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The Role of Androgens in Life History Theories of Attachment

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A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Psychology

THE ROLE OF ANDROGENS IN LIFE HISTORY THEORIES OF ATTACHMENT

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by

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Abstract

Life history theories (LHTs) of attachment address how attachments to caregivers in infancy/childhood and to romantic partners in adulthood are used to negotiate mating and reproductive choices. Greater insecure-avoidant attachment has been suggested to be associated with the adoption of a low-investment, short-term reproductive strategy. The role of sex hormones, including the androgen testosterone (T), in the development of attachment-related reproductive strategies has been speculated in some LHTs. This research tested an integrated-LHT model of early environment, attachment, and reproductive strategies in men, using structural equation modeling. Androgen-related effects were hypothesized to occur prenatally and/or in adulthood, consistent with various LHTs of attachment. A sample of 195 young men (M = 21.06 years) from the University of Western Ontario completed self-report paper-and-pencil questionnaires assessing their romantic attachment style, retrospective attachment to caregivers in childhood, sexual variables (e.g., sociosexuality, age at first intercourse), and personality variables such as aggression, impulsivity, and risk-taking. Testosterone was measured in saliva, while an indirect estimate of prenatal T was derived from the 2D:4D finger length ratio. Degree of androgen receptor (AR) sensitivity, as indexed by the CAG repeat polymorphism in the *AR* gene, was also obtained. Results showed that adult romantic attachment style (avoidant *vs.* anxious) mediated the relationship between childhood attachment insecurity and men's sexual reproductive strategy. Greater avoidance predicted a more opportunistic sexual strategy and greater anxiety predicted lower levels of the same strategy. Degree of childhood attachment insecurity, as retrospectively reported, mediated the relationship between quality of early family structure and engagement in non-sexual evocative behaviours believed to be associated with a more opportunistic reproductive strategy (non-sexual reproductive strategy). Adult T was an independent positive predictor of avoidant attachment, and of the non-sexual reproductive strategy, while weaker AR responsivity predicted higher levels of romantic attachment anxiety. Furthermore, romantic attachment configurations were found to mediate the relationship between androgenic variables and sexual behaviour. These findings highlight the figural role of attachment in life history based models of mating strategies, and provide some of

the first empirical support for the hypothesis that romantic attachment in men is, in part, sex-hormonally-based.

Keywords: Attachment, romantic attachment, life history theory, testosterone, sex hormone, androgen, digit ratio, CAG repeat, men, sexual strategy

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"Appreciation is a wonderful thing. It makes what is excellent in others belong to us as well."

-- Voltaire

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1. Introduction

Attachment theory (Bowlby, 1969/1982; 1973; 1980) provides a framework through which to understand the nature and development of an individual's close emotional bonds with a caregiver or loved one. Originating in infancy, attachment is conceptualized as a "behavioural system", the purpose of which is to innately motivate the child to form affective bonds with caregivers by organizing his/her own behaviours in order to maintain proximity to the caregiver. Infants' biological predisposition for proximity seeking (Bowlby, 1969/1982) is viewed as evolutionarily adaptive, serving to increase the likelihood of being protected from danger, thereby resulting in a survival advantage. While emotional and/or physical proximity seeking is central to all attachment relationships, there is, however, individual variation in the types of attachment behaviours used to achieve this goal. Differences in the local environment in which humans develop, including early family experience, lead individuals to differ in the care-eliciting behaviours used to maximize caregiver ability. The result is the development of different learned *attachment styles*.

Two broad categories of attachment have been recognized: secure and insecure (Ainsworth et al., 1978; Main & Goldwyn, 1984). Children who are securely attached generally experience consistently available, sensitive caregiving. Such relational experience allows these children to use the caregiver as a "secure base" for exploration of the world and to seek help and comfort from him or her when distressed. Children who are insecurely attached can be further classified into three distinct types: avoidant, anxious/ambivalent, and disorganized. Insecure-avoidant children generally experience a rejecting, cold, and uninvolved caregiver and treat the caregiver as unavailable and do not ask for help or comfort when distressed. The insecure-anxious/ambivalent style is characterized by inconsistent caregiver availability, which results in a child who is easily distressed and asking vigorously for help and comfort but not easily calmed. Finally, children exposed to frightening or threatening parenting behaviour may develop attachment disorganization. This pattern is associated with both approach and avoidance behaviours as caregivers are simultaneously seen as sources of comfort and fear.

These behaviours, although beginning in infancy, are not limited to this period in human development. Bowlby (1969/1982,1979) speculated that attachment is an integral part of human existence "from cradle to the grave", and that attachment patterns formed in infancy and childhood represent internal working models (IWMs) that are used to anticipate, interpret, and guide current and *future* interpersonal interactions. Research has demonstrated continuity in attachment patterns from childhood to adulthood (correlation size ≈ .40) (e.g. Hamilton, 2000; Waters et al., 2000; Fraley, 2002), with level of stability in patterns dependent on the persistence of IWMs formed in childhood (e.g., Bowlby, 1969/1982; Sroufe, 1979; Sroufe, Egeland, & Kreutzer, 1990; for further review see Fraley, 2002) and exposure to factors that can disrupt them (i.e., environmental changes or seminal events experienced later in development) (e.g., Thompson, Lamb, & Estes, 1982; Trivers, 1985; Scharfe & Bartholomew, 1994, Lewis, 1997, Waters et al., 2000). In adulthood, the concept of attachment can be applied to romantic/love relationships (Hazan & Shaver, 1987), with the romantic partner viewed as the prototypical instantiation of an attachment figure (Hazan & Shaver, 1987; 1994; Ainsworth, 1991).

Assessment of attachment to romantic partners in adulthood is mostly accomplished through self-report questionnaires, based on the social psychological tradition, although interview-based protocols do exist (e.g., Bartholomew & Horowitz, 1991). In their original conceptualization, Hazan and Shaver (1987) extrapolated the main features of the three major infant attachment styles described by Ainsworth and colleagues (1978) to assess individuals' alignment with secure, anxious-ambivalent, and avoidant patterns of attachment in a romantic context. Since then, factor analytic study of many self-report attachment questionnaires has revealed two robust dimensions of anxiety and avoidance that underlie romantic attachment patterns (Brennan, Clark, & Shaver, 1998). Thus, adult romantic attachment is generally conceptualized along the two dimensions of anxiety and avoidance (Fraley & Shaver, 2000; Brennan et al., 1998, Bartholomew & Horowitz, 1991), such that securely attached adults exhibit a pattern of little worry or concern about the availability and willingness of significant others to meet attachment needs (low anxiety) and little discomfort and avoidance of emotional intimacy (low avoidance). Among the patterns of insecure attachment, *dismissing-avoidant* adults,

as so-named by Bartholomew and Horowitz (1991), display low anxiety and high avoidance. These individuals distance themselves from their romantic partners, show a low need for closeness, and describe themselves as self-sufficient. In contrast, *preoccupied* (anxious-ambivalent) adults display a pattern of high anxiety and low avoidance, report a strong desire for intimacy, feel uncomfortable when not involved in close relationships, and worry about being rejected by their partners. Finally, what Bartholomew and Horowitz (1991) called *fearful-avoidant* adults are both highly anxious and highly avoidant and display a mix of desire for closeness and fear of rejection.

Bartholomew (1990) suggested that the dimensions of anxiety and avoidance may overlap with individuals' images of themselves and of others, which Bowlby (1973) viewed as defining features of attachment working models. Positivity *vs.* negativity of the 'self' model—the degree to which individuals have internalized a sense of their own self-worth, and which may correspond to levels of anxiety/dependency in close relationships, intersects with positivity *vs.* negativity of the 'other' model—the degree to which others are generally expected to be available and supportive, and which may correspond with the tendency to seek out or avoid closeness in relationships. Thus a positive model of the self and others corresponds with a secure attachment style, while a positive model of the self combined with a negative model of others corresponds to a dismissing-avoidant style, a negative self model and positive other model corresponds to a preoccupied style, and negative self and other models corresponds to the fearful-avoidant style. Factor analytic study and multidimensional scaling analyses have provided empirical support for the four-group model (Bartholomew & Horowitz, 1991; see Feeney, 2008 for review). This is consistent with reports of a fourth infant attachment style marked by characteristics of both avoidance and anxiety (e.g., Main, Kaplan, & Cassidy, 1985; Main & Soloman, 1990).

Given that attachment behaviours are not simply a characteristic of early development, but also extend into adulthood, it is important to understand their function in adult life. The emotional bond formed between an individual and his/her romantic partner can also be viewed as evolutionarily adaptive (Zeifman & Hazan, 2008). Although not providing survival value, as in infancy or childhood, attachment to a

romantic partner is reproductively advantageous. By increasing the likelihood that one's genes will be passed on to the next generation, romantic attachment may be viewed as a proximate mechanism to enhance reproductive success (Zeifman & Hazan, 2008). Consequently, an individual's approach to attachment with romantic partners in adulthood may have important consequences for mating and reproduction (Del Giudice & Belsky, 2010).

1.1. Research Overview

The current dissertation was directed toward two broad aims. The first purpose was to empirically investigate the role of attachment in the development of mating and reproductive strategies in men. As will be described in Section 1.2, various *life history theories* of attachment exist, which have postulated how early environmental experiences and attachment relationships influence the development of corresponding approaches to sexual behaviour and mating. Although various theories have been proposed, there has been little attempt to put these models to an empirical test and as a result the construct of adult romantic attachment and how it relates to various developmental antecedents and reproductive strategies has been poorly articulated. The present research represented a first, systematic attempt to assess the function and derivation of attachment within the context of an integrated-life history theory model. The integrated model to be tested and the hypothesized predictive relationships will be outlined in Section 1.9. An overview of the various life-history theories themselves will be reviewed in Section 1.2.

The second aim of the present study was to incorporate and test a novel biological perspective on attachment (see Section 1.4) by investigating the role of testosterone in the development of individual differences in attachment style, and within the context of life history theories of attachment. Life history theories have broadly implicated sex hormones, including the androgen testosterone, but specific details are lacking. As will be presented in Sections 1.3, 1.6, and 1.7, the behavioural correlates of the insecure-avoidant romantic attachment style, which has been proposed to represent a more male-typed attachment pattern, can be shown to overlap with many of the behavioural

correlates of high testosterone exposure that have been identified in the neuroendocrinology literature.

These aims will be discussed in further detail in Section 1.9, following an overview of the life history perspective.

1.2. Attachment within a Life History Theory Perspective

In the past three decades a significant body of work within the broader attachment literature has begun to integrate ideas derived from evolutionary biology with conventional thought and empirical observation on adult romantic attachment (see Simpson & Belsky, 2008). By focusing on its *reproductive* consequences, life history theories (LHTs) of attachment attempt to extend the concept of evolutionary adaptiveness of attachment across the lifespan (e.g., Belsky, Steinberg, & Draper, 1991; Chisholm, 1999; Del Giudice, 2009). LHT approaches address, in general, how an organism allocates time and resources in order to optimize his/her reproductive fitness (for review see Kaplan & Gangestad, 2005). Attachment relationships established in early life are believed to provide crucial information about the safety and predictability of an individual's local environment, which in turn are used to negotiate three strategic reproductive trade-offs later in life: (1) current *vs.* future reproduction, (2) quantity *vs.* quality of offspring, (3) mating *vs.* parenting effort.

I will now present the major tenets of the predominant LHTs of attachment that have been discussed in the literature (please refer to Table 1 which provides a summary of the various theories reviewed). Following this, I will describe some of the main evidence in support of these theories, including a review of the existing literature on associations between attachment style and behaviours that have been implicated by the LHTs of attachment and reproduction.

1.2.1. Belsky, Steinberg, and Draper Model (Psychosocial Acceleration Theory)

In the first systematic attempt to integrate attachment theory with the life history perspective, Belsky et al. (1991) proposed that in stressful conditions, characterized by

Table 1

Summary of LHTs of Attachment

Theory	Attachment Classification	Relevant Environmental Antecedents	Somatic Development	Reproductive Strategy	Role of Romantic Attachment
Belsky et al. (1991)/ Belsky (1997)	Insecure (Insecure-avoidant)	• High stress • Marital discord • Single parenthood • Insensitive parenting • Unstable resources	Relatively accelerated timing of pubertal maturation	• Short-term • Opportunistic • Earlier sexual activity • Low investment	Dismissing-avoidance: feature of reproductive strategy
	Secure	• Low stress • Marital harmony • Supportive parenting • Adequate resources	On time/ rel. delayed timing of pubertal maturation	• Long-term • Later sexual activity • Investment-oriented	Secure attachment in adulthood
	Insecure-anxious			• "Helper-at nest" • Delayed strategy • Relationship dependency	Preoccupied attachment in adulthood
Chisholm (1999)	Insecure	• High parental stress • High local mortality rate • Parental absence • Unstable resources		• In men: Young Male Syndrome • Increased sexuality, risk-taking, impulsivity, aggression • "Uncommitted" style	Not implicated
	Secure	• Low parental stress • Low local mortality rate • Parental presence • Stable resources		• In men: lower levels of Young Male Syndrome features • Increased relationship commitment	Not implicated
Del Giudice (2009)	Insecure → avoidance (boys)	• High stress • Insensitive parenting • Parental unwillingness to invest	Relatively accelerated adrenarche	• Short-term • Uncommitted mating • Opportunistic sexual behaviour	Avoidant-based reproductive strategies in adulthood
	Insecure → anxiety (girls)	• Moderate stress • Parental inability to invest	Relatively accelerated adrenarche	• Investment-eliciting • Closeness with partners • Short-term orientation in females	Anxiety-based reproductive strategies in adulthood
	Secure	• Low stress • Sensitive parenting	Normal timing of adrenarche	• Long-term • High relationship commitment • Future reproduction	Secure attachment to partners in adulthood

Table 1 continued

Summary of LHTs of Attachment

Theory	Attachment Classification	Relevant Environmental Antecedents	Somatic Development	Reproductive Strategy	Role of Romantic Attachment
Miller and Pasta (2000)	Not discussed	• Child's perception of low family affection • Child's perception of low fear	Relatively accelerated pubertal timing	• Early and frequent mating • No added push for childbearing	Not discussed
	Not discussed	• Low family affection • High perception of fear	Relatively accelerated pubertal timing	• Opportunistic childbearing	Not discussed
	Not discussed	• High family affection • Low perception of fear	Relatively delayed pubertal timing	• High parental investment	Not discussed

marital discord, single parenthood, and unstable employment, among other features, parenting style tends to become harsher, less sensitive, and/or more unpredictable, leading a child to adopt a more insecure attachment pattern. Attachment insecurity is then used as a working model through which the child interprets his/her environment: learning that resources are scarce and unpredictable, that people are unreliable, and that interpersonal bonds are fleeting and undependable. The child's subjective experience of the rearing environment and parental relationship behaviour will result in the development of an understanding of what the future will hold for his/her *own* relationships, with more exposure to unstable relationship behaviour associated with the belief that mating relationships tend to be short and uncommitted.

Belsky and colleagues (1991) suggest that the outcome of this psychological development is accelerated somatic development, specifically accelerated timing of pubertal maturation. The authors argue that in contexts of early relational stress, and by extension insecure attachment, it may be adaptive for individuals to reliably increase reproductive investment in order to increase the probability of having their genes passed on to the next generation. One way this could be facilitated is through accelerated timing of pubertal maturation, within a biologically acceptable range, enabling for sexual activity and reproduction to begin at a relatively earlier age. Consequently, earlier maturation should be associated with a tendency to adopt a reproductive strategy based on a short-term, opportunistic relationship orientation, early reproduction, and low parental investment, as proposed by Belsky et al. (1991). The exact biological mechanism by which early relational factors influence pubertal timing has not been determined (Mustanski et al., 2004; Graber & Brooks-Gunn, 1996), but could be related to increased eating in high-risk environments and associated rapid weight gain and growth that lead to earlier pubertal onset (e.g., Kuzawa et al., 2010; Bogaert, 2005).

Several studies have demonstrated that childhood exposure to psychosocial stressors accelerates pubertal timing in boys (Arim et al., 2011; Mustanski et al., 2004; Meschke et al., 2003; Chasiotis et al., 1998; Kim & Smith, 1998) and girls (e.g., Meckelmann, Pfeifer, & Rauh, 2013; James et al., 2012; Belsky et al., 2010; Ellis & Essex, 2007; Moffitt et al., 1992), and earlier maturation has an impact on subsequent

sexual behaviour (e.g., James et al., 2012; Belsky et al., 2010; Kim & Smith, 1998; Smith, Udry, & Morris, 1985), as well as non-sexual risky behaviour (e.g., Wiesner & Ittel, 2002; Williams & Dunlop, 1999; Duncan et al., 1985). In contrast, the development of secure attachment is hypothesized to lead to relatively on time, or even delayed (within a biologically acceptable range), pubertal maturation, in order to allow for the child to reap the benefits (e.g., sensitive parenting, felt security) of a relatively benign and/or supportive family environment. This should then result in the adoption of a long-term, investing orientation towards mating relationships, delayed mating, and high parental investment (i.e., focus on quality). Thus from an evolutionary standpoint, the trade-off made by those who are insecurely attached is suggested to be towards current reproduction, higher offspring quantity, and a greater focus on mating effort.

Belsky (1997) further argued that the low-investment, short-term reproductive strategy predicted by insecure childhood attachment was specific to the insecure-avoidant style. Within an environment of evolutionary adaptation, children who developed avoidant attachment styles were hypothesized to continue to display dismissing-avoidant attachment behaviours in adulthood, which Belsky conceptualized as "a central feature of an opportunistic and facultative reproductive strategy" (Belsky, 1997, p. 372). In contrast, it was hypothesized that childhood insecure-anxious attachment leads to the development of so-called "helper-at-nest" behaviour, which in adulthood results in the display of behaviours that promote dependency in significant relationships. Belsky speculated that this life history interpretation of anxious/preoccupied attachment might occur more frequently among firstborns and particularly female firstborns, although this speculation has yet to receive empirical support.

The hypothesized relationship between avoidance and short-term mating orientation has been well supported in the adult attachment literature. Individuals classified as avoidant on self-report measures of romantic attachment or who display higher levels of self-reported romantic attachment avoidance on dimensional measures (e.g., Experiences in Close Relationships (ECR) Questionnaire) have been found to be more willing to engage in casual sex or sex without love (Brennan & Shaver, 1991; 1995; Feeney, Noller, & Patty, 1993; Gentzler & Kerns, 2004), more likely to have sexual

"hook-ups", sex with strangers, or one-night stands than individuals who self-reported as either anxious-ambivalent or as securely attached (Cooper, Shaver, & Collins, 1998; Paul, McManus, & Hayes, 2000), to show less commitment in romantic relationships (Simpson, 1990; Gentzler & Kerns, 2004; Schmitt, 2005), and to be more likely to have dated more than one person (Kirkpatrick & Hazan, 1994). Furthermore, Jackson & Kirkpatrick (2007), who developed a multi-item self-report measure of mating orientation, found that degree of avoidance, as assessed by the ECR, was positively correlated with scores on the short-term mating orientation subscale of their measure and negatively correlated with scores on the long-term mating orientation subscale in undergraduate students. By contrast, higher levels of ECR-rated attachment anxiety were associated with *less* interest in short-term mating.

1.2.2. Chisholm Model

Building upon the model proposed by Belsky et al. (1991), Chisholm (1993, 1996, 1999) further speculated about the associations between early family experience, the formation of attachment bonds, and the subsequent development of reproductive strategies in adulthood. Although both Belsky et al. and Chisholm propose that parental behaviour and associated experiences in the rearing environment will influence attachment style formation in the infant and child, a point of divergence is how Chisholm interprets the cause of individual differences in parental behaviour and the role of parent-child attachment in this context. According to Chisholm (1993), levels of parental stress are driven by the causes and correlates of the *mortality rate* within the local environment in which children are reared, including experiences of poverty, exploitation, and disease, and the feelings of fear and hopelessness they engender. Children, in turn, indirectly and implicitly react to the outcomes of the local mortality rate by developing attachment behaviours that will maximize their reproductive success. Common individual differences in attachment can thus be interpreted as facultative adaptations to parental behaviour, which itself is a function of the death rate in the local environment. Environments with higher mortality rates are likely to be of higher risk and uncertainty for the child, setting the pathway towards a more insecure *vs.* secure attachment pattern, and in turn the development of an optimal reproductive strategy based on high effort

devoted toward mating, maximizing of current reproductive opportunities, and low investment in each offspring (Chisholm 1996, 1999).

Chisholm's life-history model discusses the significance of father absence and its potential negative impact on the socioeconomic status (SES) of the child, which increases risk and uncertainty and by extension environmental stress (Chisholm, 1999). The insecure attachment pattern that is proposed to develop subsequent to parental stress, economic or otherwise, is hypothesized to vary depending on the types of relational cues the child perceives to be receiving from his/her parent (Chisholm, 1996). Specifically, avoidant attachment represents a facultative adaptation to parental *unwillingness* to invest in the child, while anxious-ambivalent attachment represents a facultative adaptation to parental *inability* to invest. Both patterns are speculated to result in the development of short-term, opportunistic reproductive strategies, again a divergence from Belsky's (1997) theorizing, who suggests that it is avoidant attachment that specifically predicts a low-investment, short-term reproductive strategy. Empirical studies have found that early environmental stress (e.g., father absence, marital conflict, low SES) is associated with attachment insecurity (e.g., Nair & Murray, 2005; Clarke-Stewart et al., 2000; Owen & Cox, 1997; Hill, Young, & Nord, 1994a; Mickelson, Kessler, & Shaver, 1997; Riggs & Kaminski, 2010), and both have been related to the development of a short-term relationship orientation (Hill et al., 1994a).

According to Chisholm (1999), the opportunistic reproductive strategy predicted by insecure childhood attachment includes specific behavioural characteristics. Males raised in high-risk environments are proposed to adopt an alternative reproductive strategy that is based on hypermasculine behaviour, increased sexuality, aggression, impulsivity, and risk-taking, the so-called "Young Male Syndrome" (Wilson & Daly, 1985). Chisholm (1999) notes that the Young Male Syndrome (and its behavioural correlates) is itself the optimal reproductive strategy for males reared in environments of high uncertainty, which is understood as the outcome of insecure attachment.

Empirical support for the postulated environmental antecedents of the Young Male Syndrome exists. Investigations by Hill et al. (1994b) and Griskevicius et al.

(2011) have demonstrated that adults who self-report relatively few resources during childhood (i.e., higher levels of childhood socio-economic stress) engage in more risky behaviour in adulthood, such as increased alcohol consumption and/or dependence and making riskier financial decisions. Hill, Jenkins, and Farmer (2008) found that retrospective self-reported levels of environmental instability across the domains of discipline, nurturance, meals, and finances positively predicted risky behaviour and impulsivity (i.e., frequency of engagement in spur-of-the-moment behaviours reflecting loss of control). Furthermore, using structural equation modelling the authors found that the relationship between early instability and risk-taking was mediated by one's conception of the future (example item measuring this construct: "Do you think that there will always be people whom you'll be able to count on in the future?"). How one thinks about the future may reflect a cognitive schema (or internal working model) of unpredictability, which may relate to attachment processes (Ross & Hill, 2002). As will be presented in Section 1.3.2, several lines of research demonstrate that attachment insecurity in both childhood and adulthood are associated with higher levels of externalizing behaviours characteristic of the Young Male Syndrome (i.e., aggression, risk-taking, impulsivity). Given that there exists evidence of developmental continuity (from childhood to adulthood) of externalizing behaviours such as physical aggression in males (e.g., Temcheff et al., 2008; Broidy et al., 2003), it is conceivable that levels of attachment insecurity in childhood could predict features of the Young Male Syndrome in adulthood. According to Chisholm (1999), attachment insecurity in childhood may organize evocative life history traits in adulthood as a way to cope with the lack of "protection" received from caregivers early in life.

In contrast, insecure women are suggested to display the "Young Female Syndrome" in similar environments, resulting in a strategy characterized by impulsive mate choice, early and frequent childbearing, and single motherhood. Thus in Chisholm's model, attachment sets the course for adult reproductive choices, but unlike Belsky's (1997) proposition, it is not further implicated once the individual reaches reproductive maturity, instead the emphasis is placed on sex-specific behavioural presentations.

1.2.3. Del Giudice Model

More recently, Del Giudice (2009) has proposed an updated life history model of attachment and reproductive strategies. Similar to the previous models outlined, Del Giudice has hypothesized that in childhood, attachment security is used as a "socioassay" of the current (and expected) local ecology. Attachment patterns in infancy and early childhood are predicted by parenting and caregiver behaviour. At this level, Del Giudice only makes a distinction between secure *vs.* insecure attachment, such that secure attachment is the outcome of sensitive and responsive parenting towards the child, while insecure attachment is the outcome of a risky environment characterized by insensitive parenting and the child's inference that he/she should expect to receive low parental investment in the future.

The early environmental experience of the child should then affect the timing of the child's transition to juvenility, which according to Del Giudice is marked by *adrenarche*. Beginning at approximately 6 years of age in both males and females, adrenarche represents the onset of androgen production by the adrenal glands and marks the start of the developmental phase known as adrenal puberty (Auchus, 2011; Auchus & Rainey, 2004). Adrenarche does not involve the secretion of testosterone from the gonads, which begins later, at puberty. Instead adrenal precursors of testosterone and estrogen, specifically dehydroepiandrosterone (DHEA), dehydroepiandrosterone sulphate (DHEAS), and androstenedione (A4) are the products secreted by the adrenal glands at this time (Ducharme et al., 1976; Smith et al., 1975). Del Giudice's emphasis on adrenarche instead of puberty, as explored by Belsky et al. (1991) and others (e.g., Miller & Pasta, 2000), is driven by the fact that middle childhood (i.e., ages 7-12) represents a period of reorganization for the attachment system. Specifically, a sex difference in patterns of insecure attachment emerges at this time. Data show that insecure boys are more often classified as avoidant than anxious-ambivalent and vice versa for girls (e.g. Finnegan, Hodges, & Perry, 1996; Granot & Mayseless, 2001; Karavasilis, Doyle, & Markiewicz, 2003; Del Giudice, 2008). In contrast, studies of children as old as six years typically find comparable portions of avoidant and anxious children in both sexes (e.g., van Ijzendoorn et al., 2000; Moss et al., 1998). There is evidence that early

environmental stress stemming from lack of parental supportiveness, including levels of parental negativity and restrictiveness of parenting style, can, in fact, accelerate the relative timing of adrenarche in both boys and girls (Ellis & Essex, 2007), which then sets the stage for the development of sex-specific insecure attachment styles. In contrast, sensitive parenting and the development of a secure attachment in early childhood will lead to normal timing of adrenarche and the maintenance of attachment security in middle childhood.

