability, subjective unpredictability were simultaneously entered into the regression analysis as predictor variables, with anxious romantic attachment as the dependent variable (Table 7). Subjective unpredictability was not statistically associated with anxious romantic attachment ($p = .13$)¹. Objective unpredictability and objective harshness were also not associated with anxious romantic attachment; however, subjective harshness was negatively associated with anxious romantic attachment. When statistically controlling for avoidant romantic attachment, but *not* environmental harshness measures, subjective unpredictability was associated with anxious romantic attachment ($\beta = .18, t = 2.63, p < .05$) in the hypothesized direction.

Because the dimensions of anxious and avoidant attachment are significantly correlated (see Table 6), we conducted another multiple regression analysis to investigate whether subjective unpredictability in childhood is associated with avoidant romantic attachment. The variables anxious romantic attachment, objective harshness, subjective harshness, objective unpredictability, subjective unpredictability were simultaneously entered into the regression analysis as predictor variables, with avoidant romantic attachment as the dependent variable (Table 7). Objective harshness, subjective harshness, objective unpredictability, subjective unpredictability were not associated with avoidant romantic attachment.

We conducted three multiple regression analyses to test Hypothesis 2, which stated that anxious romantic attachment will be associated with IPV perpetration across the domains of psychological aggression, physical assault, and sexual coercion (Table 8). In each regression analysis we simultaneously entered the variables objective harshness, subjective harshness, objective unpredictability, and subjective unpredictability, avoidant romantic attachment, and anxious romantic attachment as predictor variables to assess the predictive utility of anxious romantic attachment on IPV perpetration. Each domain of IPV was entered separately as the dependent variable. As hypothesized, anxious romantic attachment was

¹ This analysis is based on women's data after omitting an outlier for the *objective unpredictability* variable: The outlier reported a total of 589 life events before 5 years. All analyses testing hypotheses 1-3 for women that included the outlier were significant in the hypothesized direction. Tests of Hypothesis 1 were no longer significant at $p < .05$ after the outlier was removed.

associated with more frequent perpetration of psychological aggression. Additionally, avoidant romantic attachment was negatively associated with perpetration of psychological aggression. Subjective harshness remained a significant predictor, such that subjective harshness was negatively associated with psychological aggression. Anxious romantic attachment was associated with more frequent perpetration of physical assault. Subjective unpredictability remained positively associated with physical assault, and subjective harshness remained negatively associated with physical assault. Lastly, anxious romantic attachment was associated with more frequent perpetration of sexual coercion. Subjective harshness remained negatively associated with sexual coercion, and objective unpredictability was positively associated with sexual coercion. Avoidant romantic attachment was not associated with physical assault or sexual coercion. Because environmental unpredictability in childhood was not associated with anxious romantic attachment as hypothesized, we did not proceed with mediation analyses to test Hypothesis 3.

Discussion

For men, but not women, the results of Study 2 support Hypothesis 1 in that greater subjective unpredictability is associated with anxious romantic attachment. Hypothesis 2 was supported for men and women in that anxious romantic attachment is associated with greater frequency of perpetrating psychological aggression, physical assault, and sexual coercion against a current romantic partner. The results support Hypothesis 3 for men only, such that anxious romantic attachment mediates the relationship between subjective unpredictability in early childhood and intimate partner violence perpetration across the domains of psychological aggression, physical assault, and sexual coercion.

General Discussion

The current research tested three hypotheses derived from life history theory (Kaplan & Gangestad, 2005) and attachment theory (Fraley & Shaver, 2000; Shaver & Hazan, 1987), utilizing the Ellis et al. (2009) features of environmental risk model. We investigated the unique association of environmental unpredictability in early childhood with romantic attachment and intimate partner violence (IPV) perpetration in adulthood. The results of Study 1 support Hypothesis 1 in that subjective environmental unpredictability in early childhood is associated with anxious romantic attachment. The

results of Study 2 corroborate the findings of Study 1 for men, but not women. The results of Study 2 support Hypothesis 2 in that anxious romantic attachment is consistently associated with male and female perpetration of IPV across the domains of psychological aggression, physical assault, and sexual coercion. The results of analyses support Hypothesis 3 for men, but not women. Anxious romantic attachment mediates the relationships between subjective environmental unpredictability in early childhood and perpetration of IPV across three domains.