Del Giudice hypothesizes that attachment patterns in middle childhood (secure *vs.* avoidant/ambivalent) will predict attachment-dependent reproductive strategies in adulthood. Insecure men are more likely to display avoidant adult romantic attachment and reproductive strategies that are in line with this attachment pattern: short-term, uncommitted mating relationships and a focus on opportunistic sexual behaviour. Insecure women, according to Del Giudice, should adopt anxious, investment-eliciting strategies when environmental risk is moderate (i.e., when environmental cues present in childhood suggested that parents/caregivers were unable to invest in the individual), while avoidant strategies should be selected when faced with greater environmental risk (i.e., when environmental cues suggested that parents/caregivers were unwilling to invest in the individual, higher mortality rate, less resource availability). Finally, secure individuals of both sexes should continue to display security in attachment relationships in adulthood and demonstrate parenting-oriented reproductive strategies focused on future reproduction and high commitment in intimate relationships. Del Giudice does, however, note that in addition to early psychosocial experiences, other environmental cues (e.g., age, important experiences later in life) and/or biological factors (e.g., genetic predisposition, hormonal factors) can also influence reproductive strategies later in development. Thus plasticity may not be confined to childhood, but in fact may extend into adulthood.

1.2.4. Miller and Pasta Model

Although not life history theorists *per se*, Miller and Pasta (2000) have also proposed a model associating early family environmental experience with somatic

development and later reproductive strategies and contraceptive behaviour. Miller and Pasta's model does, however, diverge in one notable way from the other three models outlined above—the authors do not explicitly implicate attachment patterns in their framework. Instead they postulate that all humans possess four types of neural-based bonding systems dedicated to the forms of social bonding that occur during the reproductive life course. They outline the *succorant* system (bonding the infant and child to parents), the *affiliative* system (bonding the child, adolescent, and adult to the sibling and peer), the *sexual* system (bonding the adolescent and adult to the opposite sex partner), and the *nurturant* system (bonding the adolescent and adult to the child). The authors hypothesize that individual differences in approaches to social bonding across the lifespan are a function of both one's biological predisposition (i.e., the neural circuitry that has been laid down, which is suggested to be influenced by gonadal hormones and a number of specific neurotransmitters), as well as the learned affective and security cues, feelings of warmth or affection and feelings of insecurity or fear, one experiences within the local environment. The result is the formation of individually adaptive social bonds.

Miller and Pasta suggest that affection- and security-related experiences within the early family environment (i.e., levels of parental affection and support, types of abuse, parental absence, economic factors including father's occupation) should predict somatic development via its impact on the bonding suprasystem. Thus, the child's perception of affection and security within the family environment should lead to the development of corresponding succorant behaviour (which may be akin to individual differences in childhood attachment proposed by the other models), which in turn will influence pubertal timing and the subsequent development of more adult forms of bonding (e.g., sexual and affiliative bonding). The authors speculate that when affection is high and fear is low, puberty is relatively delayed and a reproductive strategy based on high parental investment is preferred. In contrast, when affection is low and fear is high, puberty is relatively accelerated and the subsequent reproductive strategy is one where childbearing begins as soon as possible, while if affection is low and fear is low, puberty is accelerated and the strategy is based on early and frequent mating but without the added push for childbearing. The authors present empirical data that show that

retrospective self-reports of greater family affection predict later age at menarche. Thus it is possible that the low affection-high fear configuration they discuss may be more representative of females than males, similar to how Del Giudice (2009) has conceptualized anxious romantic attachment-based reproductive strategies in women (i.e., impulsive mating with an associated heightened desire for long-term relationships, intimacy, and romance). In men, anxious romantic attachment may instead be associated with a more cautious sexual approach (e.g., Gentzler & Kerns, 2004; Kirkpatrick & Davis, 1994; Schmitt, 2005).

To round out their model, the authors speculate about the mechanism by which early environmental experience influences pubertal timing. They implicate the hypothalamic-pituitary-gonadal (HPG) axis, suggesting that perception of the amount of parental nurturance in the home perhaps affects a genetic switch that alters levels of circulating gonadal hormones. Changes in the hormonal environment should then lead to the advancement or retardation of the onset of puberty, including its physical and behavioural correlates.

1.3. Behavioural Correlates of Attachment Style

1.3.1. Sexual/Reproductive Behaviours

Empirical studies have supported the behavioural profile associated with the reproductive strategies predicted by secure *vs*. insecure attachment. Secure attachment, as judged by both categorical (e.g., Hazan & Shaver (1987) measure) and continuous self-report measures of attachment style, has been related to stable, investment-oriented romantic relationships (e.g., Hazan & Shaver, 1987; Simpson, 1990; Kirkpatrick & Davis, 1994). In contrast, a large body of research (see Section 1.2.1) has demonstrated that insecure attachment patterns, and avoidance more particularly, are correlated with adult romantic relationship behaviours consistent with a short-term mating orientation, such as more unrestricted sociosexuality, increased promiscuity, greater acceptance of casual sex, decreased likelihood of starting a committed relationship, and permissive attitudes towards infidelity (e.g., Simpson, 1990; Brennan & Shaver, 1991;1995; Feeney

et al., 1993; Kirkpatrick & Hazan, 1994; Cooper et al., 1998; Paul et al., 2000; Gentzler & Kerns, 2004; Schmitt, 2005; Jackson & Kirkpatrick, 2007, Schindler, Fagundes, & Murdock, 2010; DeWall et al., 2011). Furthermore, university students who described an avoidant romantic attachment style were not only more likely to experience a relationship breakup, but also felt significantly less upset and more relief by this outcome compared to secure or anxiously attached individuals (Feeney & Noller, 1992). Similarly, Simpson (1990) found that university-aged men who self-reported higher levels of avoidance on a Likert-type rating scale derived from Hazan and Shaver's (1987) measure showed significantly less emotional distress following the dissolution of a romantic relationship. Level of emotional distress was not found to relate to the secure or anxious attachment styles in men, or across all attachment classifications in women. Sex-specific associations have also been observed by Gentzler and Kerns (2004) who found that higher ECR-rated anxiety in men, but not in women, was significantly correlated with fewer lifetime sexual partners. In addition, Bogaert and Sadava (2002) demonstrated that attachment anxiety correlated with earlier age of first intercourse and more lifetime partners in women only. These findings are consistent with Del Giudice's (2009) theory, which suggests that opportunistic mating in women can be linked with anxious strategies but is not for men.

Some studies do not, however, corroborate the general pattern of results presented above. Within a sample of stable, heterosexual couples (married or cohabitating for at least six months) Brassard et al. (2007) found that higher levels of attachment avoidance in men, as assessed by the ECR, were associated with greater self-reported avoidance of sex. Two studies conducted in adolescents found that avoidant individuals were less likely than those who were securely or anxiously attached to have ever had sexual intercourse (Cooper et al., 1998; Tracy et al., 2003).

These contrasting findings highlight the apparent paradox between the discomfort with intimacy characteristic of avoidant attachment and the opportunistic reproductive approach predicted by this same attachment pattern. These divergent aspects of the avoidant style are not, however, necessarily incompatible when the motives behind engagement in sexual behaviour are taken into consideration. Schachner and

Shaver (2004) demonstrated in a sample of university students that attachment avoidance, as rated by the ECR, was significantly and negatively correlated with sexual motives related to intimacy and expressing emotional value for one's partner. Avoidance was also positively associated with having sex for non-romantic goals such as to avoid long-term relationships and to increase one's status among peers. This could help to reconcile the findings of Brassard and colleagues (2007), who found that attachment avoidance and interest in sexual contact was *negatively* correlated in men, but within the context of being in committed, stable relationships, where not having sex may be reflective of the goal of avoiding intimacy. In contrast, Schachner and Shaver (2004) found that attachment anxiety was significantly and positively correlated with having sex to reduce feelings of insecurity and to feel valued by one's partner. Similar results were found by Davis, Shaver, and Vernon (2004) as well as Tracy and colleagues (2003) in a sample of adolescents, where the anxious pattern of sexual behaviour was especially evident among girls. These findings are consistent with the theory set out by Belsky (1997) outlining differing sexual/reproductive goals for avoidant *vs.* anxious strategists.

1.3.2. Externalizing Behaviours

Another body of research has explored associations between attachment style and a range of externalizing behaviours. Studies conducted in children have found that avoidant attachment is related to higher levels of aggression with peers (e.g., Card & Hodges, 2003; Erickson, Sroufe, & Egeland, 1985; Finnegan, Hodges, & Perry, 1996; Granot & Mayseless, 2001; Renken et al., 1989), as well as diagnoses of conduct disorder (Rosenstein & Horowitz, 1996). Anxious-ambivalent attachment has, instead, been found to predict withdrawal and passive behaviour with peers (e.g., Card & Hodges, 2003; Finnegan et al., 1996; Cassidy & Berlin, 1994; Erickson et al., 1985), as well as increased susceptibility to affective disorders (Rosenstein & Horowitz, 1996). In addition, avoidant children tend to more frequently take on the role of bullies, possibly to assert dominance over their peers (Troy & Sroufe, 1987). Consistent with the theoretical predictions of Del Giudice (2009), the results from some of these studies point to sex-specific associations. Renken et al. (1989) demonstrated that avoidance was significantly correlated with higher levels of physically aggressive behaviour in boys, but not in girls.

Furthermore, Finnegan and colleagues (1996) found that avoidant coping was not only correlated with more externalizing problems (i.e., physical and verbal aggression towards peers, argumentativeness, disruptive behaviour, dishonesty, and dominance over peers), but was also correlated with fewer internalizing problems (i.e., withdrawal, anxiety/depression) but only in boys; preoccupied (anxious) coping was instead significantly associated with higher internalizing problems in males but not in females.

The Young Male Syndrome, as described in Chisholm's (1999) model, refers to the behaviours of aggression, risk-taking, and impulsivity that characterize the alternative reproductive strategy in adult men. Compared to studies conducted in children, in adults the relationship between attachment style and overt behaviours produces a somewhat less clear pattern of results. The general consensus is that attachment insecurity is related to aggressive/abusive behaviours. Most such investigations have been conducted in the context of intimate relationships and/or with men who have a history of violent behaviour. Across these studies, physical aggression perpetrated on female relationship partners has been significantly associated with an avoidant attachment style (e.g., Holtzworth-Munroe, Stuart, & Hutchinson, 1997; Lafontaine & Lussier, 2005; Lawson, 2008; Waltz et al., 2000), anxious attachment (e.g., Bookwala & Zdaniuk, 1998; Fournier, Brassard, & Shaver, 2011; Dutton et al., 1994; Holtzworth-Munroe et al., 1997; Roberts & Noller, 1998), as well as fearful attachment (e.g., Dutton et al., 1994; Mikulincer & Shaver, 2007). It is important to note, however, that because physically aggressive behaviours expressed in adulthood are socially undesirable and potentially illegal, they may be more difficult to study in the general population compared to in children where physical aggression does not yet take a deviant status. This might help to partly explain why relationships are less clear when studied in adult men.

The apparent indiscriminate nature of these results could also be reconciled by the fact that avoidance and anxiety predict physically aggressive behaviours in different contexts. More specifically, dismissing-avoidant attachment in men predicts physical aggression that is motivated by instrumentality (i.e., the deliberate use of violence as an instrument for social influence or to assert authority or control over others), while attachment anxiety (as well as fearful-avoidance) suggest physically aggressive/abusive

behaviours motivated by impulsivity or affective difficulties (Tweed & Dutton, 1998; Babcock et al., 2000). This interpretation of the relationship between avoidance and aggression is consistent with reports demonstrating a significant, positive correlation between men's avoidance scores and their self-reported levels of interpersonal dominance (e.g., Mauricio & Gormley, 2001; Gormley & Lopez, 2003; Hawley, Shorey, & Alderman, 2009; Gormley & Lopez, 2010). The study by Gormley and Lopez (2010) not only found a positive relationship between levels of avoidance and dominance, but also found that attachment anxiety negatively predicted men's dominance scores.

Insecure attachment patterns have also been related to higher levels of verbal aggression and an associated externalizing behaviour, expression of anger. Lafontaine & Lussier (2005) found within a community sample of heterosexual couples that men's avoidance of intimacy (as judged by scores on the ECR) was positively correlated with psychologically aggressive behaviour including insulting and swearing at one's partner. Similarly, Lawson (2008) found that comfort with closeness in relationships (a dimension of attachment avoidance) was negatively correlated with partner reported levels of men's verbal aggression, as rated by the psychological aggression subscale of the Conflict Tactics Scale. In contrast, investigations by Dutton et al. (1994) and Fournier et al. (2011) found that attachment anxiety, not avoidance, was positively correlated with male perpetration of verbal abuse on female partners. With respect to anger, some studies demonstrate that attachment avoidance is associated with greater anger expression (Hudson & Ward, 1997; Troisi & D'Argenio, 2004) and less suppression or inhibition of anger (Hudson & Ward, 1997; cf., Mikulincer, 1998; Creasey & Hesson-McInnis, 2001).

The literature on attachment and risk-taking, another component of the alternative male reproductive strategy proposed by Chisholm (1999), has explored both sexual and non-sexual risky behaviours. These studies have utilized both self-report and behavioural measures of risk-taking and again point to a dichotomy between secure *vs.* insecure patterns of adult romantic attachment; security predicts less engagement in risky behaviours, while insecurity predicts greater involvement. Attachment avoidance has been positively related to high risk drinking behaviour such as heavy alcohol consumption and intoxication, primarily assessed through self-report measures, in a

number of studies conducted in adolescents and adults (e.g., Tracy et al., 2003; Senchak & Leonard, 1992; Laberge, Lussier, & Godbout, 2012; Brennan & Shaver, 1995; Doumas, Turrisi, & Wright, 2006; cf., Letcher & Slesnick, 2014). Furthermore, in a nationally representative sample of approximately 8000 men and women, Mickelson and colleagues (1997) found that interview-rated alcohol abuse and drug abuse were significantly and positively correlated with avoidant attachment scores but not with anxious attachment scores. A significant negative correlation was found between secure attachment and these same variables. It should be noted, however, that given the tendency for people to underreport socially undesirable behaviour including risky lifestyle behaviours (e.g., heavy drinking, drug use), the results of studies employing self-report measures may need to be interpreted cautiously. A study by Schindler et al. (2005) unexpectedly found a significant negative correlation between severity of drug use (reflecting frequency and quantity of substance use, danger of the substances, and methods of consumption among other factors, and validated by urinalysis) and dismissing-avoidant attachment scores in a sample of substance-dependent adults. It is possible that within a more "disordered" sample the relationship between attachment avoidance and drug-taking behaviour may be different than in the general population.

Some studies have also found that dismissing-avoidant attachment is positively correlated with risky sexual behaviours including less reliable contraceptive use among university students (Zlokovich & Snell, 1997) and college men's engagement in coercive sexual behaviour directed at female partners (Smallbone & Dadds, 2000; 2001). Other studies have not, however, supported this association, instead finding that attachment anxiety, not avoidance, was significantly associated with less reliable condom use (Strachman & Impett, 2009; Feeney et al., 1999) and more general sexual risk taking in men (Laberge et al., 2012).

Research exploring the association between yet another dimension of Chisholm's theory, impulsivity, and attachment styles is rather sparse. One study conducted in a non-clinical sample of young adults found that both attachment avoidance and anxiety positively related to levels of impulsivity assessed by the revised NEO personality inventory, but that associations were stronger with anxiety (Scott, Levy, & Pincus, 2009).

In contrast, Johnston (1999) failed to find any association between attachment style (secure, anxious, or avoidant) and an 8-item measure of impulsivity in a largely male sample. This study was, however, not limited to a young adult population, instead subjects ranged in age from 19 to 72 years, which could have moderated the findings. Finally, in a study of children, poorer quality attachment to mother (assessed by a crude self-report measure) significantly predicted higher levels of impulsivity in boys, but not in girls (Chapple & Johnson, 2007).

1.3.3. Internalizing Behaviours

Consistent with studies conducted in the area of attachment and externalizing behaviours, secure attachment has been associated empirically with positive psychological adjustment, including lower levels of depression and anxiety (e.g., Marganska, Gallagher, & Miranda, 2013). In contrast, insecure adult attachment has been linked to both depression and anxiety symptoms. Some studies have found that both anxious and avoidant attachment are concurrently related to depressive symptoms (e.g., Mickelson et al., 1997; Hankin, Kassel, & Abela, 2005), however, closer inspection of the literature suggests that anxious attachment may be more strongly associated to depression than is avoidant attachment (e.g., Marganska et al., 2013; Murphy & Bates, 1997; Riggs & Kaminski, 2010; Wei et al., 2005). Simonelli, Ray, and Pincus (2004) and Williams and Riskind (2004) found that individuals who self-reported secure and dismissive (avoidant) romantic attachment styles reported significantly fewer depressive symptoms, as assessed by the Beck Depression Inventory, than those with preoccupied or fearful styles.

A similar pattern of results has been found in studies investigating the relationship between romantic attachment style and symptoms of anxiety. Although some studies find both anxious and avoidant attachment to be positively associated with anxiety symptoms (e.g., Mickelson et al., 1997; Cooper et al., 2009), overall, anxious not avoidant attachment scores, as measured by self-report questionnaires of romantic attachment, have been found to better predict anxiety symptoms (e.g., Hankin et al., 2005; Marganska et al., 2013). Furthermore, two studies have shown that university

students classified on the basis of their self-report as dismissing-avoidant score significantly lower on self-report measures of state and trait anxiety, as well as pathological worry compared to preoccupied or fearful types (Simonelli et al., 2004; Williams & Riskind, 2004). In children, internalizing behaviours have also more strongly been related to anxious-ambivalent attachment, and negatively related to avoidant attachment in some studies (e.g., Finnegan et al., 1996; please see beginning of Section 1.3.2. for review of these findings).

Self-esteem has been consistently found to be higher in securely attached individuals than insecurely attached individuals (e.g., Collins & Read, 1990; Feeney & Noller, 1990). That being said, the fact that the insecure-avoidant pattern has been empirically associated with positive working models of the self and negative working models of others (Bartholomew, 1990), has led to studies finding that avoidance is positively correlated with levels of self-esteem in both children (e.g., Cassidy, 1988) and adults (e.g., Bartholomew & Horowitz, 1991; Bylsma, Cozzarelli, & Sumer, 1997; Griffin & Bartholomew, 1994; cf., Mickelson et al., 1997; Roberts, Gotlib, & Kassel, 1996). Consistent with the reproductive profile hypothesized by life history theorists to be associated with avoidant attachment, Schmitt (2005) demonstrated in a large cross-cultural study that possessing a short-term mating orientation was significantly associated with higher levels of self-esteem, and that this relationship was specific to men and not women.

1.4. The Biological Basis of Attachment

Although attachment is generally conceptualized in the literature as a learned construct, the fact that it is viewed as an innate human tendency (Bowlby 1969/1982), with a confirmed evolutionary significance, suggests that biological substrates should also contribute to the development of attachment bonds and individual differences in attachment style. Behavioural genetic studies have demonstrated significant genetic contributions to attachment classifications in children (e.g., Finkel & Matheny, 2000; Minnis et al., 2007) and in adults (e.g. Brussoni et al., 2000; Torgersen et al., 2007; Donnellan et al., 2008). In addition, molecular genetic studies have identified specific

candidate genes associated with attachment disorganization in infancy and childhood (e.g., Lakatos et al., 2000; Gervai et al., 2005; Spangler et al., 2009) and with romantic attachment avoidance and anxiety in adulthood (Gillath et al., 2008). Across these studies, polymorphisms in dopaminergic and serotonergic genes have been overwhelmingly implicated. Mechanistically, empirical evidence supports the idea that genetic variation influences susceptibility to environmental experiences, producing a so-called biological sensitivity to context, leading to individual differences in attachment style (e.g., van IJzendoorn & Bakermans-Kranenburg, 2006; Gervai et al., 2007; Reiner & Spangler, 2010; Salo et al., 2011).

The life history models outlined above similarly speculate that both social experience and biological factors contribute to the development of varying reproductive strategies. Belsky et al. (1991) and Miller and Pasta (2000) hypothesize that pubertal maturation represents a bridge between early environmental experience and later relationship behaviour. Puberty is a time of gross hormonal change, whose onset is marked by the dramatic increase in the production of steroid hormones by the gonads via the hypothalamic-pituitary-gonadal (HPG) axis (Swerdloff & Odell, 1975). For males, androgen concentrations rise significantly, with a greater than 20-fold increase in the levels of the androgen testosterone over the course of puberty, while females show only a two-fold increase (Elmlinger et al., 2005, Forest, 1979). In contrast, girls show a substantial increase in estradiol levels compared to boys across the same time frame (Sizonenko, 1978), as a result of increased ovarian production of this major form of estrogen. Accelerated pubertal timing is hypothesized by these theorists to be associated with more opportunistic, mating-oriented reproductive approaches. Earlier transitioning into puberty necessitates that the sex-specific hormonal increases occur earlier compared to same-aged peers. The resulting elevation differences appear to persist into young adulthood. Gesquiere and colleagues (2005) have demonstrated in non-human primates that earlier maturing males consistently had higher testosterone concentrations compared to late maturers at every assessment time point within their study (puberty through to young adulthood). Thus, the sex hormonal correlates of early *vs.* late maturation may

play a central role in men's reproductive behaviour profiles, as predicted by these theories.

Del Giudice (2009) has broadly speculated that *prenatal* exposure to sex hormones, which organize early brain development, could contribute to sex-specific differences in attachment behaviours. Although the exact mechanism by which hormonal exposure during the pre- and perinatal developmental phases can lead to diverging life history trajectories is unclear, individual differences in sex hormone exposure during early development may function similar to genetic variation described above, leading to a biological sensitivity to context and phenotypic differences in attachment and reproductive strategies. Maner and colleagues (2014) have suggested that the masculinizing effects of prenatal androgens in the central nervous system, in concert with environmental instability, are consistent with the initiation of a faster (i.e., more opportunistic) life history strategy both within and across the sexes. Del Giudice (2009) also speculates about the possibility that sex hormone exposure in *adulthood* may represent a "switch" activating sex-specific and genotype-dependent attachment-related behaviours, including reproductive strategies. Similarly, Chisholm (1999) has explicitly suggested that the Young Male Syndrome, his interpretation of the alternative male reproductive strategy, is caused, in part, by testosterone, which he views as a "drug" for engaging in risky activities that maximize current reproduction.

To date, in those few studies where hormones have been investigated in the attachment literature, the majority of the research has focused on the adrenocortical hormone, cortisol, not testosterone. Theoretical interest in cortisol revolves around its established role in the stress response; cortisol is secreted from the adrenal cortex in response to the presence of either physical or psychological stressors. It has been suggested that childhood exposure to non-optimal caregiving and associated attachment adversity impairs the basic functioning of the hypothalamic-pituitary-adrenal (HPA) axis, the human body's primary stress response system (e.g., Repetti, Taylor, & Seeman, 2002; Wismer Fries, Shirtcliff, & Pollak, 2008). Consequently, basal levels of cortisol may systematically differ across the different attachment styles. Studies in adolescents and adults, of which the majority of the work has been conducted in women, have discovered

significant associations between attachment anxiety and basal cortisol. Gordon et al. (2008) and Jaremka et al. (2013) have found that anxiously attached individuals have higher resting cortisol than those who are less anxiously attached, and that levels of attachment avoidance were generally unrelated to daily cortisol levels. Anxiously attached individuals have also been found to show significantly heightened cortisol levels upon awakening compared to those who are securely attached (Oskis et al., 2011), but show a more attenuated cortisol awakening response (i.e., the natural rise to peak cortisol levels that occurs 30-40 minutes after awakening) (Quirin et al., 2008; Oskis et al., 2011). In the only study conducted exclusively in men to date, Rifkin-Graboi (2008) found that attachment insecurity was positively associated with mid-afternoon cortisol levels and attachment preoccupation (anxiety) was positively correlated with later day (17h30) and night-time (21h00) basal cortisol values, but no significant associations were found with waking cortisol.

Further support, however, for the role of *sex hormones* in the attachment system stems from the literature exploring sex differences in attachment. A sex difference in insecure attachment emerges in middle childhood, where boys are more often avoidant than anxious-ambivalent and vice versa for girls (e.g. Finnegan et al., 1996; Granot & Mayseless, 2001; Karavasilis et al., 2003; Del Giudice, 2008, Chen & Chang, 2012). This pattern appears to continue, at least into young adulthood. Meta-analytic study has demonstrated that men show higher romantic attachment avoidance and lower romantic attachment anxiety compared to women across a number of geographical regions (Del Giudice, 2011). Furthermore, the degree to which men and women endorse avoidant/dismissive statements is also sexually differentiated; on average men's romantic attachment avoidance scores, assessed by either interview or self-report measures, are significantly higher than women's (e.g., Bartholomew & Horowitz, 1991; Scharfe & Bartholomew, 1994; Schmitt et al., 2003; Brassard et al., 2007, cf. Gentzler & Kerns, 2004). Some evidence suggests that the sex difference in the avoidant (Schmitt et al., 2003) and anxious dimensions of attachment (Picardi et al., 2002; see also Chopik, Edelstein, & Fraley, 2013) is largest during the reproductive years (approximately ages 18-35).

Any theory of the biological basis of attachment must be able to account for the sex differences that are consistently observed in romantic attachment and attachment-related behaviours. Although psychosocial or learned differences between the sexes are a possible source of many gender differences, the universality of sex differences in attachment across different cultures (e.g., Schmitt et al., 2003) suggests that biology could also play a role. A proximate mechanism underlying the sex difference could possibly be differential levels of sex hormones, including androgens. That being said, it is possible that large cultural differences governing the acceptability of expressing sexual/reproductive behaviours are also important. The sexual/romantic attitudes and mores associated with certain cultures, such as East Asian cultures, could obscure the role of biological factors on romantic attachment and related sexual behaviour, and thus may need to be taken into consideration. For example, in the aforementioned cross-cultural study by Schmitt et al. (2003), the authors found that sex differences in romantic attachment were smaller in East Asia compared to other regions of the world including America, Europe, the Middle East, and South/Southeast Asia.

I will now describe the basic mechanisms by which androgens exert their influence on the brain (Section 1.5), followed by a review of relevant literature in both humans and non-human animal species that explores the associations between prenatal (Section 1.6) and adult levels of testosterone (Section 1.7) and the expression of attachment and related behaviours.

1.5. Testosterone: Mechanisms of Action

The androgens, which include testosterone (T), are steroid hormones synthesized from cholesterol and secreted by the gonads and the adrenal glands in response to stimulation from the hypothalamus and pituitary (Brown, 1994). T exerts its physiological effects on the brain by binding to androgen receptors (ARs) located in neurons throughout the nervous system. The distribution of neural ARs is quite specific, with receptors found in brain regions critical for learning, memory, and emotion such as the hippocampus and its pyramidal neurons (Beyenburg et al., 2000; Kritzer, 2004), temporal cortex (Puy et al., 1995), prefrontal cortex (Finley & Kritzer, 1999), and

amygdala (Abdelgadir et al., 1999). By contrast, ARs are found in lower densities or not at all in other cortical regions (Brown, 1994; Kritzer, 2004). Once bound to AR, T forms a hormone-receptor complex which is internalized into cell nuclei, and in turn binds to androgen-responsive genes at specific binding domains in these genes known as androgen response elements (Choong & Wilson, 1998). Binding can then either activate or suppress gene transcription, which, in turn, can impact protein synthesis and modify cell function (Rubinow & Schmidt, 1996).

The neuronal effects of such binding in the central nervous system occur both during fetal or neonatal development or during adult life (Rubinow & Schmidt, 1996; Swerdloff et al., 1992). Some recent theories suggest androgens could also be active in the pubertal brain (e.g., Schulz, Molenda-Figueira, & Sisk, 2009; Sisk & Zehr, 2005), although this possibility is still speculative. During pre- or perinatal development, androgens have *organizational* effects on brain development in many species. Organizational effects refer to the actions of T during specific defined periods of sensitivity in early brain development that *permanently* alter the structure or functional potential of the nervous system (Phoenix et al., 1959; Breedlove & Hampson, 2002; Wallen, 2009). In humans, gestational weeks 8-24 are believed to constitute such a sensitive period, as the fetal testes transiently secrete high levels of T during this interval (Collaer & Hines, 1995). In other species, AR binding during the "sensitive" window has been found to impact the structure of the brain, including the size of brain nuclei, synapse formation, and axonal and dendritic branching (Gorski et al., 1978; Williams & Meck, 1991; Breedlove, 1992), with different characteristics influenced at somewhat different times during the critical period in development (Smith & Hines, 2000).

Activational effects of T, in contrast, refer to *reversible* changes in brain function brought about by current levels of circulating T in the post-pubertal or adult organism acting upon neural substrates that may or may not also be organized early in life (Eckel et al., 2008). Compared to organizational effects, activational effects occur later in the lifespan, during or after adolescence (Phoenix et al., 1959). In adulthood, AR binding has been found to have neuroprotective effects against oxidative stress (Ahlborn, Prins, & Ceccatelli, 2001) and excitotoxicity in hippocampal neurons (Pouliot, Handa, & Beck,

1996), as well as neuroregulatory effects on neurotransmitter metabolism (Bitar et al., 1991), neurotransmitter (e.g., serotonin) receptor activity (Mendelson & McEwen, 1990; Kendall, Stancel, & Enna, 1982; Hernandez et al., 1994), and neurotransmitter receptor concentrations (Nakamura, Fujita, & Kawata, 2002; Adler et al., 1999). T levels in adulthood have also been found to influence the functional anatomy of brain regions that include the amygdala, hippocampus, and frontal cortex, as revealed by functional neuroimaging studies (Moffat & Resnick, 2007; Maki et al., 2007).

1.6. Is There an Effect of Prenatal Testosterone on Attachment and Related Behaviours?

LHTs of attachment suggest that attachment patterns developed in early life can have long-term effects, including effects on adult reproductive strategies. Although it is conceivable that learning alone could account for the developmental continuity, it is alternatively possible, as speculated by Del Giudice (2009), that T exposure in the prenatal or early postnatal period could contribute to the organization of a neural predisposition toward specific attachment patterns and their persistence into adulthood.

1.6.1. Prenatal Androgen Exposure and Attachment Behaviours

The association between early androgen exposure and attachment per se has not been formally investigated in humans. Some indirect evidence pertinent to this question comes from a study by Helleday and colleagues (1993) who found that adult women with congenital adrenal hyperplasia (CAH), a condition where the adrenal cortex secretes high levels of androgens during gestation, scored significantly higher than age-matched healthy control women on the "social detachment" subscale of the Karolinska Scales of Personality. Higher scores indicate higher levels of detachment in social interactions and lower levels of attachment towards other people (e.g., "I feel best when I keep people at a certain distance"). It should be noted, however, that CAH is a clinical condition, and some women with CAH experience associated physical abnormalities (e.g., genital anomalies), making it possible that there are other condition-related reasons for their higher levels of social detachment than differences in prenatal T exposure alone.

Additional evidence of a possible association between levels of prenatal testosterone and early attachment stems from research conducted in nonhuman animals. Although evidence from animal studies is necessarily indirect, such studies do allow for T levels to be experimentally manipulated, which is not feasible in humans. Wallen, Maestripieri, and Mann (1995) found that infant male rhesus monkeys randomly assigned to receive neonatal treatment with a GnRH antagonist (i.e., T suppressant) initiated and maintained significantly more time in close proximity to their mothers (similar to female monkeys), compared with males who received the antagonist combined with exogenous replacement T, when assessed at one year of age. Males in the T replacement condition (who had supranormal T levels) spent a significantly smaller percentage of their time in proximity to their mothers than either the suppressed T males or females (but not compared to control males). The authors' reasoned that their findings of an inverse relationship between neonatal T exposure and proximity seeking/maintenance reflect a T-dependent change in the character of the infant's interaction with the mother, rather than changes in maternal response to the infants. In studies conducted in two other species, prenatal T administration has been found to dramatically reduce separation-induced distress vocalizations in the young male quail (Bernroider, Holtzrattner, & Rottner, 1996) or guinea pigs (Panksepp, 1998).

1.6.2. Prenatal Androgen Exposure and Attachment-Related Personality Profile: Evidence from Non-Human Animal Studies

A larger body of work has examined associations between early androgen exposure and a variety of personality variables, including those hypothesized by life history theorists to be related to insecure attachment, and particularly the avoidant style in boys and men. The empirical basis for studying these associations in humans stems from research conducted in non-human mammals.

Nonhuman animal studies have consistently provided evidence that early androgen exposure, occurring during the prenatal or neonatal period, *organizes* aggressive behaviour, and that these influences are expressed later in life as the levels of aggressive behaviour displayed spontaneously in experimental contexts. For example,

Epple, Alveario, and St. André (1987) reported that neonatally castrated male saddle-back tamarins displayed significantly less aggressive behaviour compared to control males when pair tested against either intact males or females. Similarly, Dixson (1993) found that neonatally castrated male marmosets displayed significantly fewer aggressive behaviours towards intact males (but not females) compared to males castrated in adulthood. In rats, Brain (1979) found that males castrated within 6 days postnatally displayed little aggression when treated with T as adults, but those castrated and treated with neonatal androgen replacement displayed normal levels of aggressive behaviour as adults.

Rodent models have also showcased that prenatal alterations in androgen exposure affect internalizing behaviour displays. Exposure *in utero* to endocrine disruptors with anti-androgenic properties or genetic mutations causing androgen insensitivity has been associated with increased anxiety-like behaviour (e.g., time spent in open arms of the elevated plus maze) (Carbone et al., 2013; Hamson et al., 2014; Zuloaga et al., 2011; cf., Lucion et al., 1996) and increased depression-like behaviour (e.g., increased immobility in the forced swimming test) (Fujimoto, Kubo, & Aou, 2006) in males.

1.6.3. Prenatal Androgen Exposure and Attachment-Related Personality Profile: Evidence from Human Studies

In humans, studying the effects of prenatal androgen exposure on behaviour is difficult because exogenous manipulation of sex hormones is not permissible for ethical reasons. Therefore, experimentation is ruled out. Some studies conducted in special populations have, however, provided preliminary support for an organizational effect of testosterone exposure during early development on human aggressive behaviour. Females with CAH, who are exposed to elevated androgen levels prenatally, have been found to display significantly higher physical aggression than control females (Berenbaum & Resnick, 1997; Pasterski et al., 2007). Another study demonstrated that both boys and girls exposed to androgenizing progestins (another class of sex hormone) *in utero* were significantly more likely to report using physical aggression in conflict

situations than controls (Reinisch, 1981). Cohen-Bendahan et al. (2005) found that girls from opposite-sex twin pairs, who are hypothesized to be exposed to higher levels of prenatal T due to diffusion of small amounts of T from the male to the female fetus *in utero*, showed higher levels of verbal, but not physical, aggression compared to girls from same-sex dizygotic twin pairs. All of these studies implicate testosterone exposure during prenatal development as the critical timepoint for the induction of the effect on aggressive behaviour.

The above-mentioned studies, although revealing, are difficult to conduct and thus have been limited in their investigative scope. In addition, these studies do not provide information on how individual differences in prenatal T exposure in normal populations affect behaviour. Although somewhat controversial, one trait that has been employed as a retrospective proxy measure of individual differences in fetal androgen exposure is the ratio of the lengths of the second to fourth digits of the human hand—the 2D:4D digit ratio (Manning et al., 1998; Manning et al., 2003). The 2D:4D ratio is a sexually dimorphic trait, and men, on average, have a lower ratio of the second to the fourth digit than women, a sex difference originally discovered by 19th century anatomists. Some evidence suggests the sex difference in 2D:4D is determined by actions of T *in utero* and thus may represent a retrospective marker of the level of androgen exposure during the critical period when the brain becomes sexually differentiated (Manning et al., 1998; Zheng & Cohn, 2011). A smaller ratio is suggestive of greater fetal androgen exposure. In support of this, women with CAH show significantly masculinized digit ratios, similar to the ratios of control men (Brown et al., 2002; Ökten, Kalyoncu, & Yaris, 2002; Rivas et al., 2014; cf., Buck et al., 2003). In addition, Lutchmaya and colleagues (2004) found that higher levels of fetal T, as measured by amniocentesis, were negatively associated with the 2D:4D ratio assessed at 2 years of age, in both sexes. The strongest support for the idea that digit ratio is influenced by androgen exposure stems from a study by Berenbaum and colleagues (2009), which found that individuals with a mutated androgen receptor resulting in complete androgen insensitivity have digit ratios that are feminized; the 2D:4D finger length ratio is higher than those of typical men and similar to those of typical women. Although nearly 500 studies have investigated links between the 2D:4D

ratio and variation in traits believed to be androgen-dependent, the validity of the measure as an accurate reflection of individual differences in prenatal androgen exposure in healthy humans has been questioned (Puts et al., 2004; Berenbaum et al., 2009, Hampson & Sankar, 2012b). Nevertheless, it remains the only practical, albeit indirect, measure available, at present, to estimate individual differences in prenatal T in adulthood.

Several studies have reported a significant correlation between the 2D:4D digit ratio and variables related to sexual behaviours. Smaller 2D:4D ratio, which may reflect greater fetal T exposure, has been associated with higher lifetime number of sexual partners reported by men (Hönekopp, Voracek, & Manning, 2006; cf., Puts et al., 2004; Rahman, Korhonen, & Aslam, 2005), and with stronger short-term relationship orientation in men but not women (Schwarz et al., 2011), preference towards casual sex (Clark, 2004; DeLecce, Polheber, & Matchock, 2014; cf., Puts et al., 2004; Charles & Alexander, 2011, Manning & Fink, 2008), increased levels of courtship behaviours expressed by men during a brief conversation with women (Roney & Maestripieri, 2004), and variables related to reproductive success (e.g., number of offspring, frequency of sex, sex drive) in men but not women (Manning & Fink, 2008).

Consistent with the studies of special populations demonstrating that higher prenatal T exposure is associated with higher levels of aggression in children, research employing finger length ratios as a marker of fetal T exposure has consistently found a negative relationship between 2D:4D and physical aggression (or conduct problems) in children (e.g., Butovskaya et al., 2013; Butovskaya, Burkova, & Mabulla, 2010; Fink et al., 2007; Liu, Portnoy, & Raine, 2012; cf., Williams, Greenhalgh, & Manning, 2003). Most of these studies have observed the negative correlation in boys and not in girls, with one study even demonstrating a positive correlation between 2D:4D and prosocial behaviour in girls only (Fink et al., 2007).

In adults, numerous studies have found that smaller 2D:4D digit ratios are correlated with higher self-reported levels of aggression, including physical aggression, verbal aggression, anger, and hostility (e.g., Bailey & Hurd, 2005a; Hurd, Vaillancourt, &

Dinsdale, 2011; Hampson, Ellis, & Tenk, 2008; Hönekopp, 2011; Shaw et al., 2012; but see Butovskaya et al., 2012; Voracek & Stieger, 2009), as well as physical aggression assessed behaviourally (e.g., McIntyre et al., 2007; Kuepper & Hennig, 2007). Again, the associations appear to predominate in men rather than women, with a recent large meta-analysis concluding that a small, but significant, negative relationship exists between 2D:4D ratios and aggression in men only (Hönekopp & Watson, 2011). A study by Benderlioglu and Nelson (2004) did, however, find a negative correlation between 2D:4D and reactive aggression in women. Reactive aggression refers to anger-like responses (which can be physical) to frustration or provocation. Finding an association between this type of aggression and digit ratios in women specifically is consistent with literature suggesting that impulsive aggression is more commonly seen in individuals with attachment anxiety, which is an attachment style more prevalent among women than men (Del Giudice, 2011). In contrast, Cousins, Fugère, and Franklin (2009) found that low 2D:4D in men, but not women, was associated with higher self-reported levels of intrasexual threats and more threatening and physically aggressive behaviour directed at female partners in order to dominate over others for the purpose of mate guarding. Similar results were found by Maner et al. (2014). These more *instrumental* aggressive tactics have also been found to correlate more strongly with attachment avoidance in men (see Section 1.3.2. for references).

With respect to other externalizing behaviours, low 2D:4D digit ratios (indicative of potentially greater prenatal androgen exposure) have been correlated with higher self-reported levels of dominance (e.g., van der Meij et al., 2012; Manning & Fink, 2008; but see Puts et al., 2004 who reported null findings) and higher levels of perceived male dominance as rated by women (Neave et al., 2003). Furthermore, two studies conducted in non-human primates found significant negative relationships between 2D:4D and dominance rank among females (Howlett, Marshall, & Hughes, 2012; Nelson et al., 2010).

More masculinized 2D:4D ratios (i.e., lower ratios) have also been associated with higher levels of risk-taking assessed primarily in the financial domain (e.g., Brañas-Garza & Rustichini, 2011; Coates, Gurnell, & Rustichini, 2009; Garbarino, Slonim, &

Syndor, 2011; cf., Apicella et al., 2008; Sapienza, Zingales, & Maestripieri, 2009). Lower ratios have also been associated with riskier driving in men (Schwerdtfeger, Heims, & Heer, 2010). Among the very few studies in adults employing self-report measures of risk-taking, two have demonstrated significant negative correlations between 2D:4D and global risk taking assessed across several spheres including financial, social, recreational, ethical, and health domains (Hönekopp, 2011; Stenstrom et al., 2011), while a recent investigation by Evans and Hampson (2014) found that the financial component of the Risk Taking Scale from the Jackson Personality Inventory-Revised was inversely correlated with 2D:4D ratio in university men.

Of the limited work conducted on markers of prenatal T exposure and impulsivity, Hanoch, Gummerum, and Rolison (2012) found a negative correlation between 2D:4D ratios and self-reported levels of impulsivity among male offenders but not among male non-offenders, while Wacker, Mueller, and Stemmler (2013) found in a sample of undergraduate men that lower digit ratios correlated with higher scores on an impulsive sensation seeking scale, which the authors argued assesses the impulsivity component of the "Young Male Syndrome".

Studies investigating the relationship between prenatal T and internalizing behaviours in adults have found that higher 2D:4D ratios are related to higher levels of trait anxiety, anxiety sensitivity, and specific phobia related to computer use (Brosnan et al., 2011; Evardone & Alexander, 2009). Furthermore, more feminized 2D:4D ratios have been found to significantly correlate with higher levels of neuroticism, a personality feature considered to be a dimensional precursor to anxiety (Austin et al., 2002; Fink, Manning, & Neave, 2004). A positive association between 2D:4D and self-reported depression in men has been supported Bailey and Hurd (2005b), but studies by Martin, Manning, and Dowrick (1999) and Austin et al. (2002) failed to find any significant relationship. The only study conducted on the topic of digit ratios and self-esteem produced null findings in a sample of young to middle-aged women (Wade, Shanley, & Imm, 2004).

The limited work conducted in children has suggested that boys with anxiety disorders may be exposed to lower prenatal T levels than other boys, as indexed by their higher digit ratios (de Bruin et al., 2006). Similarly, a study by Williams et al. (2003) found a positive correlation between 2D:4D and parent-reported scores on the emotional difficulties subscale of the Strengths and Difficulties Questionnaire in boys aged 2-5 years, but not in girls. The subscale is comprised of five items assessing primarily symptoms of anxiety (e.g., "Many worries, often seems worried") but also depression (e.g., "Often unhappy, down-hearted, or tearful"). Using the same questionnaire in an older youth sample, Fink et al. (2007), however, failed to find any significant association between 2D:4D and emotional difficulties in either boys or girls.

In sum, the overall pattern of results suggests that greater exposure to T early in life may be associated with higher levels of sexual and externalizing behaviours, as well as lower levels of internalizing behaviours, particularly anxiety. Measures believed to index higher prenatal androgen exposure, in general, appear to relate to the sexual and personality profile predicted by life history theories of attachment to be associated with insecure attachment (i.e., shorter-term mating orientation and increased sexual behaviour, as well as the aggression, risk-taking, and impulsivity of the "Young Male Syndrome"), and possibly the avoidant style more specifically in men.

1.7. Is There an Effect of Adult Testosterone on Attachment and Related Behaviours?

The fact that prenatal T exposure might influence attachment-related behaviours does not preclude the possibility that circulating levels of T in adulthood could also influence attachment. Studies of other species have shown that some behaviours organized by exposure to T early in life only become *activated* when the brain is further acted upon by circulating T in adulthood. In line with this proposition, Del Giudice (2009) theorizes that sex hormonal exposure in adulthood may act as a "switch" activating attachment-related reproductive behaviours organized earlier in life (see Section 1.4). Thus it is possible that attachment predispositions may be laid down in the central nervous system (CNS) early in development, but that androgen-related individual

differences in attachment-related behaviours may not be expressed overtly until appropriate hormonal stimulation is present in adulthood. Alternatively, for other behaviours, research has also shown that activational effects can occur completely independently of organizational effects. From this perspective, effects of androgen on attachment-related behaviours may potentially occur only once an individual is at adolescence or beyond when the testes secrete adult-like levels of hormone, and when reproduction and mating become relevant concerns. Belsky et al. (1991) and Miller and Pasta's (2000) hypotheses about the downstream reproductive consequences of pubertal timing are consistent with this interpretation of activational effects. Relatively earlier pubertal maturation in boys, which is associated with higher endogenous T levels at adolescence and in young adulthood (Gesquiere et al., 2005), represents the catalyst for more opportunistic, mating-oriented reproductive behaviour in these models. Similarly, Chisholm (1999) specifically implicates circulating levels of T as a causal factor leading to his conceptualization of the alternative male reproductive strategy, the Young Male Syndrome. Reversible effects of T on neurochemistry are the usual mechanism that underlies activational effects at the behavioural level and could be a biological basis for T's activation of attachment-related behavioural patterns.

1.7.1. Sexual/Relationship Behaviour

Research exploring the link between circulating levels of basal T in adulthood and sexual behaviour in men has generally pointed to a positive association between these two variables. The strongest support for adult T concentrations exerting a causal effect on sexual behaviour in men stems from experimental hormone-manipulation studies conducted in healthy humans. In a double-blind, placebo controlled study, Bagatell et al. (1994) demonstrated that men (ages 20-40) exogenously treated with a gonadotropin releasing-hormone antagonist, which suppresses endogenous T levels, had a significant decrease in frequency of intercourse, kissing and fondling behaviour, as well as sexual fantasies during the treatment period compared to men in a placebo condition. Moreover, men who received both the T antagonist and exogenous, replacement T maintained their sexual function, suggesting that T was the relevant causal factor in maintaining sexual behaviour in normal men. Similarly, in a sample of healthy young men

pharmacologically induced to be in a hypogonadal state and then randomly assigned to receive either placebo (maintaining the low T state) or replacement T (returning T to baseline levels), Schmidt and colleagues (2004) found that men in the hypogonadal condition reported a significant decrease in sexual interest, as measured by daily ratings of symptoms, compared to baseline and compared to men in the T replacement condition. Other studies administering T to supraphysiologic levels in young men have, however, failed to find any significant effect of changes in circulating T on sexual function (e.g., Bhasin et al., 2001; O'Connor, Archer, & Wu, 2004). These patterns of findings suggest that it may be *physiological* levels of T, falling in a biologically acceptable range, that are relevant in maintaining sexual behaviour in normal men.

The vast majority of the work on this topic is, however, correlational in nature, but nonetheless continues to support the possibility of an activational effect of T on male sexual and relationship behaviours, as suggested by the experimental studies. Across a number of observational studies, single men typically have been found to have higher T levels than men in committed, monoamorous relationships (e.g., Booth & Dabbs, 1993; Mazur & Michalek, 1998; Burnham et al., 2003; Gray et al., 2004; van Anders & Watson, 2006). Higher levels of T have also been correlated with greater numbers of sexual partners in younger (Bogaert & Fisher, 1995; Halpern et al., 2002; Peters, Simmons, & Rhodes, 2008) and older men (Pollet et al., 2011). Furthermore, two studies conducted in African communities found that men in polygynous relationships have higher T levels than their monogamously partnered counterparts (Gray et al., 2003; Alvergne, Faurie, & Raymond, 2009). In a North American sample, van Anders, Hamilton, and Watson (2007) similarly found that men who were monoamorously partnered had significantly lower T levels than either single men or men in polyamorous relationships (i.e. non-religious love relationships with more than one partner). Additionally, the authors found that men who believed in a polyamorous lifestyle, but were not currently multipartnered, had significantly higher T levels than monoamorous men, suggesting that T might be linked with a specific type of relationship orientation; specifically a shorter-term, mating-focused orientation.

Consistent with this possibility, van Anders and Goldey (2010) found that not only single men, but also men self-identifying as being in *casual* relationships had significantly higher T levels than men in long-term committed relationships. Moreover, overall interest in more/new partners was a significant, positive predictor of T levels regardless of partnering status. McIntyre and colleagues (2006) found that young adult men in relationships, but who nonetheless remained interested in new sexual encounters (as assessed by their scores on the sociosexual orientation inventory (SOI)), maintained high T levels despite being paired; there was no association between sociosexuality and T among single men. Edelstein, Chopik, and Kean (2011) similarly found that partnered men with higher scores on the desire component of the SOI (i.e., greater desire for uncommitted sexual activity) had T levels that were comparable to those of single men. The association between sociosexuality and T as a function of partnering status in men has not, however, been supported in one other investigation (van Anders et al., 2007). Finally, in a recent study of heterosexual couples, partnered men's T was negatively correlated with self-reported level of investment within their current relationships (Edelstein et al., 2014).

1.7.2. Aggressive Behaviour

A relationship between circulating T in adolescents or adults and human aggression has long been hypothesized, however, evidence in favour of this association from human studies is mixed. In contrast, research conducted in non-human animals more consistently find that T is related to aggressive behaviour in males (e.g., Lumia, Thorner, & McGinnis, 1994; Kalin, 1999).

Among human adults, the consensus from a number of reviews and meta-analytic studies is that there is an inconsistent and weak but positive correlation between endogenous T and both self-report and behavioural measures of aggression (Archer, 1991; Archer, Birring, & Wu, 1998; Albert, Walsh, & Jonik, 1993). This relationship may be stronger among offender/physically violent subsamples than among normal adults (Archer, Graham-Kevan, & Davies, 2005) but has not been supported in other meta-analytic studies (e.g., Archer et al., 1998; Book, Starzyk, & Quinsey, 2001). Two studies

that employed a double-blind, randomized, cross-over design in a sample of healthy adult men found that exogenous administration of T to supraphysiologic levels resulted in significantly more aggressive responding on a behavioural measure of psychological aggression compared to placebo or baseline (Kouri et al., 1995; Pope, Kouri, & Hudson, 2000). Kouri and colleagues (1995) also found that total scores on a widely used trait-based measure of aggression (the Aggression Questionnaire) were significantly higher than baseline following testosterone administration. Closer inspection of these results indicated that this association was primarily attributable to an increase in the *physical aggression* subscale of the questionnaire; all other subscales did not differ from baseline. Other exogenous T administration studies in healthy, male volunteers have, however, produced null findings with a variety of self-report and behavioural measures (e.g., O'Connor et al., 2002, 2004).

One factor that may help to unify the generally disparate findings is a consideration of participants' ages. According to Archer and colleagues (2005), the associations between T and aggression appear to be most pronounced when people are in their twenties and early thirties. Another factor that merits exploration is the possible mediation of the relationship between T and aggression by dominance. A concept related to aggression, dominance is defined as "limitations imposed on the behaviour of another through the implied threat of aggressive acts" (Archer, 1991). A review conducted by Archer (2006) concluded that across 13 studies (see Archer, 2006 for the list of studies) the majority were consistent with a positive correlation between T levels and various measures of dominance, including leadership, toughness, personalized power, and aggressive dominance.

Consistent with this interpretation, experimental study in non-human primates has found that the exogenous administration of T to cynomolgus monkeys caused a significant increase in contact and non-contact aggressive behaviours compared to controls, but only among those monkeys who held a dominant social status (Rejeski et al., 1988). A recent study by Slatcher, Mehta, and Josephs (2011) demonstrated that among young adult men, higher T was positively correlated with the frequency of dominance behaviours displayed during a laboratory intrasexual competition scenario.