Tests of Hypothesis 1 are in accordance with previous theory regarding the unique association of environmental unpredictability in early childhood with anxious romantic attachment in adult relationships (Simpson et al., 2011). These findings also corroborate the results of comparative research demonstrating a causal relationship between unpredictable rearing environments and increased anxiety in bonnet macaque infants (Andrews & Rosenblum, 1994). For men, Study 1 and Study 2 document a positive relationship between subjective unpredictability in early childhood and anxious romantic attachment in adulthood. This relationship was trending toward significance in our sample of women in Study 2, suggesting that subjective unpredictability may be an important determinant of anxious romantic attachment in women, as predicted by life history theory. Romantic attachment dimensions constitute aspects of reproductive strategies (Del Giudice, 2009). However, because of asymmetries in reproductive biology (i.e., costs of the development of sperm and ova) and an asymmetry in minimum obligatory parental investment (i.e., fertilization and gestation occur within females), men can potentially benefit more from extreme reproductive strategies (e.g., highly vs. lowly anxious) than can women. Thus, the magnitude of the relationship between environmental unpredictability and anxious attachment may be greater in men than in women, potentially explaining the marginally significant effect for women in Study 2. Future research could secure data from a larger sample of women to afford greater statistical power to detect the relationship between subjective environmental unpredictability and anxious romantic attachment.

The current research explored whether objective or subjective accounts of environmental risk in early childhood are more informative for testing life history hypotheses. Differential susceptibility theory

(Belsky & Pluess, 2011) suggests that individual differences can cause individuals to overestimate both negative and positive rearing experiences. Our results suggest that subjective reports of environmental risk—specifically, environmental unpredictability—may be particularly informative for future research in this domain. Although, it is important to note that the current research did not secure measures to directly test differential susceptibility theory (e.g., infant temperament). Environmental unpredictability can also affect parenting (e.g., Szepeswol et al., 2015). Because young children may use parental investment as cues to local environmental risk (Ellis et al., 2009), extreme and negative parental factors (e.g., child abuse; Godbout, Sabourin, & Lussier, 2009) may mediate the development of anxious romantic attachment.

The results of the current research suggest that men and women may be likely to develop anxious attachment bonds to their romantic partner when exposed to *unpredictable* early rearing environments, specifically. Under conditions of environmental stress, men and women allocate greater resources to early reproduction and greater mating effort. Anxious romantic attachment, rather than avoidant romantic attachment, may facilitate greater mating effort and earlier reproduction. Correlational models have shown that anxious romantic attachment is associated with high sexual motivation (Davis et al., 2004), a strong desire for romantic partnerships, and greater likelihood for short-term romantic relationships (Simpson & Belsky, 2008). These characteristics may be particularly advantageous in unpredictable environments, thereby facilitating high mating motivation and a greater number of reproductive opportunities. Further support for this notion can be inferred by the results of the current research, which demonstrated no relationship between unpredictability and avoidant attachment in Study 1 or Study 2. In Study 2 for men, but not women, environmental unpredictability is significantly associated with the development of anxious attachment bonds in adulthood when accounting for environmental harshness. This difference in the association between environmental risk in childhood and anxious romantic attachment in men and women highlights a possible sex difference in the development of the adult attachment system within a life history framework that could be explored in future research.

For men and women in Study 2, however, both environmental harshness is *negatively* associated with the development of anxious attachment bonds in adulthood. However, this result was in an unexpected direction, such that *less* harsh childhood environments were associated with *greater* attachment anxiety. Subjective harshness was also negatively associated with female-perpetrated IPV in that *less* harsh childhood environment was associated with greater frequency of IPV. This effect of subjective harshness does not corroborate previous research documenting that harsh environments predict greater IPV (see Figueredo et al., 2012), and is opposite of what life history theory proposes. As such, these results should be interpreted with caution.

Study 2 replicates several empirical documentations of the relationship between anxious romantic attachment and IPV perpetration. Extending upon these findings, we examined the relationships between specific attachment bonds—rather than general attachment styles—and three domains of IPV. Recent research has demonstrated that the attachment bond to a particular individual, as contrasted with one's general attachment style, is more important (i.e., explained more variance) in predicting negative affect associated with the individual (Barry, Lakey, & Orehek, 2012; Cook, 2000). Results of Study 2 suggest that anxious romantic attachment motivates IPV, rather than anxious attachment being a consequence of IPV, for both men and women.