Furthermore, the strong positive association between T and dominance behaviour was only evident among men high in self-reported dominance, as assessed by the Personality Research Form (PRF). Sellers, Mehl, and Josephs (2007) have also found that higher scores on the dominance subscale of the PRF are correlated with higher T levels in university students (T levels in male and female participants were standardized separately to control for sex differences and correlations were collapsed across sex). Other correlational studies conducted in adult men measuring trait dominance or perceived dominance have failed to produce significant associations with adult T (e.g., Johnson, Burk, & Kirkpatrick, 2007; Neave et al., 2003).

1.7.3. Other Externalizing Behaviours

Although physically aggressive and dominant behaviours as well as more unrestricted sexuality can be conceptualized as "risky behaviour", and is in fact conceptualized this way in much of the risk-taking literature, there do remain other types of behaviours that fall into the risk-taking category and which correlate with circulating T levels in adulthood. In men, higher basal T levels have been associated with engagement in risky *health* behaviours such as cigarette smoking (Booth, Johnson, & Granger, 1999; Knussmann & Christiansen, 1989; Fisher et al., 1997), alcohol use and abuse (La Grange et al., 1995; Mazur & Booth, 2014), and drug use (Booth, Johnson, & Granger, 1999; Mazur & Booth, 2014), as assessed by self-report. Furthermore, within a large-scale study of American Veterans (mean age = 37 years), Booth, Johnson, and Granger (1999) found that high T men (after controlling statistically for age), compared to low T men, had a greater probability of having sexually transmitted diseases and physical injuries. A recent investigation by van Anders and colleagues (2012) found that higher salivary T in young adult men predicted safer sex practices, including higher scores on a safer sex composite measure and safer sex resilience (i.e., more likely to follow through on condom use in the face of barriers to do so). These findings remained even after controlling (via multiple regression) for variables that may affect associations between T and sexual risk-taking such as sexual frequency and relationship status. Although it would appear that these findings suggest that higher T protects against sexual risk-taking, the authors reason that engaging in safer sex practices may paradoxically represent a

bolder choice for men as it might be more socially risky for their relationships or their reputation, in general, to be sexually responsible.

A number of laboratory studies have found that higher levels of basal T are correlated with more risky financial decision-making in men (e.g., Apicella et al., 2008; Evans & Hampson, 2014; Stanton, Liening, & Schultheiss, 2011a; Reavis & Overman, 2001). Using a task involving certain outcomes and risky gambles, Stanton and colleagues (2011b) suggested a U-shaped relationship between T and economic risk preferences. Finally, Goudriaan et al. (2010) found that young men who underwent an experimental manipulation that produced high-normal levels of T and low-normal levels of estradiol (the major type of estrogen found in humans) showed a significant increase in risk-taking, compared to baseline. No such increase was found for men randomized to have low-normal T and high-normal estradiol levels.

Although not conducted in an adult sample, a study by Booth et al. (2003) is worth noting. The authors assessed the associations between T, risk-taking, symptoms of depression, and parent-child relationship quality in a sample of boys and girls aged 6-18 years. Results showed that endogenous T levels were independently related to the quality of relationships that sons formed with their mothers, as rated by child reports of intimacy with the parent and parents' reports of their acceptance of their child, among other factors. In boys only, higher T was related to poorer relationship quality with mothers. In addition, poor parent-son relationship quality moderated the association between T and risk-taking, as assessed by youths' self-reports of the frequency of engagement in 18 risky activities over the past year (e.g., "skip a day of school"; "stay out all night without parents' permission). Given the nature of these questions, however, children between the ages of 6-9 years did not complete the risk-taking measure. T-related risk-taking behaviour was more evident as parent-son relationship quality decreased and was less evident as parent-son relationship quality increased. T was positively correlated with risk-taking only when parent-son relationship quality was rated to be low. This was true regardless of stage of development. These findings support the idea that individual differences in the quality of the relationship a son forms with his parent, which may be

indicative of the nature of the attachment relationship, is associated with T, and that the relationship may have implications for adjustment problems, such as risk-taking.

The literature on adult T and impulsivity has generally considered studies investigating the relationship between T and overt behaviours (e.g., criminality and aggression, sensation seeking) as evidence of a T-impulsivity association. Among the few studies that investigated impulsivity specifically, or have employed measures of trait impulsiveness, the findings are mixed. O'Connor et al. (2002) found that hypogonadal young men reported significantly lower levels of impulsiveness (i.e., a lacking of "futuring" or forethought), as assessed by the Barratt Impulsivity Scale-11 (BIS-11), compared to healthy young men. No significant differences were found for the cognitive or motor components of impulsivity. Similarly, Schmidt and colleagues (2004) found that healthy young men at baseline had significantly higher levels of sensory impulsiveness (but not motor or interpersonal impulsivity), assessed using an earlier version of the BIS, compared to their scores following pharmacologically-induced hypogonadism. Two studies employing a behavioural measure of impulsivity, the delay-discounting task, have, however, failed to produce consistent associations between T concentrations and impulsivity in young adult men (Ortner et al., 2013; Takahashi et al., 2006). Some work in non-human animals has demonstrated that gonadectomy in adult male rats enhances behavioural inhibition to footshock, indicating improved impulse control (Svensson, Söderpalm, & Engel, 2000), while testosterone treatment induces behavioural disinhibition, reflecting impulsive-like behaviour (Svensson et al., 2003), lending support to an activational effect of T on impulsiveness.

1.7.4. Internalizing Behaviours

Higher levels of T appear to be associated with higher levels of externalizing behaviours, and conversely may also be associated with lower levels of internalizing symptoms. Studies of young men who are hypogonadal have found that self-reported levels of depressive symptoms are significantly higher among the hypogonadal group compared to healthy controls, and that exogenous T administration over a set treatment period results in a significant reduction in depressive symptoms from baseline (Aydogan

et al., 2012; O'Connor et al., 2002). Similarly, Schmidt and colleagues (2004) found that pharmacologically-induced hypogonadism (low T levels) precipitated depressive symptoms in a subset (~10%) of healthy young men with no previous history of psychiatric illness, supporting the possibility that reduced T may predict the onset of depressive symptoms. Studies of non-human animals in which T levels have been manipulated in adulthood provide further support for a causal relationship (e.g., Bernardi et al., 1989; Buddenberg et al., 2009; Carrier & Kabbaj, 2012). Assessment of basal T in a sample of undergraduate men also found that T was negatively related to depression, and specifically was associated with self-reported sleep symptoms of depression (Sankar & Hampson, 2012; but see van Honk et al., 1999 who found no significant association between T and depression in healthy young men). In contrast, administration of exogenous T to men without a psychiatric history does not appear to have any effect on self-reported levels of affective symptoms (O'Connor et al., 2004).

Higher T concentrations have also been suggested to have an anxiolytic effect. In young men, a hypogonadal state has been associated with higher levels of anxiety in several studies (e.g., Ayodogan et al., 2012; O'Connor et al., 2002; cf., Schmidt et al., 2004). Studies measuring basal T in healthy males have similarly pointed to a negative relationship between T and self-reported anxiety symptoms (e.g., Berglund et al., 2011; Granger et al., 2003; cf., Maner et al., 2008; van Honk et al., 1999). Again, experimental T-manipulation studies conducted in non-human animals support the possibility of a causal effect of T on anxiety symptom reduction, although the mechanism behind this association is not yet known (e.g., Aikey et al., 2002; Carrier & Kabbaj, 2012; for further references see review by McHenry et al., 2014).

Among the limited work available on the topic of androgenic effects on self-esteem, the data point towards a positive relationship between levels of self-esteem and T concentrations in adulthood. Johnson and colleagues (2007) demonstrated that T levels were a positive predictor of scores on a global self-esteem scale in a sample of undergraduate men. Vermeersch et al. (2010) found similar results, albeit in an adolescent male sample (mean age = 14.4 years). In a placebo-controlled study, a positive effect of exogenous T treatment on self-esteem was found in a group of

hypogonadal young men (O'Connor et al., 2002). Significant increases in men's levels of self-esteem were seen between the second and third assessment timepoints in the study (i.e., week 4 and week 8). Consequently, it cannot be ruled out that the observed changes in self-esteem may have been due to associated physical changes secondary to T administration, including concomitant restoration of sexual function. In another study, pharmacologically-induced hypogonadism in healthy men for a period of two months failed to significantly reduce self-esteem scores compared to baseline (Schmidt et al., 2004). Because these men were in a hypogonadal state only transiently, it is possible that the physiological and sexual changes associated with acute hypogonadism may not have been substantive enough to cause negative self-interpretations in participants.

1.7.5. Attachment Behaviours

Finally, some indirect evidence does currently exist of a possible association between circulating T and attachment. Among fathers, those that are more involved in childcare have been found to have significantly lower T levels than those who do not participate in care (e.g., Alvergne et al., 2009; Gettler et al., 2011; Kuzawa et al., 2009; Muller et al., 2009). These findings support the idea that men with lower T are more likely to make a long-term investment in their offspring's care compared to men with higher circulating T, and that interest in forming close, emotional bonds through investment in parenting *vs.* mating effort may be negatively associated with T.

Within a sample of children, Strong and Dabbs (2000) investigated the relationship between children's salivary T levels and their everyday behaviours, including parent-child attachment, broadly. Parents' ratings of children on the "Attached" subscale of the Parenting Stress Index, comprised of two items: "My child wants to be close to his/her mother" and "My child likes to be cuddled or touched", were negatively correlated with T levels in the whole sample, as well as within the prepubertal (3-8 years) and early pubertal (9-12) subgroups separately. Correlations were conducted with boys and girls combined, because at these ages no significant difference in mean T levels between the sexes was evident. As discussed in Section 1.7.3, a study by Booth et al. (2003) demonstrated a significant association between T and parent-child relationship

quality. Among boys, higher T levels were significantly correlated with poorer quality relationships with mothers (i.e., levels of intimacy between child and mother, as well as mother's level of understanding and acceptance toward their child). No such associations were found for girls.

In a recent study examining the interpersonal styles associated with basal T levels in men, Turan and colleagues (2014) hypothesized that high T individuals should show more agency and dominate over others, while also showing lower levels of communion (i.e., unfriendliness, low interpersonal warmth). As part of their assessment of the communal dimension, the authors administered a self-report measure of romantic attachment. Basal T was found to positively correlate with romantic attachment avoidance in their sample, but not with attachment anxiety. The findings from this investigation corroborate the discussion in Section 1.4, providing the first direct evidence of a sex hormonal effect on psychological attachment. The authors did not, however, explore the relationship between adult T and attachment within the broader context of reproductive strategies/orientations, as suggested by life history models.

1.7.6. Summary

Review of the literature appears to suggest that basal levels of T in adult men may be positively correlated with behaviours consistent with greater investment in mating effort (e.g., greater number of sexual partners, more likely to be single) and a shorter-term mating orientation. In keeping with the personality profile predicted by life history theorists to be associated with attachment insecurity, and potentially attachment avoidance in men, some evidence suggests that men's circulating levels of T are positively related to aggression and aggressive dominance, as well as a range of risky behaviours, but are negatively related to behaviours falling into the internalizing category, such as depression and anxiety. Preliminary work in the area of T and attachment is in support of a positive relationship between basal T levels and behaviours more closely aligned with avoidant attachment in men, consolidating the possibility of androgenic influences on psychological attachment in men. The manner in which

androgens, including T, influence attachment patterns and related reproductive strategies still remains to be understood, however.

1.8. A Consideration of Androgen Receptor (AR) Functionality

In humans, T exerts its predominant influences on the brain by binding to ARs in various brain structures. However, ARs are known to vary in their level of functionality following T-binding. Differences in AR functionality are mediated in part by genetic factors including the length of a polymorphic polyglutamine stretch, made up of a variable number of trinucleotide (CAG) repeats, in exon 1 of the AR gene, which is located on the X chromosome (Zitzmann, 2009). Normal CAG repeat sequences range between 9 and 35 repeats, with an average of 20 to 22 (Edwards et al., 1992; Krithivas et al., 1999; Hsing et al., 2000). The relative length of the CAG repeat stretch confers differences in transactivational activity (Hsiao et al., 1999; Irvine et al., 2000) and AR expression (Choong et al., 1996; Ding et al., 2004). Short CAG repeat length is associated with increased transcription of androgen-responsive target genes, while long repeat length is associated with lower levels of AR induced gene transcription (see Zitzmann, 2009). In principle, therefore, it is possible that not only differences in circulating T *levels*, but also individual differences in AR gene CAG length, by influencing the capacity of the CNS to respond to T, may be associated with differential reproductive strategies/orientations in men.

The length of the CAG polymorphism in the AR gene has been associated empirically with conditions that are T-related, including prostate cancer, infertility, male-pattern baldness, cardiovascular disease, and bone density loss (see Zitzmann & Nieschlag, 2003). In the case of prostate cancer, for example, where higher T levels influence the development of the disease, reports suggest that short CAG repeats increase the risk of cancer development and/or age of onset of the disease. Although the findings remain equivocal (e.g., Jönsson et al., 2001), shorter CAG repeat length has been related, in some studies, to greater levels of androgen-dependent psychological traits in men, including physically aggressive behaviour (e.g., Cheng et al., 2006; Rajender et al., 2008; cf., Hurd et al., 2011; Butovskaya et al., 2012), self-reported dominance (Simmons &

Roney, 2011), and trait impulsiveness (Aluja et al., 2011; Westberg et al., 2009). In contrast, longer CAG repeat length (conferring weaker AR functionality) has been associated with greater symptoms of depression (e.g., Sankar & Hampson, 2012; Härkönen et al., 2003; Schneider et al., 2011) and anxiety (e.g., Schneider et al., 2010; Härkönen et al., 2003; cf., Su et al., 2007; Westberg et al., 2009).

Only two studies, to date, have investigated the relationship between polymorphism in the AR gene and socio-sexual behaviours. Simmons and Roney (2011) demonstrated a statistical trend ($p = .063$) towards higher scores on the attitudinal component of the Sociosexual Orientation Inventory among men with shorter CAG repeat lengths, while Roney, Simmons, and Lukaszewski (2010) found that following a brief conversation with a woman, men who showed a larger increase in T levels had shorter compared to longer CAG repeat lengths. Based on their findings, the authors speculated that shorter CAG lengths might predict greater physiological and behavioural investments in heterosexual mating. No studies, at present, have looked to see if the CAG repeat polymorphism predicts individual differences in the degree to which men are calibrated towards specific attachment styles, although such a relationship is plausible if androgens do indeed influence attachment orientation in men.

1.9. Model Presentation

The life history theories of attachment and reproduction that were described in Section 1.2 speculate about a series of causal pathways in the development of an adult's attachment patterns towards romantic/sexual partners that have yet to be empirically tested in a sample of young men. Figure 1 illustrates the life history based model that was tested in the present study, and in the discussion that follows I will outline the predictive pathways that were tested.

In the present dissertation, the causal pathways were tested using structural equation modelling (SEM). SEM is a statistical technique that uses a hypothesis testing approach to test the pattern of inter-variable relations within a theory that is specified *a priori*. In this way, SEM can determine whether a hypothesized theoretical model (e.g.,

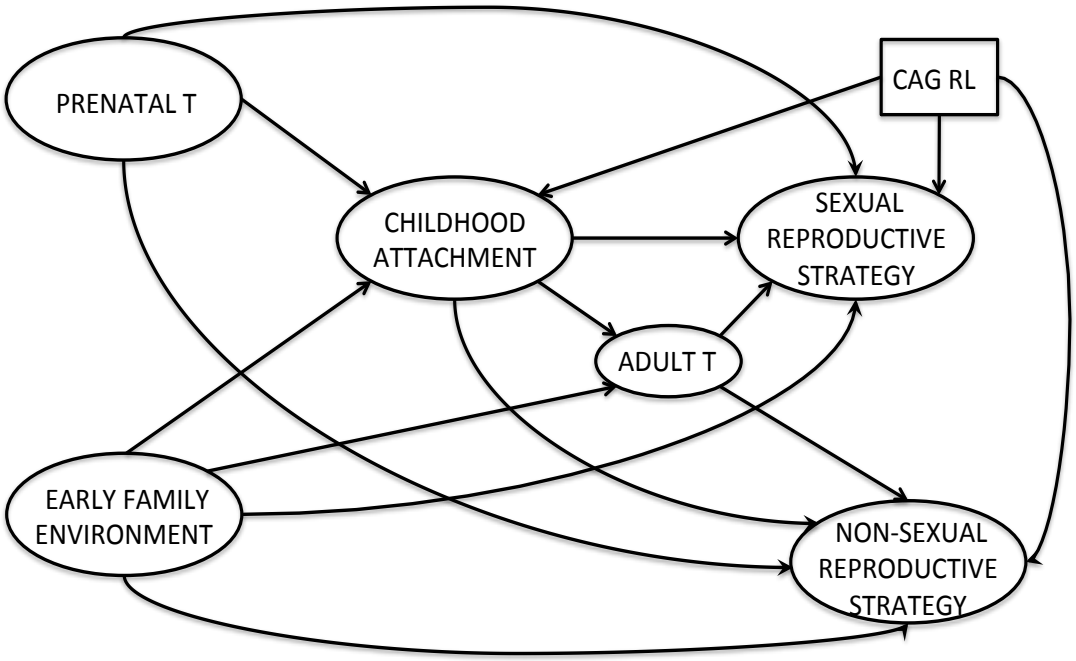

Figure 1. Integrated life history based model. An integrated model of early environmental experience, childhood attachment, and reproductive strategies in men, and their hypothesized inter-relationships with androgens.

LHT-based model) is consistent with empirical data collected to reflect or test the theory. Another advantage of SEM, that made it an appropriate analytic tool for this dissertation, is that it allows for the study of the relationship among latent constructs that are indicated by multiple measures or indicators (e.g., mating orientation, early developmental environment).

The three LHT models that have been discussed above share certain core elements, but also differ in important respects (see Table 1 for a summary of the various LHTs presented). They hypothesize that a boy's early family environment should be a determinant of the type of attachment pattern he displays in childhood. At this level, Belsky et al. (1991) and Chisholm (1999) conceptualize childhood attachment along the dimension of security *vs.* insecurity, as does Del Giudice (2009) within the context of early childhood. Although Belsky (1997) further discusses the differential (and sex-specific) reproductive consequences of avoidant *vs.* anxious-ambivalent attachment in childhood, as does Del Giudice (2009) from middle childhood onwards, Chisholm (1999) predicts that both avoidant and ambivalent (i.e., insecure) children will adopt life history strategies maximizing short-term reproductive effort, and that the two attachment strategies are simply responses to different safety threats. Thus, as outlined in Figure 1, early family environment was hypothesized to be a latent variable that predicts levels of attachment security/insecurity to parents in childhood.

Figure 1 goes on to show that childhood attachment security was hypothesized to predict men's reproductive strategy (both sexual and as defined by non-sexual evocative traits). This is consistent with Chisholm's (1999) theory which speculates that greater childhood attachment insecurity should lead to the display of the constellation of "Young Male Syndrome" traits, characterized by increased aggression, impulsivity, risk-taking, as well as increased sexuality. Belsky (1997) and Del Giudice (2009) hypothesize that childhood attachment will predict adult romantic attachment-specific reproductive strategies characterized by sexual behaviours such as mating orientation (short- *vs.* long-term), number of sexual partners, and onset of sexual activity (earlier *vs.* later). Of note, because adult romantic attachment style has been conceptualized by some theorists to be *a part of* the sexual reproductive strategy (e.g., Belsky, 1997, Kirkpatrick, 1998; Del

Giudice, Angeleri, Manera, 2009), various measures of romantic attachment style were tentatively included as indicators of the sexual reproductive strategy. That being said, other work has suggested that romantic attachment style is a *correlated trait that precedes* reproductive strategy development (e.g., Del Giudice, 2009; Hill et al., 1994a). Consequently, based on the results, the modelling of romantic attachment was modified accordingly (as Section 3.2.5 will later show).

A more avoidance-based reproductive strategy should hypothetically be associated with reduced commitment and short-term mating, while a more anxiety-based reproductive strategy should be associated with a delayed, indirect mating approach designed to maximize closeness with kin and partners (Belsky, 1997; Del Giudice, 2009), although anxiety in women may involve an opportunistic relational mating style (e.g., Del Giudice, 2009). While not explicitly outlined in the LHTs reviewed, a direct causal pathway between early family relationships and behaviours associated with more opportunistic reproduction (e.g., increased sexuality and hypermasculine behaviour) has been hypothesized in some literature (e.g., Draper & Harpending, 1982) and empirical study has provided some tentative support for this connection (e.g., James et al., 2012; Alvergne, Faurie, & Raymond, 2008). Consequently, the connections between early family environment and the sexual and non-sexual reproductive strategies were also modelled, as illustrated in Figure 1.

The potential effects of androgens, which are implicitly but not explicitly outlined in the life history based models, can theoretically occur at one of two time points based on evidence from the neuroendocrine literature reviewed. One possibility is the prenatal period. As shown in Figure 1, prenatal T levels could directly impact levels of childhood attachment insecurity or alternatively could directly predict the sexual or non-sexual reproductive behavioural profile seen in adulthood (including behaviours such as aggressiveness or impulsiveness, as reviewed above). Significant associations at this level would provide support for the organizational effects of androgens on attachment and related reproductive strategies in men.

T's effect within a LHT-based model could alternatively be seen as activational in nature with circulating levels of T in adulthood directly predicting attachment-related sexual and non-sexual reproductive strategies that may or may not have been organized earlier in life (see Figure 1). An effect of adult circulating androgens is thus the second time point where an effect of androgens on attachment bonds or attachment-related behaviours might theoretically be exerted. Recall that the theories of Belsky et al. (1991) and Del Giudice (2009) (as well as Miller & Pasta, 2000) postulate that timing of somatic maturation, secondary to early environmental experience and psychological development, will support the reproductive strategy adopted by men. Given that there is evidence that accelerated pubertal development is associated with having higher endogenous adult T (Gesquiere et al., 2005), it is possible that levels of attachment insecurity in childhood or the early family context could predict basal T levels found in adult men. Thus, these predictive associations were modelled, as shown in Figure 1.

A final androgen-related factor to consider within the model is the role of the CAG repeat polymorphism in the gene that codes for the androgen receptor. Individual variation in the length of this polymorphic stretch can be quantified by using DNA genotyping. As illustrated in Figure 1, measured CAG repeat lengths, which inversely affect androgen receptor *activity* following T-binding, could independently predict sexual and non-sexual reproductive strategies by altering the 'effective levels' of androgen to which the nervous system is exposed. Androgen receptor polymorphism could also be an independent predictor of individual differences in childhood attachment style. Importantly, only characteristics that are influenced through AR binding may be expected to be associated with the AR CAG polymorphism; if T is important in the organizational development of a particular trait but acts through a metabolite of T such as estradiol that does not bind to AR, then we would not expect to find an association. In contrast, the genetic polymorphism itself cannot plausibly cause or be the cause of individual differences in the actual concentration of adult or prenatal T[1]. Similarly, neither early

[1] Although Crabbe et al. (2007) has hypothesized that adult T synthesis may be controlled by feedback mediated by the AR (and thus the CAG genotype) in the hypothalamus and pituitary, most empirical evidence suggests that circulating levels of T are not correlated with CAG polymorphism (e.g., Hampson & Sankar, 2012a; Goutou et al., 2009; Krithivas et al., 1999).

family experience nor childhood attachment can cause individual variability in the length of the CAG repeat sequence.

The following hypotheses were thus proposed: (1) support for Chisholm's (1999) theory would be demonstrated if a test of the model reveals that a less stable early family environment positively predicts childhood attachment insecurity, and attachment insecurity then positively predicts either the non-sexual or sexual reproductive behaviours, or both, (2) support for Belsky et al. (1991) and Del Giudice's (2009) theories would be demonstrated if a less stable early family environment positively predicts childhood attachment insecurity, and in turn attachment insecurity positively predicts the sexual reproductive strategy characterized by more avoidant and less anxious romantic attachment style, (3) the relationship between androgens (prenatal T, adult T, and/or CAG RL) and attachment and related behaviours would be supported based on the model results.

2. Method

2.1. Sample and Recruitment

The final sample size included in all analyses was N =195, out of an original 240 who were enrolled, with participants ranging in age from 18-35 years (M = 21.06, SD = 3.43). All participants were physically healthy heterosexual men recruited from the University of Western Ontario. Participants were recruited through posters placed throughout the university campus, as well as through an introductory psychology participation pool (see Appendix A for a copy of the recruitment poster). Reimbursement was in the form of monetary compensation ($15 CAD) if recruited through posters, or course credit, if recruited through the participation pool.

One hundred and fifty-five participants (79.5% of the sample) were undergraduate students, 38 (19.5%) were graduate students, and 2 (1%) were staff and/or working full-time. Although a university sample may be more restricted than the general population on certain variables pertinent to attachment (e.g., SES), university populations are commonly used in studies of romantic attachment (e.g., Edelstein et al., 2010; Gormley &

Lopez, 2010; Gillath et al., 2008; Gentzler & Kerns, 2004; Schachner & Shaver, 2004). Thus a student sample was considered to be both acceptable and conventional for this type of research. Table 2 summarizes the major demographic variables for the study sample.

In order to be eligible, participants were required to be between the ages of 18-35 years. This age range was selected because many men between these ages are likely to be looking for partners while others may be in stable relationships, enabling greater variability in relationship patterns to be seen. In support of this, Ranta, Dietrich, and Salmela-Aro (2014) found within a sample of over 1000 "emerging adults" (defined as being between the ages of 20-23 years) a nearly even split between the number of participants who were single (41% of sample at age 20; 34% at age 23) *vs.* dating or seeing someone (38% at age 20; 27% at age 23). Cohabitation with a partner was also relatively common (20% of sample at age 20) and became more common in the older age group (34% at age 23). Similarly, De Vaus, Qu, and Weston (2003) found that over the course of their 20s, the percentage of men who were unpartnered went from nearly 90% to 57%, and this number continued to drop with increasing age. Over age 35, the proportion of individuals who were married was quite high and stable (60-70%), while levels of unmarried cohabitation or being single were quite low (less than 10% and 30%, respectively). These data again point to greater variability in partnering status during young adulthood compared to middle age. A further reason for limiting the testing to the 18-35 year age range was because of the belief that short-term sexual strategies may be more frequently adopted in young adulthood, and with increasing age there may be a shift away from shorter-term to longer-term strategies (Buss & Schmitt, 1993).

Participants were required to have had at least one romantic or sexual partner, either currently or over the past 1 year. This criterion was selected to ensure that participants were capable of rating their *typical* experience in a romantic or sexual situation. Only heterosexual men were recruited because the LHT predictions of how attachment style may influence reproductive strategies, are specific to opposite-sex relationships.

Table 2

Demographics of Study Participants

Variable	Mean (SD)	Range (min-max)	% of sample
Age (N = 195)	21.06 (3.43)	18-35	
Total SES of parental household (based on parental occupation and education; N = 195)	13.24 (2.19)	6.50-16.00	
Financial SES of parental household (based on parental occupation alone; N = 195)	11.93 (3.75)	4.00-18.00	
Education (N = 195)			
First year undergraduate students			43.59
Upper year undergraduate students (U2-U4)			35.89
Graduate students			19.49
Staff/working full time			1.02
Ethnicity (N = 195)			
Caucasian			71.79
South Asian (e.g., Indian, Pakistani, Sri Lankan)			12.31
Other (Black, First Nations, Middle Eastern, Hispanic)			15.90

To avoid the possibility that T levels may be altered as a result of medication use, participants were excluded if their responses to two questions on the demographics questionnaire (see Section 2.2 for description of demographics questionnaire) reflected that they had a medical condition that could influence T metabolism or that they used medications (e.g. antidepressants) that can artificially alter T levels. Participants who reported a history of endocrine pathology were also excluded.

A decision was made to exclude 45 volunteers, who self-identified as East Asian, from the final data analyses (resulting in a reduced sample size of 195 out of an original 240), because of the complexities introduced by significant cultural differences that could have influenced the structural relationship seen between outcome variables of interest (see Section 1.4) and because of linguistic concerns related to English proficiency in this subsample. There is evidence in the literature that young adults of East Asian heritage show differences compared with other ethnic groups on major aspects of sexuality, including more restricted sociosexuality and conservative sexual attitudes, as well as a lower proportion of young adults ever having had intercourse and an older age at first intercourse (e.g., Brotto, Woo, & Ryder, 2007; Meston, Trapnell, & Gorzalka, 1996; for review see Okazaki, 2002), irrespective of the length of time participants in these studies spent in the dominant (i.e., Western) culture. In fact, Asian volunteers in the current study were found to differ significantly on these (and other) variables. Their more conservative sexual mores and behaviours made the Asian subsample difficult to compare with the rest of the sample, and in fact their inclusion altered correlational relationships otherwise seen between biological variables and key behavioural variables. For example, the correlation between Adult T and the primary measure of romantic attachment avoidance (ECR avoidance) was in the opposite direction for the Asian subsample compared to Non-Asians (r = -.16 *vs*. r = .22, respectively). By contrast, within the next largest non-Caucasian ethnic group in the study, the South Asians (N = 24), the pattern of associations between androgenic variables and key behavioural variables was in keeping with the rest of the Non-Asian subgroup and differed from the East Asians (e.g., r ECR avoidance & Adult T = .43).

There was also a validity issue related to linguistic proficiency. The current study required the completion of a large number of self-report questionnaires, totalling over 300 items. Some of the questionnaires included questions that were semantically complex and thus validity of the responses could only be assured in participants who were adequately fluent in English. Two-thirds (64%) of the Asians indicated that English was not their primary language. Although not in itself indicative of comprehension of questionnaire content, these data coupled with the observation that numerous Asian participants appeared to have difficulty understanding test instructions provided by the experimenter and often took very substantially longer to complete the questionnaires, suggested that their comprehension of the test material could not be assumed.

2.2. Procedure

Participants were scheduled for a single one-hour visit to the laboratory, where they completed a set of confidential paper-and-pencil questionnaires and where biological specimens were collected. Each participant was tested individually in a quiet testing room between 1300 and 1800 hrs, to control for circadian variation in T. Circulating T levels are most steady in the afternoon and early evening (Gupta, Lindemulder, & Sathyan, 2000), a time of day that is thus recommended for studies where individual differences in T are the focus of investigation (Yang et al., 2007). On arrival, DNA sampling was performed as described below, to determine each individual's AR genotype (CAG repeat length). Two saliva specimens were then collected for the measurement of T, one immediately after the DNA sampling and a second approximately 35 minutes later. T concentrations from the two specimens were assayed independently then averaged to yield single mean values. When collected under well-controlled conditions, there is an excellent correlation ($r = .85$) between a single timepoint measure of T and the mean of seven samples taken over one year (Vermeulen & Verdonck, 1992) or even longer time periods (Mazur & Michalek, 1998). In addition to saliva collection, a digital photocopy of the underside of each participant's right and left hand was taken to measure the 2D:4D digit ratio. Specimen collection and hand measurement are described below.

Participants completed a series of paper-and-pencil self-report questionnaires

(described in detail below), in person. Because of the large number of questionnaires administered, the individual questionnaires were printed on different coloured paper to help maintain participants' attention. Questionnaires were organized into two separate booklets, which were administered independently during the test session (see Appendix B for order of questionnaire presentation). In an effort to maintain perceived confidentiality of responses, following the completion of each questionnaire booklet participants placed the completed booklet into a sealed envelope before returning it to the experimenter.

In addition to the completion of the questionnaire booklets, participants also completed a demographics questionnaire (see Appendix C for copy of questionnaire), which was administered at the start of the test session while participants collected the first of the three saliva samples. The demographics questionnaire inquired about health and environmental factors that can affect T levels (e.g., medications, hormonal conditions, waking time, smoking status, recent alcohol use), hand measurements (i.e., having sustained injuries that could affect the growth of the fingers), or attachment patterns (e.g., parents' occupations and education levels used to compute family socioeconomic status, family structure, sibling order). In addition, other demographic variables assessed were self-reported ethnicity and participants' first language.

2.3. Instruments and Measures

2.3.1. Attachment Scales

Participants completed a series of self-report questionnaires to assess the degree to which they conformed to particular patterns of adult romantic attachment. Several researchers have contended that questionnaire-based measures of romantic attachment are more predictive of mating outcomes such as couple stability and sexual behaviour and more accurately represent one's orientation towards short-term vs. long-term mating than interview-based measures such as the Adult Attachment Interview (AAI; George, Kaplan, & Main; 1984, 1985, 1996), which may be primarily measuring one's level of caregiving/parenting outcomes (e.g., Del Giudice, 2009; Bernier & Dozier, 2002; Kirkpatrick,1998). Consistent with this, the correlation between AAI classification and self-reported romantic attachment has been found to be low (r = .09) (e.g., Roisman et

al., 2007). That being said, questionnaire-based methods do demonstrate a moderate correlation with interview measures assessing the *same* content domain (e.g., romantic relationships), with correlation coefficients ranging in size from $r = .27$ to $r = .50$ (Griffin & Bartholomew, 1994; Bartholomew & Shaver, 1998). These findings suggest modest convergent validity between the two main research traditions in the attachment literature, and support the use of self-report questionnaires to assess romantic attachment.

In the present study, two attachment questionnaires were administered. In order to assess individual differences in typical attachment to a romantic partner, participants completed the *Experiences in Close Relationships* (ECR) Questionnaire (Brennan, Clark, & Shaver, 1998). The ECR is considered to be a preferable measure of romantic attachment compared to other commonly used scales (Fraley, Waller, & Brennan, 2000). It is comprised of two subscales: an 18-item *anxiety* subscale, which assesses an individual's concern about abandonment in a romantic context, and an 18-item *avoidance* subscale, which assesses an individual's discomfort with closeness in a romantic context. Sample items include: "I worry a fair amount about losing my partner" (anxiety), and "I don't feel comfortable opening up to romantic partners" (avoidance). Participants are asked to rate the extent to which they agree with each statement using a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Ratings are based on how an individual *generally* experiences relationships and not just in what is happening in a current relationship. Following the usual scoring procedure, items on each of the subscales were summed and averaged. In my sample, the alpha coefficient for the avoidance subscale was $\alpha = .91$ and $\alpha = .92$ for the anxiety subscale. These statistics are highly similar to those obtained by other researchers using the ECR (e.g., Brennan et al., 1998; Edelstein et al., 2010).

The ECR provides a continuous rating of participants' levels of attachment avoidance and anxiety with a typical romantic partner. Research suggests that attachment is a quantitatively distributed variable that may be better modelled with graded dimensions rather than categories, especially in the realm of adult attachment (e.g., Fraley & Waller, 1998). Consequently, the primary measure of interest was participants' continuous scores along the two dimensions (see Section 3.2.1 for how measures of

romantic attachment, including continuous measures from the Relationship Questionnaire described below, were integrated into the LHT-based model tested).

Although a revised version of the ECR has been developed (ECR-R; Fraley et al., 2000), empirical examination of the ECR-R's construct validity has found that several of the new items comprising the Anxiety subscale have large amounts of unexplained variance (Fairchild & Finney, 2006). The authors suggest that some of these new items may not be addressing issues specific to attachment anxiety (e.g., "My partner only seems to notice me when I'm angry") and thus may not be representing the latent construct for which they were written. Furthermore, it has been suggested that many of the ECR-R items are conceptually redundant, thereby reducing scale parsimony (i.e., Fairchild & Finney, 2006; Fraley et al., 2000). For these reasons, I decided to use the original ECR as the primary measure of romantic attachment.

Because of the relevance of romantic attachment within the current study, a second measure of adult romantic attachment was administered—The *Relationship Questionnaire* (RQ; Bartholomew & Horowitz, 1991). The RQ is a widely used and well-validated measure of romantic attachment (e.g., Schmitt, 2005; Sibley, Fischer, & Liu, 2005). The RQ consists of four short paragraphs describing the four attachment styles. For example, the dismissing prototype reads as follows: "I am comfortable without close emotional relationships. It is very important to me to feel independent and self-sufficient, and I prefer not to depend on others or have others depend on me." Respondents were asked to read each description and rate the *degree* to which each description "corresponds to your general relationship style" on a 7-point Likert scale, ranging from 1 (not at all like me) to 7 (very much like me). Responses to the four questions provided a continuous measure of the degree to which each participant endorsed avoidant, anxious, secure, and fearful attachment behaviours. The RQ also contains a forced-choice question where participants are asked to choose which of the four paragraphs is *most* characteristic of their personality. Because of the relative brevity of both the continuous and categorical components of the RQ, its psychometric properties are considerably weaker than the ECR. Nevertheless, the RQ remains a commonly used measure of romantic attachment within the attachment literature. In addition, it is the

only measure, among popular measures of attachment, to demonstrate independence from self-deceptive biases (Leak & Parsons, 2001). Reliability estimates for the RQ categorical classifications over an 8-month interval is .35, with approximately 60% of individuals self-reporting the same attachment pattern from time 1 to time 2. Test-retest reliability for the RQ continuous ratings is higher, ranging from .70 over a 3-week interval to .50 over 8-months (Scharfe & Bartholomew, 1994; Sibley et al., 2005).

Although LHTs of attachment (e.g., Belsky, 1997; Del Giudice, 2009) predict continuity between attachment patterns in childhood and adulthood, discontinuity in attachment across development may sometimes exist (for review see Fraley, 2002). Changes in attachment categories have been found in response to environmental (including emotional) experiences that diverge from existing experience. For example, supportive spousal relationships may help to moderate the effects of difficult early attachment relationships (Brown & Harris, 1978; Crockenberg, 1987; Quinton, Rutter, & Little, 1984). In addition, major life transitions that involve the adoption of new social roles, such as leaving for university or getting married may be opportune times for people to reorganize their internal working models of attachment (Scharfe & Bartholomew, 1994). Trivers (1985) reasoned that offspring behaviour is only guided by parental behaviour as long as the offspring is *dependent* on the parent. Thus childhood personality traits, including attachment, influenced by parents are adaptive in the limited context of parental care, but can be modified or replaced in the transition to adulthood.

The *Retrospective Attachment Questionnaire* (RAQ; Parkes, 2006) was administered to assess participants' attachment to parental figures in childhood. The RAQ is a self-report questionnaire that asks adults about their childhood relationships with parents, using 30 yes-no questions rated for each parent independently (e.g., "Was either parent inclined to tease you or make you feel small?"), and about their childhood emotional experiences, using 33 additional yes-no questions (e.g., "Did you find it hard to accept cuddles, or other demonstrations of affection?"). Questions on the first part of the RAQ referred to the parents who raised the participant during childhood. As such, participants raised in single-parent homes were unable to answer the 30 questions about their childhood relationship with their absentee parent. No established procedure exists,

however, for handling missing data due to parental absence, which likely has important consequences for an individual's attachment history (C. Parkes, Personal Communication, September 11, 2013). To handle this issue, participants who failed to provide responses for one parent on Part I of the questionnaire due to single parenthood were assigned a "yes" response for five specific items. These items all inquired about separation from or absence of a parent (e.g., "Were you separated from either parent for more than a month before the age of 6 years?"; "Was your parent often away or not available?"). The remaining 25 items were coded as "no" because the absentee parent was not available for the participant to have had any of the experiences described with him/her during their childhood. By contrast, an established procedure does exist for handling random individual missing responses on Part I and Part II of the RAQ (see Parkes, 2006).

Based on responses to the RAQ, continuous scores of attachment security/insecurity, anxiety, avoidance, and disorganization were derived following the standard computational criteria outlined by Parkes, 2006. Higher scores reflected greater levels of insecurity and/or its subtypes. Scores reflected style of attachment to the parental unit, rather that to mothers and fathers individually. The categorization of attachment patterns using the RAQ demonstrates high test-retest reliability, ranging from .81 to .91 across the different attachment styles (Parkes, 2006). Internal consistency estimates for the four attachment patterns have been reported to be strong, ranging from α = .80 (avoidant attachment) to α = .94 (secure/insecure attachment score) (Parkes, 2006). Within the current study, alphas ranged from moderate to high: $\alpha_{insecure}$ = .85; $\alpha_{anxious/ambivalent}$ = .85; $\alpha_{avoidant}$ = .58; $\alpha_{disorganized}$ = .66. Although the RAQ is relatively new in the literature, Crowell et al. (2008) endorse the RAQ as a potentially valuable measure of attachment history.

2.3.2. Personality and Motivational Scales

In order to measure individual differences in willingness to engage in casual, uncommitted sexual relationships, or as Buss and Schmitt (1993) frame it, the orientation towards or away from a short-term mating strategy, participants completed the *Sociosexual Orientation Inventory* (SOI; Simpson & Gangestad, 1991). The SOI is a 7-

item scale that assesses attitudinal (e.g., "Sex without love is OK") and behavioural markers (e.g., "With how many partners have you had sex on *one and only one* occasion, in your lifetime?") of sociosexual orientation. One question from the revised version of the SOI (SOI-R; Penke & Asendorpf, 2008), which inquires about frequency of sexual fantasies outside of a committed relationship ("How often do you have fantasies about having sex with someone you are not in a committed romantic relationship with?"), was included in the present questionnaire to further assess attitudes towards engagement in uncommitted sex. The first 3 items are assessed using an open-ended response format, while the remaining 5 items are rated on a Likert scale, with item 4 rated on a scale from 1 (never) to 8 (at least once a day), items 5-7 rated on a scale from 1 (strong disagree) to 9 (strongly agree), and item 8 rated on a scale from 1 (never) to 5 (at least once a day). A higher score on the SOI is indicative of a more *unrestricted* sociosexual orientation. The SOI demonstrates an adequate level of internal consistency ($\alpha = .73$ as found by Simpson & Gangestad, 1991; $\alpha = .75$ in the current study) and a high temporal reliability ($r = .94$) over a two-month test-retest period (as cited in Schmitt, 2005). Discriminant validation evidence reveals that sociosexuality does not correlate highly with sex drive, sexual satisfaction, sex-related anxiety, or sex-related guilt, but predicts if someone has engaged in sex with more than one partner in a given time period (Simpson & Gangestad, 1991).

The primary distinction between the original SOI and the revised version, the SOI-R, is the inclusion of sociosexual desire questions on the SOI-R (Penke & Asendorpf, 2008). Given that I also administered the Sexual Desire Inventory (see below; Spector et al., 1996), which directly measured men's motivation for sex in the abstract, there was deemed to be no added advantage to using the SOI-R. Moreover, the SOI-R and its facets have been found to be unrelated to romantic attachment styles (Penke & Asendorpf, 2008), which contrasts with the SOI, which has been found to significantly correlate with romantic attachment patterns across several cultures (e.g., Schmitt, 2005, Brennan & Shaver, 1995; Jackson & Kirkpatrick, 2007).

Because the literature suggests that the adoption of a short-term, opportunistic mating approach involves a low level of commitment in romantic relationships (e.g., Belsky et al., 1991), Lund's (1985) nine-item *Commitment Scale* was administered. The

Commitment Scale assesses participants' commitment in a romantic relationship (e.g., "How likely is it that you and your partner will be together six months from now?"). Responses to each of the nine items are made on a 1 (not at all) to 7 (very much) scale. A higher score is indicative of a greater level of commitment. Because the questions on this scale inquire about level of commitment within a *current* or existing romantic relationship, the measure could only be completed by participants who were in a romantic relationship at the time of testing. Reliability, as measured by Cronbach's alpha, is typically high (α = .85 in the current study; α = .82 as found by Lund, 1985). Higher scores on the Commitment Scale are seen in individuals who define themselves as more exclusive and pledge to continue their current romantic relationships (Lund, 1985).

Because higher sexual motivation or desire may be required to more successfully engage in a short-term mating strategy (Buss, 1998), the 15-item modified version of the Sexual Desire Inventory (SDI; Spector et al., 1996) was administered. The SDI is a measure of sexual desire in the abstract and thus can be completed independent of partner availability (e.g., "How strong is your desire to engage in sexual activity with a partner?"). The current version of the SDI was adapted by the addition of one question: "During the last month, how often have you had sexual thoughts?" (see also van Anders, 2012). Subjects are asked to indicate the strength and frequency of sexual desire over the past month on an 8-point scale that ranged from "no desire" to "strong desire." The inventory produces total, solitary, and dyadic SDI scores. Internal consistency of the 15-item measure used in the current investigation was high at α = .88. In Spector et al. (1998), the SDI showed a test-retest reliability of 0.76 over a 1-month period. The SDI has been validated in numerous studies (Spector et al., 1996; Spector & Fremeth, 1996; Galyer et al., 1999; King & Allgeier, 2000).

The *Aggression Questionnaire* (AQ; Buss & Perry, 1992) was administered, with the addition of 5 supplementary items. The AQ assesses four factor analytically derived components of aggression, including instrumental components (*physical aggression*, *verbal aggression*), affective components (*anger*), and feelings of ill will and injustice, which constitute the cognitive component of aggression (*hostility*). Five additional verbal aggression items taken from the Verbal Aggressiveness Scale (Infante & Wigley, 1986)

were added to the original 29-item scale, in order to supplement the verbal aggression subscale of the AQ. This was done because the AQ verbal aggression scale consists of only five items, which is very limited. All statements (e.g., "I have become so mad that I have broken things") were rated on a 5-point Likert scale ranging from 1 (extremely uncharacteristic or men) to 5 (extremely characteristic of me). The score on each subscale is the sum of the item ratings. The total aggression score is the sum of the four subscales. Internal consistency across the four scales has been found to generally range from $\alpha = .70 - .85$ (Buss & Perry, 1992; Harris, 1997; Hampson et al., 2008). Similarly, in the current sample, alpha reliability was found to range between $\alpha = .77 - .83$. For the total modified AQ score, Cronbach's alpha was even stronger at $\alpha = .90$. Test-retest reliabilities for the subscales were found to be high over a nine-week interval ($r = .72 - .80$; Buss & Perry, 1992). The AQ also demonstrates moderate to high convergent validity with other measures of aggression, including scales designed for clinical use (Harris, 1997).

The *Risk-Taking Scale* from the Jackson Personality Inventory-Revised (JPI-R) (Jackson, 2004) was used to measure risk-taking tendencies. Participants are asked to provide true or false answers for 20 items (e.g., "I think I would enjoy almost any type of gambling") that assess four facets of risk-taking: monetary, physical, social, and ethical risk-taking. Internal consistency reliability values are high, ranging from .81 to .84 using coefficient alpha (Jackson, 1994); a similar estimate was obtained in the current study ($\alpha = .83$). Test-retest reliability for the Risk-Taking Scale has been found to range between .84 and .95 in a sample of college students (Jackson, 1994). In a test for validity, Jackson (1994) reported correlations with the completion of an adjective checklist of $r = .75$.

Selected subscales of the Personality Research Form—Form E (PRF-E; Jackson, 2003) were used to measure dominance, impulsivity, and autonomy. Participants read each statement such as "I try to control others rather than permit them to control me" (Dominance), "I often stop in the middle of one activity in order to start something else" (Impulsivity), or "I could live alone and enjoy it" (Autonomy) and give a true-false response based on agreement with the statement. Cronbach's alpha reliability coefficients have been found to be high for all three components, with $\alpha = .90$ for

Dominance, α = .79 for Impulsivity, and α = .76 for Autonomy (Jackson, 1999; Paunonen, 1998). I obtained comparably high internal consistency values with α = .75 for Impulsivity, α = .75 for Autonomy, and α = .76 for Dominance. Evidence of convergent validity for the PRF-E subscales has been demonstrated (Jackson, 1999). For example, Dickman (1990) found high correlations between the PRF Impulsivity scale and other measures of impulsivity, ranging from *r* = .64 to .83.

In order to quantify participants' typical mood patterns, the *Profile of Mood States* (POMS; McNair et al., 2003) was administered. The POMS asked participants' to rate each of 65 mood-related adjectives on a 5-point Likert scale, ranging from 0 (not at all) to 4 (extremely), reflecting the extent to which each word accurately described the participants' typical mood. Ratings can be summed to yield scores on six factor-analytically derived subscales: Tension, Depression, Anger, Vigor, Fatigue, and Confusion. Only subscale scores for Tension and Depression were computed for the current study because of the known associations between internalizing problems and attachment insecurity and T, respectively. High levels of internal consistency have been found for each of the subscales in normative samples of adult men, ranging from .83 (Confusion) to .92 (Depression and Anger) (McNair, Lorr, & Droppleman, 1992). Consistent with this, Cronbach's alpha values for the Tension and Depression subscales in the current study were α = .88 and α = .93, respectively. The POMS total score correlates highly with another general measure of mood state, the Visual Analog Mood Scale (*r* = .79), while the Tension and Depression subscales have both been found to correlate highly with other well-known measures of anxiety and depression, respectively (Nyenhuis et al., 1999).

Because higher levels of self-esteem may represent a socially competitive trait predictive of a shorter-term mating approach (Buss & Schmitt, 1993), The *Rosenberg Self-Esteem Scale* (RSE; Rosenberg, 1965) was administered. The RSE consists of 10 items assessing global self-esteem (e.g., "On the whole, I am satisfied with myself"), rated on a 4-point scale ranging from strongly disagree to strongly agree. Previous studies have reported high internal consistency estimates, ranging from .72 to .90 (Gray-Little, Williams, & Hancock, 1997; Robins, Hendin, & Trzesniewski, 2001). Similarly,

within the current investigation the Cronbach's alpha was high at α = .88. The RSE also shows test-retest reliabilities ranging from .82 over a 1-week interval (Fleming & Courtney, 1984) to .63 over a 6-month period (Byrne, 1983) and .50 on a 1-year retest (McCarthy & Hoge, 1984). The RSE converges moderately to highly (*r* = .62 - .93) with other measures of global self-esteem (Robins et al., 2001).

The *Marlowe-Crowne Social Desirability Scale Form C* (MC-C; Reynolds, 1982) was administered to evaluate whether participants were responding to questionnaires in an accurate and truthful manner. The MC-C is a 13-item short form of the original Marlowe-Crowne Social Desirability Scale (Crowne & Marlowe, 1960). Shorter forms are suggested to be more amenable for use in personality research as they correspond more closely to the length of other unitary trait/state measures of personality (Reynolds, 1982; Fisher & Fick, 1993). The MC-C is composed of 5 items which are keyed "true" (i.e., highly desirable behaviours but low probability of occurrence, e.g., "I'm always willing to admit it when I make a mistake") and 8 items which are keyed "false" (i.e., socially disapproved behaviours but high probability of occurrence, e.g., "There have been times when I was quite jealous of the good fortune of others"). Each item is rated on a 2-point (true-false) scale. High scale scores indicate a strong tendency to respond in a socially desirable fashion. The MC-C demonstrates good psychometric properties with internal consistency estimates ranging from .62 to .76, including in the current study (α = .62) (Ballard, 1992; Loo & Thorpe, 2000; Reynolds, 1982; Zook & Sipps, 1985) and a six-week test–retest correlation of .74 (Zook & Sipps, 1985). Scores on this form have been found to correlate highly with the original Marlowe-Crowne Scale with reported values of .91 to .96 (Fischer & Fick, 1993; Loo & Thorpe, 2000; Reynolds, 1982). Because the MC-C uses the same response format as the Risk-Taking scale and PRF-E, the items for all of the scales were randomly ordered and merged to form a composite questionnaire for the purposes of test administration.

In order to obtain information about each participant's relationship/dating history, a Dating History Questionnaire was created and administered (see Appendix C). Developed by the experimenter, the questionnaire was comprised of seven questions inquiring about participants' current partnering status (i.e., single, steady partner but

living apart, steady live in partner, more than one steady partner, married, divorced, separated, widowed), the length of participants' most recent relationship (in months), participants' typical relationship length (in months), age at first intercourse (if sexually active), as well as the total cumulative lifetime number of intimate relationships (both sexual and romantic). For comprehensiveness, participants were also asked the number of children they had, as this may be indicative of greater mating effort (e.g., Pollet, Cobey, & van der Meij, 2013). The last question provided participants with an open opportunity to explain to the experimenter if there were any reasons why their answers on the questionnaires would be atypical (e.g., recent relationship dissolution, current stressor).

2.4. Hand-Related Measurements

Digital images of the underside of both the right and left hands were used to measure the ratio of the lengths of the second to fourth digits (2D:4D ratio). Images were obtained by using a digital copier/scanner, and one hand was imaged at a time. Participants were asked to place their fingers in a splayed position on the glass scanning surface and press lightly so as to distribute pressure evenly over the surface of the hand. Finger length was measured from the images produced using a high-precision digital calliper (Digital Measurement Metrology, Inc., Model ABS) with a resolution of 0.005 mm. The physical landmarks used to measure digit length were the most basal crease where the finger joins the palm and the most distal point on the fingertip (see Figure 2 for illustration of hand measurements made). The experimenter was the primary rater. Inter-rater reliability for the 2D:4D measurement is typically very high, with intra-class correlations of $r = .95$ or higher (e.g., Hampson & Sankar, 2012b; Berenbaum et al., 2009).