Additional results from Study 2 are consistent with a life history model for the proximate mechanisms of male-perpetrated IPV, specifically. Evolutionary psychological theories contend that men perpetrate IPV, and especially partner-directed sexual coercion, to guard or protect their paternity (Thornhill & Palmer, 2000). Complementing this perspective, we provide a developmental model of male-perpetrated IPV. We suggest that unpredictable early environments may result in anxious attachment bonds that facilitate more reproductive opportunities, but also produce hypervigilance to rejection cues and increased negative affect (Mikulincer & Shaver, 2007). In turn, anxious romantic attachment acts as a motivational proximate mechanism in response to threats of rejection and abandonment (e.g., perceptions of infidelity). Corroborative research demonstrates that men convicted of perpetrating violence against their wives report greater anxiety about rejection and abandonment,

dependency, and preoccupation with their wives (Holtzworth-Munroe, Stuart, & Hutchison, 1997). These results suggest proximate mechanisms that accord with evolutionary theories of male-perpetrated, perhaps motivated proximately by fears of abandonment or rejection.

Limitations and Future Directions

The current research has limitations that should be considered when interpreting the results. We measured environmental harshness and environmental unpredictability using self-report measures that have been used in previous research (Griskevicius et al., 2013; Griskevicius, Delton, et al., 2011; Griskevicius, Tybur, et al., 2011; Simpson et al., 2012; Szepeswol et al., 2015). We secured retrospective reports from adults concerning early childhood experiences. Due to the nature of these data, recall and reporting errors are concerns. However, our results are in accordance with previous research using retrospective self-report methodology (Szepeswol et al., 2015), longitudinal methodology (Simpson et al., 2012), and experimental comparative research (Andrews & Rosenblum, 1994), which is suggestive of accurate retrospective reports. Future research could secure mortality rates of childhood environments to provide alternative tests of the hypothesized relationship between environmental unpredictability and anxious romantic attachment.

The results of the current research are correlational and cross-sectional and, therefore, cannot support strong causal statements. Although cross-sectional, the relationship between childhood rearing experiences and adult romantic attachment is unlikely to be bi-directional in nature. We recognize that perceptions of past experiences, particularly parenting experiences, may be affected by current attachment anxiety, however. The relationship between anxious attachment and perpetration of IPV could also be hypothesized in the opposite direction in that those who perpetrate IPV may develop anxious attachment toward their romantic partner, and thus IPV may be the mediator between environmental risk and attachment anxiety. In an attempt to rule out this alternative explanation, we conducted multiple regression analyses (Study 2) in which we entered the three domains of IPV with anxious romantic attachment as the dependent variable. The results of the current research do not support this alternative directional relationship.

Analyses conducted in Study 2 document a negative effect of subjective environmental harshness on anxious romantic attachment. These results are contrary to predictions derived from life history theory. Aside from alternative theoretical explanations (see Discussion), a possible explanation for these discrepant findings is that they reflect a measurement issue. A subtle difference in the subjective harshness measure compared to the other three environmental risk measures is reflected in the specific time period to which participants referred to answer these questions. The subjective harshness measure asked about childhood, more generally, whereas the measures of objective harshness, objective unpredictability, and subjective unpredictability were specified between birth and five years. Research documents that later childhood (6-16 years) is not predictive of life history relevant outcomes (Simpson et al., 2012). The difference in time period for the subjective harshness measure may be distorting or masking true effects.

The unexpected results concerning environmental harshness and avoidant attachment in Study 2 may be due to the larger than expected correlation between avoidant attachment and anxious attachment (see Del Giudice, 2011). Given that the bivariate correlations between avoidant attachment and the other study measures were positive, but in multiple regression analyses the associations between avoidant attachment and the study measures were negative, the portion of variance that avoidant attachment shares with anxious attachment may be distorting the relationships between the variables in bivariate analyses.

The current research does not afford controlling for the influence of shared genetic variation in life history traits and adult outcomes. Life history traits are heritable, and there is evidence that some of the adult outcomes investigated as purported consequences of early experiences may be accounted for by shared genetic variation (e.g., Figueredo et al., 2004). Researchers have begun to use sibling and twin study designs to control for the effects of shared genes, allowing for more accurate assessments of the influence of life history-specific environmental cues (e.g., Ellis, Schlomer, Tilley, & Butler, 2012)—providing support for both behavioral genetic hypotheses and life history hypotheses. Without accounting for shared genetic variation *and* environmental conditions, our conclusions must remain tentative (Barnes,

Boutwell, Beaver, Gibson, & Wright, 2014). Correlational designs like our own nevertheless contribute to the literature. Future research should replicate these findings using genetically-informed study designs.