2.5. AR Genotyping

To minimize saliva impurities, participants abstained from eating, drinking fluids other than plain water, smoking, chewing gum, or brushing their teeth for 30 minutes before sample collection. Before the first saliva sample was obtained, participants rinsed their mouths with water. Participants then collected about 2 mL of saliva into a sterile

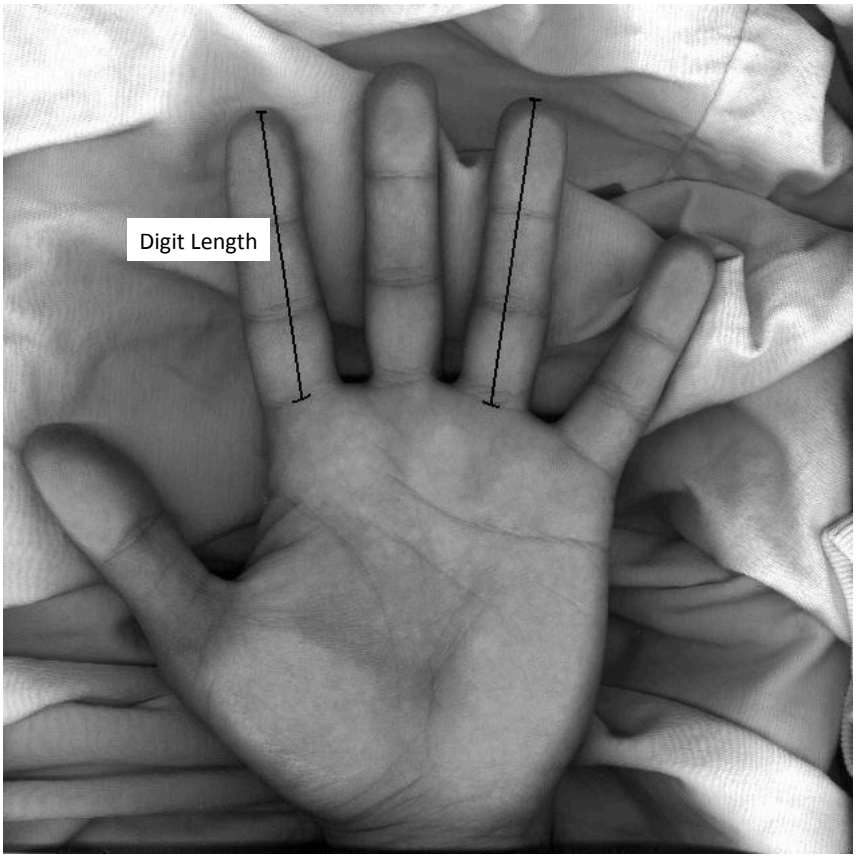

Figure 2. Illustration of hand-related measurements. Overview of the hand measurements performed on the digital images taken of participants' right and left hands.

Oragene·DNA vial (DNA Genotek, Inc., Kanata, Ontario, Canada). Once collected, the whole saliva was mixed with 2 mL of Oragene·DNA stabilizing solution and stored prior to analysis. Saliva sampling produces a higher DNA yield than mouthwash or buccal swab methods, and better quality DNA than the buccal swab (Rogers *et al*., 2007). The median yield using the Oragene method is 110 ug.

Genotyping of the repeat polymorphism in the gene coding the androgen receptor (*AR*) was performed by The Center for Applied Genomics at The Hospital for Sick Children in Toronto (Canada). In brief, 50 ng of DNA was extracted from the saliva samples, and the CAG repeat region of the *AR* was amplified using polymerase chain reaction with one primer labeled with 6-FAM dye for visualization (5'-CTTTCCAGAATCTGTTCCAG-3') and a second unlabeled primer (5'-GAAGGTTGCTGTTCCTCATC-3'). Amplified fragments were run through capillary electrophoresis and were read using an ABI3730XL DNA Analyzer (Applied Biosystems Inc, Foster City, California) to separate the polymerase chain reaction products according to size. Quantification of the length of the CAG repeat region from each sample was accomplished using GeneMapper software (version 3.5; Applied Biosystems). Repeat numbers were confirmed by sequencing a subset of samples with alleles of different lengths.

2.6. Testosterone Measurement

For the T measurements, participants collected 3 mL of whole saliva into a polystyrene culture tube. A separate tube was supplied for the first and second saliva collection. Participants were instructed to use passive drool to collect the saliva, where the chin is tilted downwards to let the saliva naturally and passively accumulate at the edge of the mouth. No saliva stimulation agent (e.g., gum) was used because constituents in commercial gums have a potential to interfere with the accuracy of certain assays (van Anders, 2010). Once a bolus of saliva had accumulated, participants were instructed to spit out the saliva into the tube. This procedure was repeated until they reached the 3 mL mark. Specimens were stored at – 20 °C until analysis.

Saliva contains only that fraction of T that is not bound to sex hormone binding globulin (SHBG); salivary T derives from the free and albumin-bound fractions of T in plasma (Quissell, 1993). These are biologically active, or potentially available to tissue for metabolic purposes, while the SHBG-bound fraction is considered to be relatively biologically inert (e.g., Manni et al., 1985; Cummings & Wall, 1985). Therefore salivary T closely approximates the bioavailable fraction of T that is available to interact with the brain (Pardridge & Demers, 1991; Sannikka *et al*., 1983). High correlations between saliva and serum free T concentrations have been reported, $r = 0.97$ (Vittek et al., 1985); $r = 0.94$ (Wang et al., 1981).

The saliva was analysed in duplicate without extraction via radioimmunoassay (RIA). A ^{125}I Coat-A-Count kit for testosterone (Siemens Healthcare Diagnostics Inc., Deerfield, Illinois) was modified for saliva according to an established laboratory protocol (Moffat & Hampson, 1996). The antiserum is highly specific for T, showing cross-reactivity with dihydrotestosterone <5% and negligible cross-reactivity with other steroids. The intra-assay coefficient of variation averaged 5%. Assay sensitivity was 6 pg/mL.

2.7. Data Analytic Approach

All data were entered using SPSS software for Windows, version 22.0 (SPSS, Inc., Chicago, IL, USA). Descriptive statistics, alpha coefficients, and zero-order correlations among study variables were computed in SPSS in order to describe the sample, as well as to provide an idea of the relationships among study variables. In order to test the fit of the hypothesized conceptual model, structural equation modelling (SEM) was conducted using SPSS AMOS version 22.0. SEM assesses the overall fit of the data to the constraints imposed by the model through maximum likelihood estimation of the model parameters. A two-step SEM approach (see Kline, 2011) was employed, consisting of an initial analysis of the measurement model using confirmatory factor analysis (CFA), followed by the analysis of the full structural equation model. The chi-square test, comparative fit index, and root mean square error of approximation were the statistics used to evaluate the fit of the model. Because the AMOS interface does not

allow for bootstrap analyses to be conducted when missing values are estimated by the program, follow-up mediation analyses of direct and indirect effects of interest were conducted using Mplus version 7.11 (Muthen & Muthen, 2010).

3. Results

3.1. Data Treatment

Prior to conducting the main analyses of this study, data on all questionnaire items, as well as biological variables (i.e., T levels, hand-related measurement, CAG repeat length), were examined to assess accuracy of data entry and the extent of missing values. Data were double entered to check for any errors in data entry or in reverse-coding for specific questionnaire items. In addition, SPSS Frequencies were computed to check for any incorrectly entered data as well as to detect any potential univariate outliers.

Inspection of the extent of missing data on every questionnaire item revealed that the total item level missingness (i.e., when participants omitted one or more items within a multi-item measure) was < 1% both within and across all questionnaires administered. There were no participants in the sample who displayed variable level missingness on a multi-item instrument (i.e., missing all items on a multi-item measure). With respect to variables measured with single-item questions (e.g., age, typical relationship length, age at first intercourse), missing data on individual variables amounted to 2% or less. Across the entire paper-and-pencil portion of the questionnaire battery, no single participant had more than 3% (i.e., 11 items or less) of data points missing. These data indicate a very small degree of missingness within the sample.

Degree of missing data across the various biological measures obtained in the current study was also explored. No participants had missing data on either of the two T measurements. One participant lacked CAG repeat data, due to limited quality or quantity of DNA available from his saliva specimen. Digit ratio data had one missing case (<1% of the sample), due to the experimenter inadvertently making two copies of the right hand for one participant.

To handle the small proportion of missing questionnaire data in the sample, a case mean substitution approach was employed. Case mean substitution assigns the participant's mean score based upon the items that are present on the measure in question to the missing score for that participant. Because this strategy assumes that for any case, the score on any data point in a given measure is closely related to the scores on the remaining data points on that same measure, case mean substitution is particularly effective when the measure or scale in question is unidimensional and when the internal reliability estimate for the measure or scale is high (Fox-Wasylyshyn & El-Masri, 2005; Osborne, 2013 pp. 121-122). When these conditions are satisfied mean substitution is similar to imputation via multiple regression and is considered a defensible practice. Several authors have found that case mean substitution is able to favourably handle item-level missingness when data are missing on up to 20% of the items, in both random and systematic patterns (e.g., Downey & King, 1998; Roth, Switzer, & Switzer, 1999; Shrive et al., 2006). Although more sophisticated imputation techniques exist, Tabachnick and Fidell (2007) and Roth and Switzer (1995) state that when the number of missing data points is low (less than 5%), as was the case in the current study (< 1% missing), the choice of technique to handle missing data is of minimal importance.

Because the internal consistency estimates for the unidimensional measures or subscales employed in this study were acceptably high (see Method for Cronbach's alpha data) and the total number of missing data points was very low, case mean substitution was conducted for item-level missingness when the amount of missing data on any one scale was ≤ 20%. If the degree of missingness on a scale was > 20%, those item data points were left as missing. Any single-item variables with missing data were also left as missing, as case mean substitution could not be performed in these cases. When conducting SEM analyses, any remaining missing data were handled through Maximum Likelihood (ML) estimation, the standard procedure in AMOS. ML imputes missing data by using all other available data points in a database and the multivariate relationship among the study variables (for available cases) to construct the best estimates for the missing values in question. ML is considered to be an appropriate technique to impute missing data when the total amount of missing data in a sample is ≤ 20%, regardless of

the pattern of missingness (i.e., systematic or random) (Fox-Wasylyshyn & El-Masri, 2005).

3.2. Analysis of Life History Theory-Based Model

3.2.1. Overview of Indicator Variables

The life history-based model tested in this study (see Figure 1) included a number of higher-order, unobserved variables. Each of these *latent* variables was measured by several observed items (i.e., manifest/indicator variables). The indicator variables were selected based on a consideration of exactly how each latent construct is defined within the various life history theories of attachment and reproduction. In what follows, a brief summary of the indicators associated with each latent variable in the integrated-LHT model will be presented. Please refer to Appendix D for a full and more detailed description of each indicator variable, its associated computation and/or coding, reliabilities of the indicators, and rationale for inclusion.

Early Family Environment. Ten manifest variables were initially used to measure the latent construct of Early Family Environment (see Figure 3 for a schematic representation of the latent variable and associated indicators). Variables listed included those that were explicitly outlined within the life history theories described in Section 1.2 and/or have been empirically related to attachment patterns in childhood, the timing of somatic development, or reproductive strategy choice. All indicators indexed the quality of the early family environment. The 10 indicators were: (1) a "Family affection" index and (2) a "Family abuse" index, derived from items from Part I of the RAQ (Parkes, 2006), (3) Mother's psychiatric health and (4) Father's psychiatric health, also derived from items from the RAQ Part I, (5) SES of the family household (either Total SES, computed from information about parental occupation and education, or Financial SES, computed only from information about parental occupation. The decision about which of the two SES indicators to include, given the overlapping computational information, was made at the level of the measurement model analyses, based on an empirical consideration of which indicator better optimized the latent construct. This topic will be

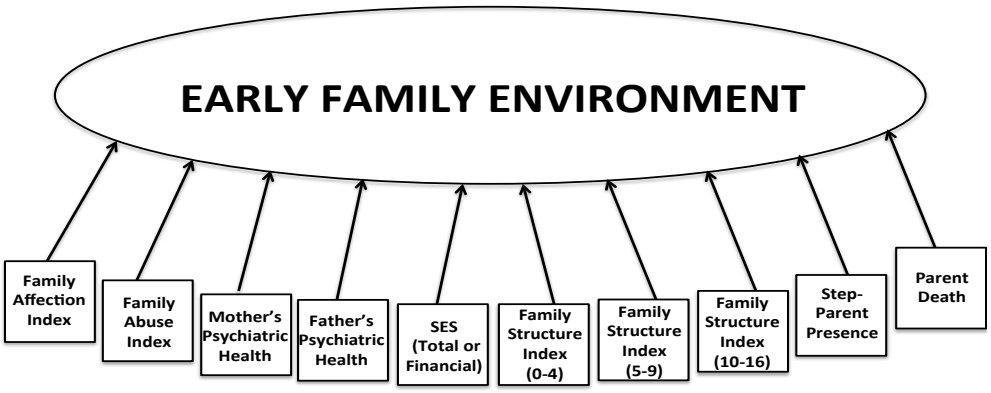

Figure 3. Indicators of Early Family Environment latent construct. Indicator (observed) variables initially used to index the Early Family Environment latent construct.

revisited in Section 3.2.5), (6) "Family structure" index for ages 0-4 years, (7) "Family structure" index for ages 5-9 years, and (8) "Family structure" index for ages 10 years and up, each of which quantified the effects of family structure (e.g., two-parent household vs. single parent living alone, etc.) during development on the quality of participants' early family environmental experience. Finally, indicators of (9) the presence or absence of a non-biological stepparent during the first 16 years of life and (10) the death of a parent during the first 16 years of life were included. Each indicator was coded such that a higher score was reflective of a poorer quality environment.

Because the latent variable of Early Family Environment is a weighted composite, where each indicator variable represents an *index* of the quality of the early family environment, the direction of causality runs from the indicators to the latent composite. This differs from the other latent constructs included in the model, which are assumed to cause the indicator variables.

Retrospective Childhood Attachment. Following Parkes' (2006) computational procedures, a total insecure attachment score was calculated from Part I and Part II of the RAQ. Higher scores on this continuous measure corresponded to a more insecure childhood attachment pattern. Scores reflected attachment to parents in general, which is consistent with the life history-based theories reviewed here that do not differentiate between the unique developmental consequences of maternal *vs.* paternal attachment configurations (for review see Del Giudice, 2009). Although individual scores for the 3 insecure attachment patterns (anxious/ambivalent, avoidant, disorganized) can be separately computed from the RAQ, because Belsky et al. (1991) and Chisholm (1999) speculate only about the causes and consequences of overall attachment insecurity (*vs.* security) without differentiating among the specific varieties of insecure attachment in their theoretical models, the decision was made to only compute the total insecure attachment score as a single indicator of the childhood attachment style.

Non-Sexual Reproductive Strategy. The indicator variables thought to be caused by the Non-Sexual Reproductive Strategy latent construct (see Figure 4) included the personality traits usually associated with the Young Male Syndrome (Wilson & Daly,

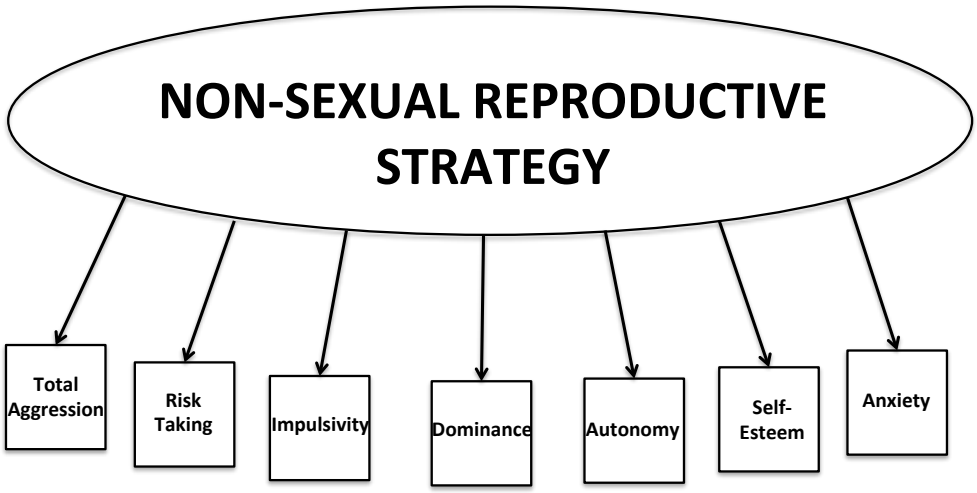

Figure 4. Indicators of Non-Sexual Reproductive Strategy latent construct. Indicator (observed) variables presumed to be caused by the Non-Sexual Reproductive Strategy latent construct.

1985), which Chisholm (1999) argues is the optimal reproductive strategy for males reared in environments of high uncertainty. Indicators of this personality cluster included total scores on the modified Buss and Perry (1992) Aggression Questionnaire, the Risk Taking Scale of the JPI-R (Jackson, 2004) and the Impulsivity subscale from the PRF-E (Jackson, 2003). Because dominance is a closely related concept to aggression (Archer, 1991), the total score on the Dominance subscale of the PRF-E was also included. In addition, measures of autonomy, self-esteem, and trait anxiety (reverse coded) were included. Total scores on the Autonomy subscale of the PRF-E, the RSE, and the Anxiety subscale of the POMS were the observed variables, respectively. Each indicator variable was coded such that a higher score reflected a higher level of the construct.

Sexual Reproductive Strategy. Both Belsky et al. (1991) and Del Giudice (2009) argue that the reproductive strategies predicted by insecure *vs.* secure attachment fall along a continuum of shorter-term to longer-term mating, earlier to later sexual activity, and unstable to enduring pair bonds. Consequently, the latent factor Sexual Reproductive Strategy (see Figure 5) was assumed to causally influence participants' age at first intercourse, their typical relationship length, as well as their total number of lifetime partners (both romantic and sexual). A current partner status observed variable was also included, which reflected whether or not participants were currently in a relationship, and if so, what type (see Appendix D), coded in a graded fashion according to how closely their current partnering status fit with a shorter-term *vs.* longer-term mating strategy.

Several components of the SOI (Simpson & Gangestad, 1991) were core indicators of the latent Sexual Reproductive Strategy construct and were individually included as separate items. Item 2 ("How many different partners do you foresee yourself having sex with during the next five years?") and Item 3 ("With how many partners have you had sex on *one and only one* occasion, in your lifetime?") were included as independent indicators. The standardized factor scores for the four items comprising the *attitudinal* facet of the SOI (items 4-8, excluding item 7) were used as an additional latent variable.

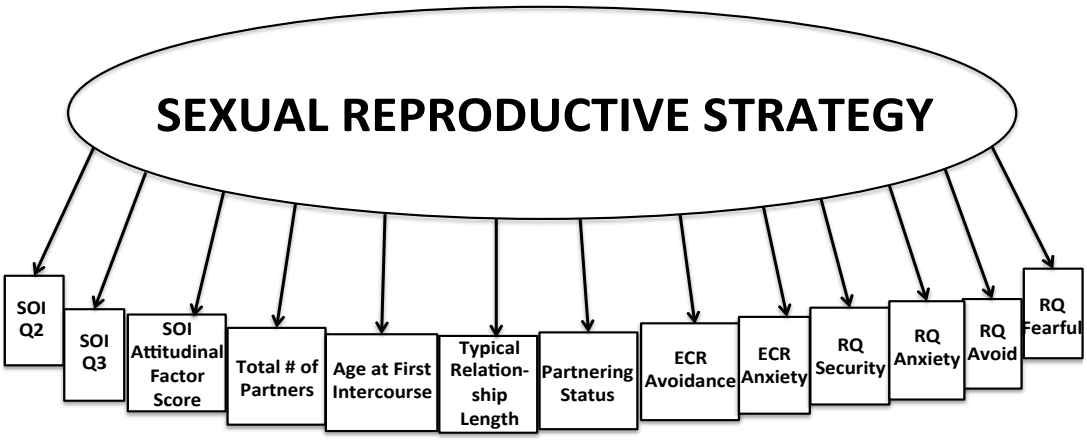

Figure 5. Indicators of Sexual Reproductive Strategy latent construct. Indicator (observed) variables presumed to be caused by the Sexual Reproductive Strategy latent construct.

As noted during the model presentation in Section 1.9, because life history theorists are not in agreement as to whether romantic attachment itself is part of one's sexual reproductive strategy (Belsky, 1997; Kirkpatrick, 1998; Del Giudice et al., 2009), or whether it is a correlated trait that predicts one's sexual strategy (e.g., Hill et al., 1994a; Del Giudice, 2009), the various romantic attachment subscale scores from the RQ and ECR were tentatively included as separate indicator variables of the Sexual Reproductive Strategy latent factor. Indicators were therefore: the ECR avoidance subscale score, the ECR anxiety subscale score, the RQ dismissing score, and the RQ preoccupied score, the latter as continuous variables. Because a person's overall level of romantic attachment security might also be a characteristic of his reproductive strategy choice, the RQ continuous security score (reverse-coded such that a higher score indicated less attachment security) was included as an indicator. Finally, there is a lack of clarity in LHT-based models about the role of adult fearful attachment (e.g., Del Giudice, 2009). Consequently, participants' RQ continuous fearful score was also included as a possible indicator variable (see Appendix D for further discussion). Each indicator variable of the Sexual Reproductive Strategy was coded (or reverse coded if necessary) such that a higher score was consistent with a shorter-term reproductive strategy.

Biological Variables. For Adult T (Range: 30.53 to 302.98 pg/mL), the internal consistency between first and second measurements was very high ($\alpha = .95$), thus it was deemed appropriate to average the two measurements and use this as a single-indicator variable in the model. Similarly, the Cronbach's alpha between the right and left hand digit ratio was in an excellent range for biological measures ($\alpha = .84$) and it was also deemed appropriate to average the right and left hand measurements as a single-indicator of individual differences in prenatal T exposure (2D:4D; Range: .90 to 1.04). The CAG repeat length for each participant was measured in duplicate, however, within our sample none of the duplicates were found to differ. Thus the CAG repeat data displayed perfect correspondence, and as such was represented as a single-indicator in the model (CAG RL Range: 13 to 30 repeats).

3.2.2. Descriptive Statistics

Descriptive statistics for all variables in the model are presented in Table 3. Means and standard deviations for all standardized measures were considered representative, as they were comparable to estimates obtained with samples of male university students in other published literature (Gentzler & Kerns, 2004; Edelstein et al., 2010; Schmitt, 2005; Bogaert & Rushton, 1989; Jackson, 1994; 1999; Buss & Perry, 1992; Hampson et al., 2008; McNair & Heuchert, 2005; Nyenhuis et al., 1999; Sinclair et al., 2010). Similarly, descriptive statistics for all androgen-related variables were comparable to those obtained in other independent studies of young adult men (e.g., For CAG RL: Medland et al., 2005; Sankar & Hampson, 2012b; Skjaerpe et al., 2009; For 2D:4D: Hampson & Sankar, 2012b; Maner et al., 2014; Medland et al., 2010; For salivary T collected at a similar time of year (i.e., Winter to Spring): Stanton, Mullette-Gillman, & Huettel, 2011; Moffat & Hampson, 2000; White, Thornhill, & Hampson, 2006). As reviewed in Sections 2.3.1 and 2.3.2, Cronbach's alpha for the various measures administered were similar to estimates cited in the literature. As Table 3 shows, most of the individual study variables had acceptable internal consistency ($\alpha \geq .75$). The lowest alpha coefficients were for the derived measures of family affection, family abuse, and parent psychiatric health from the RAQ (α ranging from .48-.64). The lower internal consistency estimates suggest that these scales contained items that assess somewhat inconsistent concepts, which is not unexpected given the nature of the behaviours described by those scales.