Conclusion

The current research offers an initial step toward integrating life history theory and attachment theory. We offer a developmental life history model of the proximate mechanisms that may function in male-perpetrated IPV. The results support the hypothesis that anxious romantic attachment in adulthood is associated with unpredictable early environments, but this relationship was more consistent for men than women across studies. The results corroborate a large literature documenting the relationship between anxious romantic attachment and IPV perpetration by both men and women. Collectively, the findings of the current studies contribute to the literature concerning the relationships of environmental risk features in rearing environments with mating-relevant adult outcomes (Ellis et al., 2009; Simpson et al., 2012). The current research suggests profitable avenues of research in the domains of environmental risk, romantic attachment, and IPV.

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Table 1. Zero-order correlations and descriptive statistics for study variables: Study 1.

Variable	1	2	3	4	5	6
1. Anxious	-					
2. Avoidant	.60***	-				
3. Objective Harshness	.08	-.001	-			
4. Subjective Harshness	-.004	.02	.47***	-		
5. Objective Unpredictability	.10	.05	.06	.25**	-	
6. Subjective Unpredictability	.32***	.26**	.14	.24**	.59***	-
Mean	2.93	2.74	7.05	4.10	3.95	1.41
SD	1.40	1.12	1.73	1.55	5.17	.50

*** $p < .001$, ** $p < .01$, * $p < .05$

Table 2. Results of multiple regression analyses for Study 1 (Hypothesis 1). Features of environmental risk predicting anxious and avoidant romantic attachment.

Predictor Variable	Anxious Attachment			Avoidant Attachment		
	B	β	t	B	β	t
Objective Harshness	.08	.10	1.20	-.05	-.08	-.97
Subjective Harshness	.09	.10	1.13	-.05	-.07	-.82
Objective Unpredictability	-.01	-.03	-.32	-.02	-.11	-1.19
Subjective Unpredictability	.58	.21	2.24*	.31	.14	1.46
Avoidant Anxious	.68	.54	7.22***	.44	.56	7.22***

*** $p < .001$, ** $p < .01$, * $p < .05$

Note. B = Unstandardized regression coefficients; β = Standardized regression coefficients; t = test statistic associated with regression coefficients.

Table 3. Zero-order correlations and descriptive statistics for study variables: Men, Study 2.

Variable	1	2	3	4	5	6	7	8	9
1. Anxious	-								
2. Avoidant	.62***	-							
3. Objective Harshness	-.07	-.09	-						
4. Subjective Harshness	-.26**	-.12	.12	-					
5. Objective Unpredictability	.14	.16	-.05	-.08	-				
6. Subjective Unpredictability	.30***	.24**	-.05	-.21*	.57**	-			
7. Psychological Aggression	.49***	.31***	-.09	-.26**	.23**	.43***	-		
8. Physical Assault	.50***	.32***	-.10	-.31***	.27**	.51***	.89***	-	
9. Sexual Coercion	.47***	.26**	-.06	-.29***	.29***	.51***	.90***	.94***	-
Mean	3.68	3.12	7.16	3.42	4.75	1.67	31.26	43.41	28.34
SD	1.36	.95	1.82	1.38	4.25	.68	39.04	62.85	35.29

*** $p < .001$, ** $p < .01$, * $p < .05$

Table 4. Results of multiple regression analyses for Study 2 (Men, Hypothesis 1). Features of environmental risk predicting anxious and avoidant romantic attachment.

Predictor Variable	Anxious Attachment			Avoidant Attachment		
	B	β	t	B	β	t
Objective Harshness	.01	.01	.24	-.03	-.05	-.85
Subjective Harshness	-.16	-.16	-2.72**	.06	.08	1.30
Objective Unpredictability	-.02	-.06	-.81	.01	.06	.75
Subjective Unpredictability	.30	.15	2.03*	.01	.01	.12
Avoidant Anxious	.93	.65	10.84***	.49	.70	10.84***

*** $p < .001$, ** $p < .01$, * $p < .05$

Note. B = Unstandardized regression coefficients; β = Standardized regression coefficients; t = test statistic associated with regression coefficients.