3.2.3. Evaluation of Assumptions

Estimation in SEM with ML assumes multivariate normality of continuous outcome variables. Because evaluation of some of the assumptions of multivariate normality is impractical (e.g., ensuring that the joint frequency distributions of all possible combinations of variables are bivariate normal), and statistical tests used to detect multivariate violations can be influenced by small departures from normality in larger samples (Kline, 2011), inspection of univariate distributions is considered to be a

Table 3

Descriptive Statistics for Model Variables

Variable	α	*M*	*SD*	Skew	*SE of* Skew	Kurtosis	*SE of* Kurtosis
Early Family Environment LV							
Family Structure Index (0-4)	--	1.12	0.58	4.75	0.17	20.94	0.35
Family Structure Index (5-9)	--	1.24	0.76	3.00	0.17	7.49	0.35
Family Structure Index (10-16)	--	1.38	0.89	2.14	0.17	3.04	0.35
Stepparent	--	0.02	0.16	6.05	0.17	34.95	0.35
Parent Death	--	0.03	0.17	5.48	0.17	28.28	0.35
Total SES[1]	--	13.24	2.19	-0.76	0.18	0.00	0.35
Financial SES[1]	--	11.93	3.75	-0.20	0.18	-0.89	0.35
Family Affection Index	0.58	1.42	1.50	0.80	0.17	-0.19	0.35
Family Abuse Index	0.48	0.82	1.14	1.44	0.17	1.85	0.35
Mother's Psychiatric Health	0.64	0.90	1.10	1.60	0.17	2.50	0.35
Father's Psychiatric Health	0.56	0.31	0.71	2.54	0.17	6.02	0.35
RAQ Insecurity	0.85	14.05	7.62	0.62	0.17	0.22	0.35
Non-Sexual Reproductive Strategy LV							
AQ Total	0.90	92.93	19.58	0.27	0.18	-0.51	0.35
Risk-Taking	0.83	12.16	4.57	-0.36	0.18	-0.71	0.35
Impulsivity	0.75	6.81	3.44	0.29	0.18	-0.52	0.35
Dominance	0.76	11.71	3.11	-0.92	0.18	0.66	0.35
Autonomy	0.75	8.04	3.49	0.11	0.18	-0.66	0.35
Self-Esteem	0.88	22.64	5.26	-0.52	0.17	-0.39	0.35
POMS Anxiety[1]	0.88	10.97	6.52	0.64	0.17	0.09	0.35

Note. LV = Latent Variable; RAQ = Retrospective Attachment Questionnaire; AQ = Aggression Questionnaire; POMS Anxiety = Profile of Mood States-Tension Subscale

[1] Means and Standard Deviations are presented for variables without score reversal

Table 3 Continued

Descriptive Statistics for Model Variables

Variable	α	*M*	*SD*	Skew	*SE of* Skew	Kurtosis	*SE of* Kurtosis
Sexual Reproductive Strategy LV							
SOI Q2	--	6.23	6.30	1.91	0.18	3.79	0.35
SOI Q3	--	3.19	5.46	4.53	0.18	30.45	0.35
SOI Attitudinal Factor	0.76	0.11	0.95	-0.48	0.17	-0.45	0.35
Total Number of Partners	--	10.85	14.27	4.44	0.17	25.91	0.35
Age at First Intercourse	--	17.11	2.06	1.25	0.18	3.17	0.35
Typical Rel'ship Length[1, 2]	--	10.60	17.88	4.12	0.18	19.29	0.35
Partnering Status	--	0.51	0.53	0.26	0.17	-1.26	0.35
ECR Avoidance	0.91	3.06	1.01	0.61	0.17	0.12	0.35
ECR Anxiety[1]	0.92	3.31	1.11	0.00	0.17	-0.71	0.35
RQ Dismissing	--	4.45	1.58	-0.28	0.17	-0.75	0.35
RQ Preoccupied[1]	--	3.02	1.61	0.55	0.17	-0.57	0.35
RQ Security	--	4.85	1.64	-0.68	0.17	-0.52	0.35
RQ Fearful	--	3.26	1.89	0.42	0.17	-1.01	0.35
2D:4D ratio	0.84	0.96	0.02	0.14	0.18	-0.03	0.35
Adult T (pg/mL)	0.95	87.13	31.06	2.26	0.17	11.89	0.35
CAG RL (# repeats)	--	21.80	2.66	-0.07	0.18	0.96	0.35

Note. LV = Latent Variable; SOI Q2/Q3 = Sociosexual Orientation Inventory Question 2/ Question 3; ECR = Experiences in Close Relationships Questionnaire; RQ = Relationship Questionnaire; CAG RL = CAG repeat length

[1] Means and Standard Deviations are presented for variables without score reversal

[2] Typical Relationship Length coded in number of months

good test of instances of multivariate nonnormality (Kline, 2011; Tabachnick & Fidell, 2007). SPSS Frequencies was used to examine departures from univariate normality. Kline (2011) and Bowen and Guo (2012) suggest that when the absolute value of skewness is > 3.0 and kurtosis is > 10.0, a variable may be problematic and require corrective action. That being said, Tabachnick and Fidell (2007) state that for larger samples inspection of the shape of the distribution for a variable may be more important than using the actual statistic. With respect to kurtosis, the authors suggest that with samples of 100 or more, underestimates of variance associated with positive kurtosis disappear, and with samples of 200 or more underestimation of variance with negative kurtosis disappears. Furthermore, even under conditions of severe nonnormality, ML estimation does not appear to affect standard errors of parameter estimates (Lei & Lomax, 2005), as well as parameter estimates themselves, especially if sample sizes are over 100 (Finch, West, & MacKinnon, 1997; Lei & Lomax, 2005). Consequently, only if variables had indices suggesting both problematic skew *and* kurtosis was corrective action deemed necessary.

As can be seen in Table 3, most variables had skewness and kurtosis values within an acceptable range. The only exceptions were a subset of the indicators of the Early Family Environment latent construct, as well as three of the indicators of the "Sexual Reproductive Strategy" latent construct. SOI Q3, Total Number of Partners, and Typical Relationship Length all showed positive skew and kurtosis. This was consistent with expectation as few participants were expected to have scores at the upper end of the distribution (i.e., very high number of one night stands, total number of partners, or very long relationship lengths). In order to handle non-normality on these variables, the commonly accepted procedure of logarithmic transformation was applied (Kline, 2011). Such transformation brought skewness and kurtosis indices within a more than acceptable range for each of the variables.

With respect to non-normal Early Family Environment indicators, the limited range of obtained scores on these variables likely contributed to the skewness they showed. Because the assumptions of multivariate normality pertain to *outcome* variables, however, correction for exogenous variables, which do not have associated tests of

significance, is not required before application of ML estimation (Kline, 2011). More is said about this later. Nevertheless, because the proportion of scores of 0 on the Stepparent and Parent Death variables were so high (over 95%) these variables were deemed too severely non-normal to include in subsequent analyses.

As a further assessment of the assumptions of normality, bivariate correlation coefficients produced through SPSS were inspected to check for the presence of multicollinearity. As shown in Table 4, which presents the correlation coefficients among the model variables, no two variables were so highly correlated that they were essentially conveying the same information. The highest correlations were among the Family Structure Index variables and between Total Number of Partners and SOI Q3 (inquiring about number of partners one has had sex with on only one occasion). Follow-up modifications stemming from these correlations are explored in the confirmatory factor analysis for the model (Section 3.2.5).

Finally, pairwise linearity was inspected using bivariate scatterplots generated through SPSS for all relevant pairs of variables. The scatterplots indicated no significant departures from bivariate linearity.

3.2.4. Correlations among Model Variables

Table 4 shows the Pearson correlation coefficients among all model variables. Several patterns of relationships were noted. As expected, childhood attachment insecurity was significantly correlated with all indicators of early family environment. In all cases, higher attachment insecurity was associated with markers of a poorer quality early family environment (e.g., less stable family structure, lower SES, higher levels of family abuse). Evidence for continuity of attachment styles from childhood to adulthood was provided by the significant positive correlations between RAQ Insecurity scores and both the ECR avoidance and anxiety subscales, and the RQ preoccupied and fearful subscales. In addition, levels of adult romantic attachment security were significantly and negatively correlated with childhood attachment insecurity.

Table 4

Correlations among LHT-Based Model Variables

	1	2	3	4	5	6	7	8	9	10	11
1	-										
2	.66**	-									
3	.46**	.68**	-								
4[1]	-.14	-.18*	-.15*	-							
5[1]	-.24**	-.34**	-.30**	.68**	-						
6	.14	.11	.14	-.21**	-.14*	-					
7	.12	.22**	.26**	-.13	-.13	-.42**	-				
8	.13	.15*	.18*	-.16*	-.13	.22**	.45**	-			
9	.00	.07	.06	-.01	.00	.19**	.20**	.34**	-		
10	.22**	.34**	.33**	-.13	-.16*	.58**	.61**	.55**	.33**	-	
11	.04	.02	-.10	-.12	-.05	.28**	.25**	.20**	.03	.41**	-
12	-.01	-.11	-.19**	.09	.15*	-.06	.01	-.07	-.09	-.13	.15*
13	-.02	.02	-.06	-.08	-.08	.11	.17*	.15*	-.02	.22**	.49**
14	.05	-.08	-.05	.09	.14	.03	.08	.00	-.08	.04	.22**
15	.02	-.11	-.08	.07	.13	.06	.02	.02	.00	-.03	-.01
16	-.21**	-.16*	-.18*	.14*	.13	-.21**	-.20**	-.24**	-.11	-.39**	-.25**
17[1]	.19**	.14	.06	-.17*	-.12	.08	.13	.25**	.16*	.29**	.31**
18	-.01	-.04	-.10	-.02	-.06	.12	-.04	-.08	.00	-.07	.19**
19[2]	.06	-.02	-.08	-.16*	-.17*	-.01	-.06	-.02	.01	-.08	.07
20	.11	-.08	-.02	-.10	-.01	.08	.11	.09	.03	-.06	.17*
21[2]	.08	-.02	-.03	-.17*	-.11	.04	.03	-.05	.09	-.02	.06
22[1]	.02	.02	.06	.01	-.09	.06	.04	.10	.06	.09	-.15*
23[1, 2]	-.05	-.05	.04	.01	.08	-.07	.06	.16*	.10	.00	-.14
24	-.05	-.10	-.12	.11	-.04	.02	-.04	.01	.00	.07	.13
25	.06	-.01	-.02	.09	-.04	.14	-.01	.02	.05	.20**	.18*
26[1]	.12	.11	.12	-.17*	-.16*	.20**	.11	.14*	.15*	.35**	.28**
27	-.11	-.06	-.04	.07	.17*	-.01	.06	.07	.09	.06	.01
28[1]	.03	.08	.02	-.02	-.01	.11	.03	.00	-.08	.19**	.23**
29[1]	-.11	-.09	-.04	-.04	.02	-.15*	-.09	-.11	-.03	-.23**	-.21**
30	.20**	.21**	.09	-.11	-.14	.12	.08	.13	.07	.32**	.19**
31	.02	-.00	.03	.04	-.04	-.10	-.04	-.02	-.11	-.14*	-.47**
32	-.05	.05	.06	.00	-.01	-.11	.07	.04	.03	-.02	.00
33	-.01	.03	-.03	.07	-.04	.02	-.07	-.03	.08	.06	.17*
34	-.03	.02	.02	-.04	-.03	.02	-.01	.05	-.02	.05	-.01

1) Family Structure (0-4), 2) Family Structure (5-9), 3) Family Structure (10-16), 4) Total SES, 5) Financial SES, 6) Family Affection Index, 7) Family Abuse Index, 8) Mother's Psych Health, 9) Father's Psych Health, 10) RAQ Insecure, 11) AQ Total, 12) Risk Taking, 13) Impulsivity, 14) Dominance, 15) Autonomy, 16) Self-Esteem, 17) POMS Anxiety, 18) SOI Q2, 19) SOI Q3, 20) SOI Attitude, 21) Total Partners, 22) Age 1st Intercourse, 23) Typical Relationship Length, 24) Partnering Status, 25) ECR Avoidance, 26) ECR Anxiety, 27) RQ Dismissing, 28) RQ Preoccupied, 29) RQ Security, 30) RQ Fearful, 31) MC-C, 32) 2D:4D, 33) Adult T, 34) CAG RL

[1] Variable presented without score reversal; [2] Variable presented following log transformation; * $p < .05$. ** $p < .01$.

Table 4 Continued

Correlations among Model Variables

	12	13	14	15	16	17	18	19	20	21	22
1											
2											
3											
4[1]											
5[1]											
6											
7											
8											
9											
10											
11											
12	-										
13	.47**	-									
14	.34**	.11	-								
15	.20**	.08	-.06	-							
16	.12	-.08	.15*	-.12	-						
17[1]	-.05	.19**	-.06	-.19**	-.35**	-					
18	.18*	.17*	.20**	.17*	.11	-.03	-				
19[2]	.11	-.04	.13	.10	.20**	-.05	.47**	-			
20	.18**	.09	.14*	.22**	-.01	-.02	.48**	.37**	-		
21[2]	.20**	.04	.18*	.24**	.07	.02	.51**	.68**	.34**	-	
22[1]	-.22**	-.13	-.23**	-.13	-.09	.00	-.30**	-.34**	-.38**	-.36**	-
23[1, 2]	-.13	-.14	-.01	-.11	.02	.07	-.39**	-.29**	-.32**	-.35**	.17*
24	-.03	.11	-.19**	.28**	-.12	.07	.26**	.04	.15*	.11	-.06
25	.04	.10	-.03	.40**	-.29**	.13	.26**	.16*	.17*	.15*	-.02
26[1]	-.16*	.16*	-.10	-.26**	-.40**	.40**	-.24**	-.18*	-.15*	-.18*	.20**
27	.06	.09	.01	.41**	.03	-.05	.19**	.19**	.35**	.22**	-.20**
28[1]	-.06	.18*	-.07	-.15*	-.20**	.24**	-.10	-.12	-.10	-.10	.17*
29[1]	.06	-.12	.08	-.21**	.31**	-.20**	-.18*	-.09	-.15*	-.12	-.01
30	-.14	.04	-.09	.00	-.32**	.32**	.00	-.03	.03	-.05	.11
31	-.20**	-.36**	-.14**	.09	.12	-.24**	-.12	.03	-.16*	.02	.16*
32	-.04	-.06	-.05	.03	-.08	.04	-.08	.00	.04	-.07	-.02
33	.10	.18*	.06	.06	-.17*	.12	.14	.02	-.07	.02	.00
34	.01	.03	.02	-.12	.03	.01	-.04	-.09	-.02	-.08	.15*

1) Family Structure (0-4), 2) Family Structure (5-9), 3) Family Structure (10-16), 4) Total SES, 5) Financial SES, 6) Family Affection Index, 7) Family Abuse Index, 8) Mother's Psych Health, 9) Father's Psych Health, 10) RAQ Insecure, 11) AQ Total, 12) Risk Taking, 13) Impulsivity, 14) Dominance, 15) Autonomy, 16) Self-Esteem, 17) POMS Anxiety, 18) SOI Q2, 19) SOI Q3, 20) SOI Attitude, 21) Total Partners, 22) Age 1st Intercourse, 23) Typical Relationship Length, 24) Partnering Status, 25) ECR Avoidance, 26) ECR Anxiety, 27) RQ Dismissing, 28) RQ Preoccupied, 29) RQ Security, 30) RQ Fearful, 31) MC-C, 32) 2D:4D, 33) Adult T, 34) CAG RL

[1] Variable presented without score reversal; [2] Variable presented following log transformation; * $p < .05$. ** $p < .01$.

Table 4 Continued

Correlations among Model Variables

	23	24	25	26	27	28	29	30	31	32	33	34
1												
2												
3												
4[1]												
5[1]												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17[1]												
18												
19[2]												
20												
21[2]												
22[1]												
23[1, 2]	-											
24	-.20**	-										
25	-.16*	.32**	-									
26[1]	-.01	.10	-.03	-								
27	-.08	.10	.27**	-.26**	-							
28[1]	-.03	.17*	-.06	.55**	-.26**	-						
29[1]	.07	-.35**	-.58**	.14	-.21**	-.08	-					
30	.02	.05	.41**	.37**	-.02	.08	-.51**	-				
31	.15*	-.00	-.06	-.28**	.04	-.18*	.06	-.10	-			
32	.04	.01	-.04	.01	.02	-.01	-.01	-.04	.08	-		
33	-.08	.14	.22**	.03	.06	.03	-.14	.14*	-.10	-.12	-	
34	-.06	-.09	-.03	.25**	-.09	.11	.07	.05	-.07	-.12	-.03	-

1) Family Structure (0-4), 2) Family Structure (5-9), 3) Family Structure (10-16), 4) Total SES, 5) Financial SES, 6) Family Affection Index, 7) Family Abuse Index, 8) Mother's Psych Health, 9) Father's Psych Health, 10) RAQ Insecure, 11) AQ Total, 12) Risk Taking, 13) Impulsivity, 14) Dominance, 15) Autonomy, 16) Self-Esteem, 17) POMS Anxiety, 18) SOI Q2, 19) SOI Q3, 20) SOI Attitude, 21) Total Partners, 22) Age 1st Intercourse, 23) Typical Relationship Length, 24) Partnering Status, 25) ECR Avoidance, 26) ECR Anxiety, 27) RQ Dismissing, 28) RQ Preoccupied, 29) RQ Security, 30) RQ Fearful, 31) MC-C, 32) 2D:4D, 33) Adult T, 34) CAG RL

[1] Variable presented without score reversal; [2] Variable presented following log transformation; * $p < .05$. ** $p < .01$.

Also as expected, measures of romantic attachment avoidance (dismissing) were significantly associated with all of the sexual reproductive strategy indicator variables, such that a higher avoidance score was correlated with behaviours indicative of a shorter-term mating approach. Similarly, less endorsement of a secure romantic attachment style was associated with a more unrestricted sociosexual orientation (*r* SOI Q2 = -.18; *r* SOI Attitudinal Factor = -.15) and with a significantly lower likelihood of being in a committed partnership (*r* Partnering Status = -.35). Other correlations between RQ security and sexual behaviours were in the anticipated direction, but were non-significant. In contrast, the measures of romantic attachment *anxiety* (preoccupied) were significantly associated with all the sexual reproductive strategy indicators in such a way that higher anxiety correlated with scores indicative of *less* endorsement of a shorter-term mating approach. This is consistent with how anxiety-based strategies may be expressed in men. No significant associations were found between the fearful attachment pattern and the indicators of the sexual reproductive strategy; however, no *a priori* hypothesis had been made with respect to this particular attachment pattern.

In general, the continuous scores on the adult romantic attachment measures did not correlate very strongly or consistently with the non-sexual personality measures. One notable exception was the Autonomy subscale. Consistent with the conceptualization of avoidance as an attachment style that is characterized by independence and distancing oneself from others, avoidance scores showed a strong, positive correlation with scores on the Autonomy subscale of PRF-E (*r* = .40 and *r* = .41), while romantic attachment anxiety, which is characterized by greater dependency in intimate relationships, was significantly and negatively correlated with levels of Autonomy (*r* = -.26 and *r* = -.15). Interestingly, and contrary to expectation, a negative correlation was found between levels of self-esteem and participants' continuous dismissing-avoidance scores; higher levels of self-esteem were, instead, associated with higher romantic attachment security scores.

In line with the hypothesized relationship, basal T levels showed a significant, positive correlation with levels of ECR avoidance (*r* = .22). T failed to show, however, any relationship with ECR anxiety. By contrast, CAG repeat length was significantly and

positively correlated with ECR anxiety (r = .25), suggesting androgenic effects on both dimensions of adult romantic attachment. T concentrations also were correlated, as expected, with some of the non-sexual behaviours (e.g., aggression, impulsivity), but contrary to expectation, did not correlate strongly with the indicators of sexual reproductive strategy. Digit ratios, a proxy marker of prenatal T levels, showed no significant inter-correlations with any other study variables. This finding is consistent with the increasing scepticism in the literature, alluded to in Section 1.6.3, about the validity of the 2D:4D finger length ratio as a marker of fetal T levels in humans (e.g., McIntyre, 2006; Berenbaum et al., 2009; Hampson & Sankar, 2012b).

Correlations coefficients between the various indicators in the LHT-based model and the Marlowe-Crowne Social Desirability Scale Form C (MC-C) were also computed. Some significant inter-correlations were found, primarily with the anxiety-related measures (e.g., ECR anxiety, RQ preoccupied, POMS Anxiety). All significant correlations were either negative in direction for correlations with negative behaviours or positive in direction for positive characteristics, suggesting some degree of socially desirable responding in the study population, which was to be expected. Inspection of histograms in SPSS Frequencies showed that scores on the MC-C were normally distributed (M = 5.50, SD = 2.51). Because socially desirable responding is particularly a problem for those who have objectively high scores on measures of social desirability, only these cases may need to be dealt with (Harris, 1997). Within the current distribution, no participants had scores that fell in an outlier range (i.e., 3 standard deviations above the mean). Using a more conservative cutpoint of 2 standard deviations above the mean, only 7 participants in the sample fell into the "outlier" category at the upper bound. Removing these participants made a trivial difference to the size of the correlation coefficients described above. Furthermore, the full structural model described below was re-run without these 7 participants and it did not change the size or direction of the associations. Finally, partial correlations, controlling for MC-C scores, between variables that were significantly correlated with the MC-C were computed. These analyses also revealed trivial changes in correlation coefficient sizes. Consequently, it was deemed that social desirability was not influencing the study findings.

3.2.5. Measurement Model

The hypothesized model depicted in Figure 1 was tested using SEM analyses with SPSS Amos v. 22.0. Kline (2011), and others (e.g., Anderson & Gerbing, 1988), recommend assessing measurement models before examining complete structural models so as to verify that the latent variable measures are psychometrically sound and that their dimensionality is as expected. Thus, before examining the fit of the complete structural equation model, confirmatory factor analysis (CFA) was conducted to assess the measurement model.

Prior to running the full CFA, independent factor analyses for each latent variable in the model were performed as a preliminary step to identify which indicators were mathematically most robust. Because each latent construct was presumed to be caused by (or indexed by in the case of the Early Family Environment latent variable) a number of indicators and, in general, there was no strong theoretical reason that one indicator would be better than another, running the CFA with this exploratory first step was a good way to identify and eliminate any weak indicators that could affect model parsimony and fit. Furthermore, for complex models, it is recommended to start with simpler models that are subsets of the whole model, in order to be able to uncover potential identification problems more easily (Kline, 2011).

Early Family Environment. A preliminary factor analysis was run with eight indicators underlying the latent construct, removing the two indicators of "Stepparent" and "Parent Death", as stated previously, because of the severely disproportional scores of 0 on these variables (Section 3.2.3). Because of the overlap in the computation of the "Total SES" and "Financial SES" indicators, factor analyses were run with each of these indicators separately. Analysis revealed that the "Financial SES" manifest variable loaded more strongly onto the Early Family Environment latent construct than did "Total SES" (standardized factor loading for Financial SES = .37 vs. Total SES = .20), with no change to the size or direction of the standardized factor loadings for the other indicators. Consequently, "Financial SES" was chosen to be used as the indicator of SES in the model. Table 5 shows the standardized factor loadings for the indicators of the Early

Family Environment latent construct. Kline (2011) recommends that all indicators specified to measure a common factor should have relatively high standardized factor loadings on that factor. Consequently, as is customary in SEM studies, a conservative cutpoint was selected of ≥ .45, rather than the .30 cutoff commonly employed in traditional factor analytic studies. As shown in Table 5, only the three Family Structure Indices met this criterion, with the pattern of factor loadings remaining the same as individual indicators not meeting this criterion were removed sequentially, according to the size of their standardized loadings. Consequently, the decision was made to retain only the three "Family Structure Index" measures as the indicators of the Early Family Environment latent construct.

Because there are difficulties identifying measurement models where some factors have only cause (formative) indicators and the composite is latent (such as Early Family Environment), one approach to deal with this issue is to combine the indicators into a single weighted manifest variable (Kline, 2011; MacCallum & Browne, 1993). This was deemed a feasible approach as the three measures of Family Structure across the ages of 0-16 showed a high degree of internal consistency ($\alpha = .80$), and were measured using identical scaling. As a result, the three Family Structure Indices were summed to form a single Family Structure variable, which measured the theoretical stress of participants' family structure across the ages of 0-16. Scores now ranged from 3-12. Furthermore, creating a Total Family Structure Index effectively addressed the skewness and kurtosis issues that were seen in the individual Family Structure Indices, bringing these univariate normality statistics into the acceptable range (skewness = 2.94, *SE* = .17; kurtosis = 8.47, *SE* = .35), although as mentioned earlier assumptions of multivariate (and univariate) normality do not apply to exogenous, independent variables. Finally, any potential issues related to multicollinearity, which can influence the results of SEM analyses, were addressed by combining the highly correlated Family Structure Indices (see Table 4 for sizes of correlations) into one.

Sexual Reproductive Strategy. The preliminary factor analysis, with all 13 indicators, log transformed as needed (i.e., SOI Q3, Total Number of Partners, and Typical Relationship Length), revealed the following standardized factor loadings (see

Table 5

Standardized Factor Loadings for Early Family Environment Latent Variable

Early Environment Indicator	Standardized Factor Loading
Family Structure Index (0-4)	.69
Family Structure Index (5-9)	.92
Family Structure Index (10-16)	.73
Financial SES[1]	.37
Family Affection Index	.17
Family Abuse Index	.27
Mother's Psychiatric Health	.20
Father's Psychiatric Health	.08

[1] Reversed score (i.e., higher score = lower SES) used in factor analysis

Table 6a). As can be seen, several measures met the ≥ .45 criterion. Interestingly, all the measures of adult, romantic attachment did not meet this cutpoint and showed substantially lower loadings. This was taken as evidence that the attachment measures, although related to the sexual behaviour measures, are not themselves tactics of the sexual reproductive strategy. Importantly, as stated earlier (see Sections 1.9 and 3.2.1), the life history theories are not explicit or in agreement as to whether romantic attachment ought to be considered a component of the sexual reproductive strategy or as a separate but correlated entity. Consequently, on the basis of the CFA results, the romantic attachment variables were extracted for separate consideration (see below).

Table 6b shows the standardized factor loadings following the removal of the 6 adult romantic attachment measures. With the exception of Partnering Status, all indicators loaded above .45. Removing Partnering Status did not change the pattern of factor loadings. Because the correlation between SOI Q3 and Total Number of Partners was large (r = .68), albeit not large enough to suggest issues with multicollinearity, the decision was made to allow the errors associated with these two variables to correlate in the CFA and subsequent structural model. Over a mathematical rationale, there needs to be a theoretical rationale for allowing for such a modification. Given that question 3 on the SOI inquires about the number of partners with whom the participant has had sex on one and only one occasion, the answer to this question should logically be related to the total number of partners (romantic and sexual) a participant has had. No other modifications were made to this latent variable.