Table 5. Results of multiple regression analyses for Study 2 (Men, Hypothesis 2). Features of environmental risk and romantic attachment predicting intimate partner violence.

Predictor Variable	Psychological Aggression			Physical Assault			Sexual Coercion		
	B	β	<i>t</i>	B	β	<i>t</i>	B	β	<i>t</i>
Objective Harshness	-0.89	-0.04	-0.61	-1.56	-0.05	-0.70	-0.19	-0.01	-0.15
Subjective Harshness	-1.67	-0.06	-0.82	-4.74	-0.10	-1.53	-2.30	-0.09	-1.30
Objective Unpredictability	-0.22	-0.02	-0.29	-0.50	-0.03	-0.43	-0.06	-0.01	-0.09
Subjective Unpredictability	18.82	.33	3.75***	37.82	.41	4.97***	21.47	.42	4.95***
Avoidant	-3.10	-0.08	-0.80	-4.37	-0.07	-0.75	-5.10	-0.14	-1.53
Anxious	12.26	.43	4.38***	18.31	.40	4.32***	10.75	.42	4.45***

*** $p < .001$, ** $p < .01$, * $p < .05$

Note. B = Unstandardized regression coefficients; β = Standardized regression coefficients; *t* = test statistic associated with regression coefficients.

Table 6. Zero-order correlations and descriptive statistics for study variables: Women, Study 2.

Variable	1	2	3	4	5	6	7	8	9
1. Anxious	-								
2. Avoidant	.72***	-							
3. Objective Harshness	-.08	-.06	-						
4. Subjective Harshness	-.32***	-.17	.31**	-					
5. Objective Unpredictability	.26**	.25*	-.03	.03	-				
6. Subjective Unpredictability	.43***	.38***	-.14	-.12	.66**	-			
7. Psychological Aggression	.54***	.28**	-.09	-.37***	.36***	.46***	-		
8. Physical Assault	.56***	.31**	-.12	-.39***	.27**	.43***	.93***	-	
9. Sexual Coercion	.56***	.28**	-.06	-.36***	.35***	.41***	.88***	.89***	-
Mean	3.18	2.69	7.11	3.85	4.40	1.57	20.62	25.77	17.67
SD	1.47	1.13	1.76	1.62	5.55	.68	34.16	54.29	30.04

*** $p < .001$, ** $p < .01$, * $p < .05$

Table 7. Results of multiple regression analyses for Study 2 (Women, Hypothesis 1). Features of environmental risk predicting anxious and avoidant romantic attachment.

Predictor Variable	Anxious Attachment			Avoidant Attachment		
	B	β	<i>t</i>	B	β	<i>t</i>
Objective Harshness	.02	.03	.39	.004	.01	.08
Subjective Harshness	-.17	-.19	-2.87**	.04	.06	.77
Objective Unpredictability	.01	.03	.38	-.01	-.04	-.41
Subjective Unpredictability	.29	.14	1.52	.21	.12	1.31
Avoidant Anxious	.81	.63	9.26***	.55	.70	9.26***

*** $p < .001$, ** $p < .01$, * $p < .05$

Note. B = Unstandardized regression coefficients; β = Standardized regression coefficients; *t* = test statistic associated with regression coefficients.

Table 8. Results of multiple regression analyses for Study 2 (Women, Hypothesis 2). Features of environmental risk and romantic attachment predicting intimate partner violence.

Predictor Variable	Psychological Aggression			Physical Assault			Sexual Coercion		
	B	β	<i>t</i>	B	β	<i>t</i>	B	β	<i>t</i>
Objective Harshness	.43	.02	.29	.08	.003	.03	.34	.02	.27
Subjective Harshness	-4.66	-.23	-2.76**	-7.49	-.23	-2.73**	-3.67	-.21	-2.53*
Objective Unpredictability	.98	.17	1.67	.46	.05	.48	1.12	.22	2.22*
Subjective Unpredictability	9.74	.20	1.88	16.88	.21	2.00*	2.99	.07	.67
Avoidant Anxious	-6.66	-.23	-2.11*	-9.08	-.19	-1.77	-5.13	-.21	-1.90
	11.07	.49	4.27***	18.89	.52	4.49***	10.29	.53	4.63***

*** $p < .001$, ** $p < .01$, * $p < .05$

Note. B = Unstandardized regression coefficients; β = Standardized regression coefficients; *t* = test statistic associated with regression coefficients.