Adult Romantic Attachment. Factor analysis, constrained to one factor, was run on the six measures of adult romantic attachment. This was done because although romantic attachment avoidance and anxiety are suggested to be separate dimensions, it was not known how the measures of total attachment insecurity (RQ security) and fearfulness (RQ fearful) would load onto these factors. As shown in Table 7a, the standardized loadings of the two measures of attachment anxiety (ECR Anxiety, RQ Preoccupied) were very low and in the opposite direction to the other variables. This suggested that attachment anxiety was orthogonal to the non-anxious (or more avoidant; please see Section 4.3 for further discussion) attachment styles, and might be better

Table 6a

Standardized Factor Loadings for Sexual Reproductive Strategy Latent Variable

Sexual Strategy Indicator	Standardized Factor Loading
SOI Q2	.71
SOI Q3	.72
SOI Attitudinal Factor	.58
Total Number of Partners	.76
Age at First Intercourse[1]	.47
Typical Relationship Length[1]	.45
Partnering Status	.22
ECR Avoidance	.30
ECR Anxiety[1]	.28
RQ Dismissing	.36
RQ Preoccupied[1]	.19
RQ Security	.21
RQ Fearful	-.02

[1] Reversed score (e.g., higher score = earlier age at first intercourse) used in factor analysis

Table 6b

Standardized Factor Loadings for Modified Sexual Reproductive Strategy Latent Variable

Sexual Strategy Indicator	Standardized Factor Loading
SOI Q2	.68
SOI Q3	.76
SOI Attitudinal Factor	.54
Total Number of Partners	.80
Age at First Intercourse[1]	.46
Typical Relationship Length[1]	.46
Partnering Status	.18

[1] Reversed score (e.g., higher score = earlier age at first intercourse) used in factor analysis

Table 7a

Standardized Factor Loadings for Adult Attachment Latent Variable

Adult Attachment Indicator	Standardized Factor Loading
ECR Avoidance	.68
ECR Anxiety[1]	-.18
RQ Dismissing	.22
RQ Preoccupied[1]	-.07
RQ Security[1]	.86
RQ Fearful	.60

[1] Reversed score (i.e., higher score = less anxiety; higher score = less secure) used in factor analysis

Table 7b

Standardized Factor Loadings for Insecure/Avoidant Attachment Styles

Avoidant Attachment Indicator	Standardized Factor Loading
ECR Avoidance	.70
RQ Dismissing	.24
RQ Security[1]	.84
RQ Fearful	.59

[1] Reversed score (i.e., higher score = less secure) used in factor analysis

Table 7c

Standardized Factor Loadings for Modified Avoidant Attachment Latent Variable

Avoidant Attachment Indicator	Standardized Factor Loading
ECR Avoidance	.74
RQ Dismissing + Fearful	.67
RQ Security[1]	.79

[1] Reversed score (i.e., higher score = less secure) used in factor analysis

represented as a separate factor. Removing the anxiety measures and running the analysis again (see Table 7b), revealed high factor loadings for all variables except for RQ Dismissing. Based on the statistical criterion established (a loading ≥ .45) the RQ Dismissing indicator was accordingly removed. However, because the dismissing and fearful styles are discussed in the theoretical literature as the two "avoidant" subtypes, a composite RQ avoidance score was created and tested, comprising the sum of participants' dismissing and fearful scores. This was done to avoid losing one of the two indicators of avoidant attachment. Since both indicators originate from the same measure and are scaled identically, summing did not affect the weighting of the items or adversely impact the psychometric properties of the measure (as it might if components of the RQ were combined with the psychometrically stronger ECR subscales). As shown in Table 7c, re-running the factor analysis revealed that the standardized factor loadings were all equally high now. No further modifications were made to the resulting Avoidant Attachment factor.

Regarding the two indicators of attachment anxiety (ECR Anxiety, RQ Preoccupied), issues with non-convergence or improper solutions are known to occur when there are only two indicators per factor (Kline, 2011; Marsh & Hau, 1999). These problems can, however, be circumvented with the use of a single indicator if the measurement error can be accurately estimated (Kline, 2011; Hayduk & Littvay, 2012; Sarkisian, 2010). Consequently, it was deemed preferable to model romantic attachment anxiety using a single indicator. Because the ECR Anxiety subscale has stronger psychometric properties than the one-item RQ, and is preferred over the RQ in analytical situations where a consideration of measurement error is important (Sibley et al., 2005), the decision was made to use the 18-item ECR Anxiety subscale over the single-item RQ preoccupied scale as the observed measure of adult attachment anxiety. Although both scales clearly load onto the anxiety dimension, the single-item from the RQ provides only a global non-specific assessment of participants' perceived level of attachment anxiety, whereas the individual items from the ECR Anxiety scale are more targeted in their focus. Thus, summing the scores to create a single indicator was not considered conceptually appropriate.

Non-Sexual Reproductive Strategy. The preliminary factor analysis was run with all seven indicators. Table 8 shows the standardized factor loadings for the indicators of the Non-Sexual Reproductive Strategy latent construct. As can be seen, "Aggression", "Impulsivity", and "Risk-Taking" were the only three measures that fell above the established cutpoint of .45, with the other indicators displaying considerably weaker factor loadings. Sequential removal of the variables not meeting the ≥ .45 criterion did not change the pattern of factor loadings. Consequently only the Aggression, Impulsivity, and Risk-Taking indicators were retained.

Full CFA Model

The full CFA measurement model was run according to the modifications described above. Indicators of all latent variables were specified as continuous. The single indicators of Total Family Structure Index, RAQ Insecurity, ECR Anxiety, 2D:4D, Adult T, and CAG RL were also included in the measurement model. All latent variables were allowed to correlate with the single observed variables and with each other. The specified correlation between the errors of SOI Q3 and Total Number of Partners was also included. The estimation process converged. The measurement model is presented in Table 9.

The model demonstrated a good fit, χ^2 (104) = 169.88, $p < .001$, Comparative Fit Index (CFI) = .91, Root Mean Square Error of Approximation (RMSEA) = .057 (90% CI = .041 to .072), PCLOSE = .22. The inferential chi-square statistic was significant, which indicates a discrepancy between the population covariances and those predicted by the model. Chi-square is, however, highly sensitive to sample size and can easily become significant even with modest sized samples (Iacobucci, 2010). Consequently, it has been suggested, with some consensus in the literature, that a model demonstrates reasonable fit if the chi-square statistic adjusted by its degrees of freedom does not exceed 3.0 (i.e., $\chi^2 / df \leq 3$) (Kline, 2004). In the current model, this criterion equaled 1.6, suggesting an acceptable chi-square fit. With respect to the approximate fit indices of CFI and RMSEA, both statistics met the rule-of-thumb values for inferring good fit (e.g., Bentler & Bonett, 1980; Hu & Bentler, 1999). Furthermore, based on the lower bound of the

Table 8

Standardized Factor Loadings for Non-Sexual Reproductive Strategy Latent Variable

Non-Sexual Strategy Indicator	Standardized Factor Loading
AQ Total	.55
Risk Taking	.50
Impulsivity	.91
Dominance	.18
Autonomy	.09
Self Esteem	-.11
POMS Anxiety	-.21

Table 9

CFA with Standardized Factor Loadings and Correlations

Latent Variable Indicators	Standardized Factor Loadings	Latent Variables	Latent Variable Correlations
ECR Avoidance	.74	Avoidant Attachment and Sexual Strategy	.30
RQ Dismissing + Fearful	.68	Avoidant Attachment and Non-Sexual Strategy	.28
RQ Secure	.77	Sexual Strategy and Non-Sexual Strategy	.28
SOI Q2	.78		
SOI Q3	.59		
SOI Attitudinal Factor	.63		
Total Number of Partners	.64		
Age at First Intercourse	.48		
Typical Relationship Length	.48		
AQ Total	.83		
Risk Taking	.28		
Impulsivity	.62		

RMSEA 90% CI (.041), the close-fit hypothesis was supported, and based on the upper bound of the 90% CI (.072), the poor-fit hypothesis was rejected (Kline, 2011).

In order to further check for sources of model misfit, the sizes of the standardized factor loadings for all indicators specified to measure a common factor were inspected. All factor loadings were significant ($p < .001$) and were large in size ranging from .48 to .83, which provided evidence in support of the convergent validity of the indicators. Thus, all the latent variables were generally well measured by their respective indicators. The only exception was the risk-taking measure, which had a loading of .28, $p < .001$. Although this indicator could not be said to explain a large proportion of the variance of the factor it loaded onto (i.e., Non-Sexual Reproductive Strategy), it was kept in the measurement model for a theoretical reason. Risk-taking (along with aggression and impulsivity) is considered a central feature of the Young Male Syndrome (Wilson & Daly, 1985), which Chisholm (1999) believes is the optimal reproductive strategy for males reared in environments of high uncertainty. Consequently, it was deemed important to preserve the risk-taking indicator, in an effort to have a more accurate non-sexual reproductive strategy construct, in spite of its low standardized factor loading.

Misfit was also assessed by looking at the correlations between factors in the measurement model and ensuring than none were excessively high (e.g., > .90 in absolute value). As shown in Table 9, no latent factors were highly correlated with each other. These findings provided evidence of discriminant validity of the factors. In addition, as discussed earlier, there was no evidence of multicollinearity between indicator variables. Thus, this measurement model was used to test the theoretical structural model.

3.2.6. Full Structural Equation Model Analyses

The second step of the two-step SEM analysis was to evaluate the structural components of the conceptual model depicted in Figure 1. Incorporating the changes from the measurement model, the structural model then tested how several androgenic markers (Adult T, CAG RL, 2D:4D) related to attachment and reproductive strategies in men within the context of life history theories.

Latent Variable with a Single Indicator. Prior to running the full structural model, one additional type of modification was made. Recall that the use of single indicator variables within SEM is better when measurement error for that variable can be accurately estimated. Latent variables allow for the isolation of the true score from the inherent unreliability of indicators. Consequently, following an established procedure (Kline, 2011), latent variables for the questionnaire-based single indicators of Total Family Structure Index, RAQ Insecurity, and ECR Anxiety were created. For each observed single indicator, measurement error was estimated by subtracting a measure of the indicator's reliability (i.e., Cronbach's alpha) from 1. In order to determine the proportion of the total variance for each single indicator that was due to measurement error, the computed estimate of measurement error was multiplied by the total variance for that indicator. The error variance for the latent variable was fixed to this value.

Latent variables were not created for the three biological variables in the model. Because the internal consistency estimates were either very high and/or the proportion of error variance was very low for all three biological measures (i.e. Adult T, CAG RL, 2D:4D), it was deemed unnecessary to create latent variables for these single indicators.

Finally, the covariances between certain pairs of exogenous variables were set to zero in order to reduce the number of parameters within the model. In SEM analyses, all exogenous variables are by default allowed to covary with one another. Within the current model this meant that Total Family Structure Index covaried with both 2D:4D and CAG RL, however, it is not physiologically possible for direct correlations between these variables to exist (and they did not exist in the current data), as an individual's biological constitution cannot be systematically related to the composition of their parental family unit. Consequently, only the 2D:4D and CAG RL, were allowed to covary with each other, as this relationship was theoretically plausible.

The resulting structural model, incorporating the above-described modifications, fit the data well, particularly for its size and complexity, as indicated by χ^2 (110) = 186.31, $p < .001$, CFI = .90, RMSEA = .06 (90% CI = .045 to .074), PCLOSE = .14.

Figure 6 depicts the standardized regression weights for all hypothesized pathways. All significant pathways were significant at $p < .05$.

Support for the theories of Belsky et al. (1991) and Del Giudice (2009) was found. Consistent with the hypotheses, the Total Family Structure Index (where a higher score is indicative of a less stable family structure) positively predicted Childhood Attachment Insecurity (standardized path coefficient $\beta = .43$), which then positively predicted levels of both Avoidant Attachment ($\beta = .36$) and Anxious Attachment ($\beta = .38$) in adulthood. The adult romantic attachment latent variables each then differentially predicted scores on the Sexual Reproductive Strategy latent variable, in a manner again consistent with Belsky (1997) and Del Giudice's theorizing. Avoidant Attachment positively predicted scores on the Sexual Reproductive Strategy latent variable ($\beta = .35$), while Anxious Attachment negatively predicted scores on the same latent variable ($\beta = -.31$).

As hypothesized, the results of the structural model also provided support for androgenic influences on romantic attachment behaviour. Adult T was found to positively predict Avoidant Attachment ($\beta = .20$). This finding is congruent with the possibility that men's circulating levels of T had an activational effect on adult avoidant attachment. In contrast, no relationship was found between Adult T and Anxious Attachment, however, CAG RL positively predicted Anxious Attachment ($\beta = .25$). A positive relationship between these two variables suggests that weaker androgen receptor functionality, as conferred by a longer CAG RL, resulting in lower levels of T activity, may be causally associated with higher levels of adult romantic attachment anxiety.

No support for the hypothesized causal pathways between the Family Structure Index and Adult T ($\beta = -.04$, $p > .05$) or between Childhood Attachment Insecurity and Adult T ($\beta = .08$, $p > .05$) was found. Thus there was no evidence from the present study that environmental and psychological factors in childhood, albeit assessed retrospectively, influenced individual differences in T levels in adulthood as suggested by the theories of Belsky et al. (1991) and Miller and Pasta (2000). In addition, significant

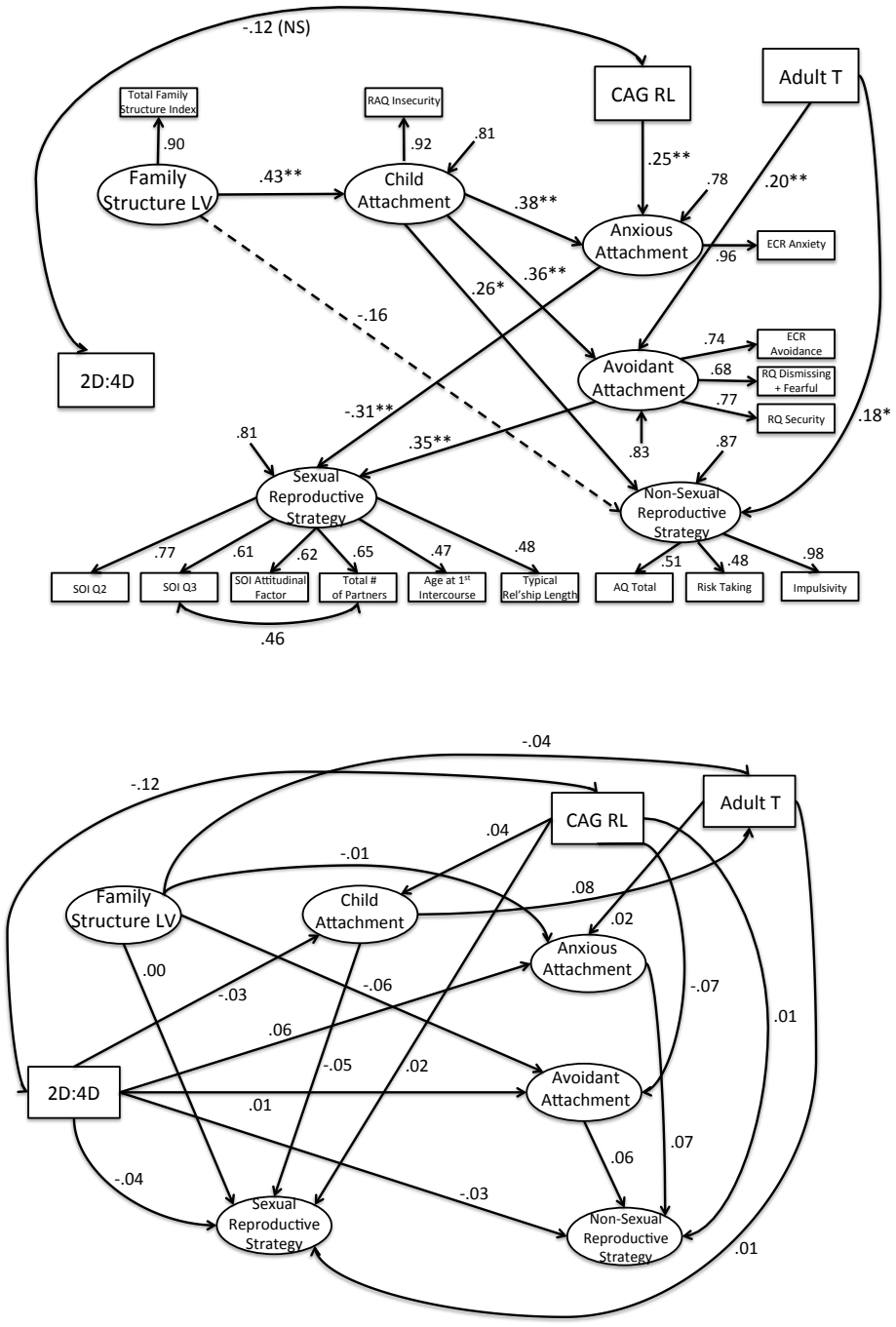

Figure 6. Structural model. The top part of the figure depicts all significant standardized path coefficients (* $p < .05$, ** $p < .01$). The dashed line represents a trend-level pathway ($.05 > p < .10$). The bottom part of the figure depicts all non-significant pathways within the same model. Ovals represent latent variables. Rectangles represent observed variables. Single headed arrows pointing towards a latent variable represent error.

relationships were not found between 2D:4D and any of the variables it was hypothesized to predict. CAG RL also did not significantly predict individual differences in childhood attachment insecurity ($\beta = .04$, $p > .05$). The current model thus provided no evidence in support of organizational effects of androgens on either attachment or related reproductive strategies.

The full structural model also provided support for Chisholm's (1999) life history theory of attachment and reproduction. A less stable early family environment, as measured by the Total Family Structure Index positively predicted Childhood Attachment Insecurity ($\beta = .43$), which in turn directly predicted higher scores on the Non-Sexual Reproductive Strategy latent variable ($\beta = .26$). Chisholm does not implicate adult, romantic attachment in his model, thus the failure to find significant relationships between either of the adult attachment latent variables and Non-Sexual Reproductive Strategy was not inconsistent with expectations ($\beta = .06$, $p > .05$ for Avoidant Attachment; $\beta = .07$, $p > .05$ for Anxious Attachment). Although no direct relationship between Childhood Attachment Insecurity and the Sexual Reproductive Strategy was found ($\beta = -.05$, $p > .05$), the "Young Male Syndrome" (Wilson & Daly, 1985) is defined more heavily by the evocative behaviours of aggression, impulsivity, and risk-taking used for the purpose of engaging in opportunistic mating, rather than sexuality alone. Finally, Adult T was a positive predictor of the Non-Sexual Reproductive Strategy ($\beta = .18$), which is in line with Chisholm's theorizing. Chisholm (1999) highlights T as the "mechanism for motivating young men to engage in risky activities that maximize current reproduction". No relationship was found between CAG RL and the Non-Sexual Reproductive Strategy ($\beta = .01$, $p > .05$).

To investigate further model optimization, all non-significant pathways, save for those in a trend range (i.e., $.05 > p < .10$), were removed from the model. Such modification made only a very minor improvement to model fit, χ^2 (113) = 183.50, $p < .001$, CFI = .90, RMSEA = .057 (90% CI = .041 to .071), PCLOSE = .22. All previously significant estimates became significant at $p < .01$ level; trend-level estimates remained in the trend range (see Figure 7).

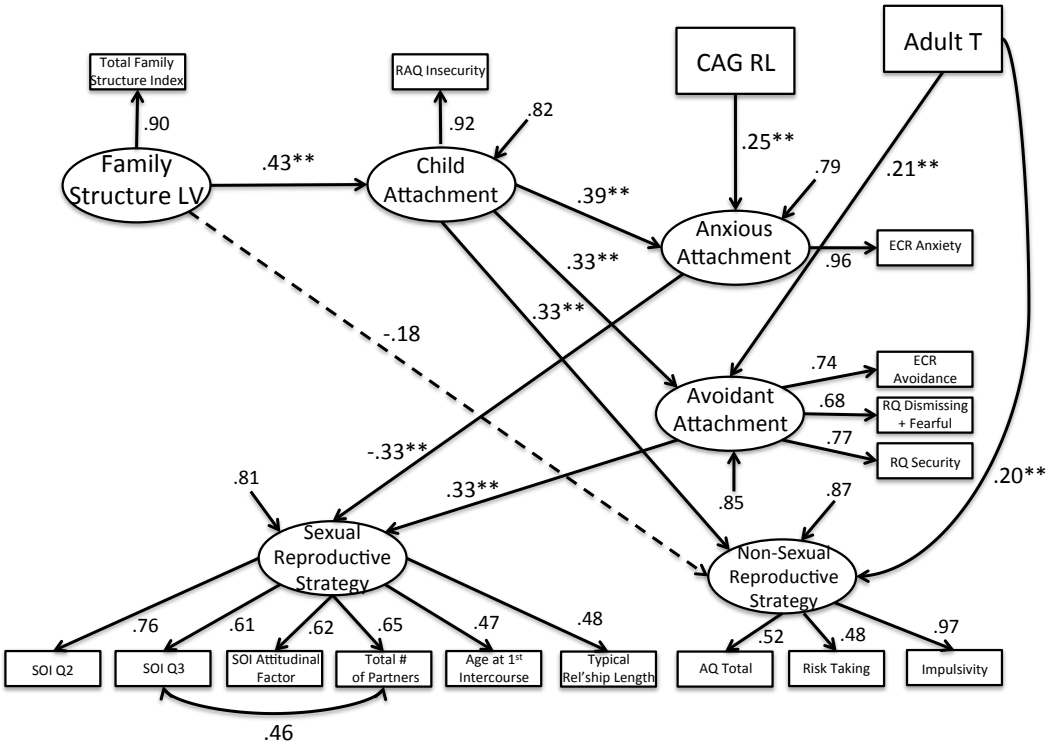

Figure 7. Structural model run with only significant pathways (* $p < .05$, ** $p < .01$). The dashed line represents a trend-level pathway ($.05 > p < .10$). Ovals represent latent variables. Rectangles represent observed variables. Single headed arrows pointing towards a latent variable represent error.

Indirect Effects. Using the full structural model with all hypothesized connections, specific indirect effects of theoretical interest were evaluated. Because the present study was interested in understanding the role of androgens in causal models of attachment and reproduction, the mediated effects of Adult T on the Sexual Reproductive Strategy and CAG RL on the Sexual Reproductive Strategy were computed. In addition, mediation effects were tested for pathways that supported the various life history theories (i.e., Total Family Structure Index to Non-Sexual Reproductive Strategy and Childhood Attachment Insecurity to Sexual Reproductive Strategy).

The indirect effects were derived through a product of the coefficients for the constituent direct paths from independent variable to intervening variable and from intervening variable to dependent variable (MacKinnon, 2008). Mediation is considered to be present when indirect effects are statistically significant. The significance of the indirect effect was computed using bias-corrected bootstrapping with 1000 resamples (Kline, 2011), an increasingly popular method of testing indirect effects (e.g., Shrout & Bolger, 2002). Bias-corrected bootstrapping is a nonparametric approach that requires fewer assumptions than traditional methods of mediation (e.g., mediated regression analysis) and tends to provide more accurate estimates (Bollen & Stine, 1990; MacKinnon, Fairchild, & Fritz, 2007; Preacher & Hayes, 2008; Preacher & Kelly, 2011; Shrout & Bolger, 2002). In addition to inspecting the *p*-value for a given indirect effect (i.e., $p < .05$), if the 95% bias-corrected bootstrapped confidence interval (95% CI) does not contain 0 it suggests the presence of mediation (Bollen & Stine, 1990; Preacher & Hayes, 2008; Shrout & Bolger, 2002). Because Amos v. 22.0 does not allow for bootstrapping when a data set includes missing cases that are estimated by the program, mediation analyses were conducted using Mplus v. 7.11. Results of the mediation analyses are summarized in Figure 8.

The bias-corrected indirect effect of Adult T through Avoidant Attachment on Sexual Reproductive Strategy was evaluated using a one-tailed test of significance. The extant literature suggests that the direction of the relationship between basal T and avoidance should be positive, as should the relationship between attachment avoidance and sexual behaviours indicative of a shorter-term mating orientation. Accordingly, a

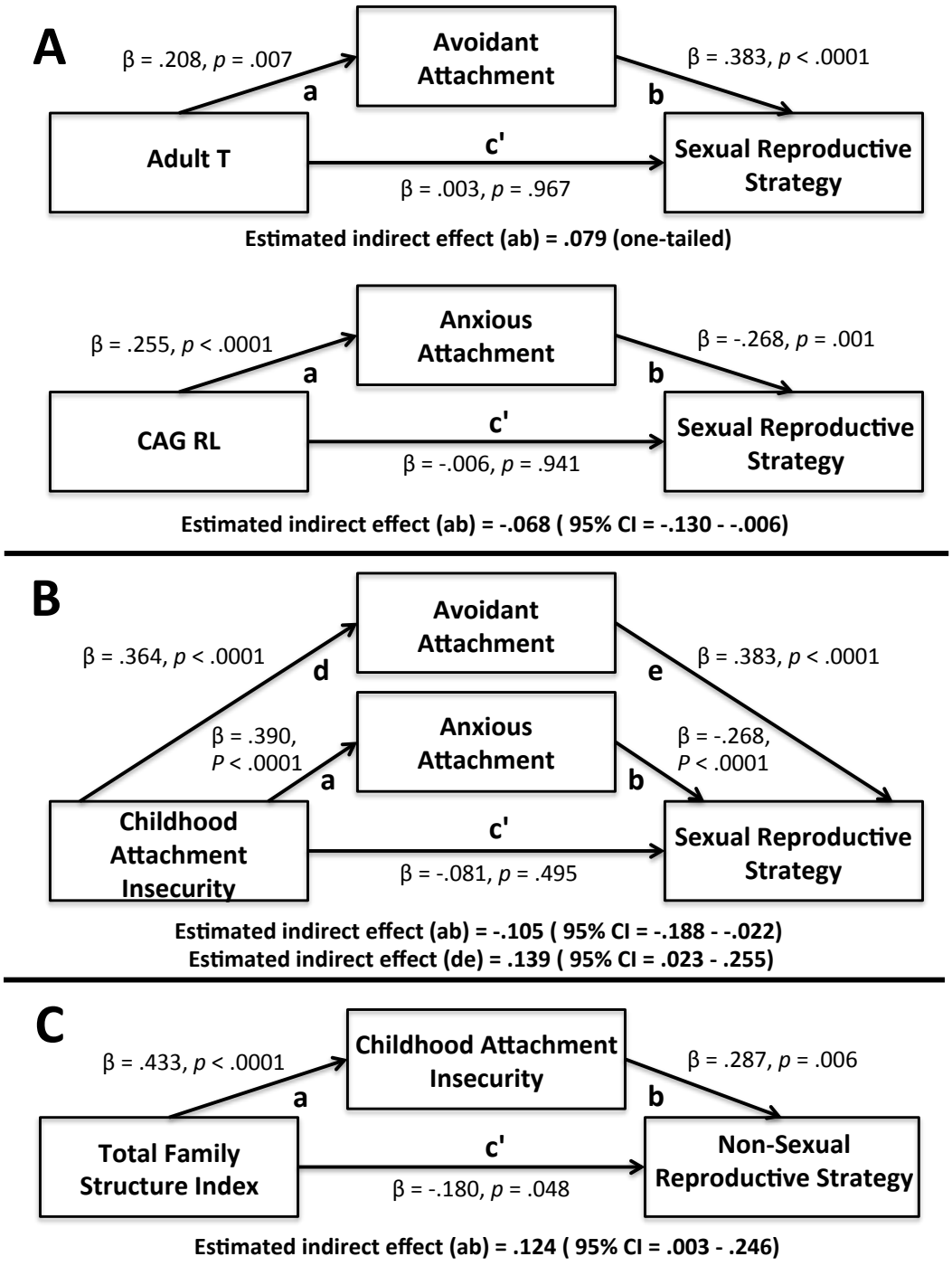

Figure 8. Summary of mediation analyses. Mediation analyses of Adult T, CAG RL, and Childhood Attachment Insecurity on Sexual Reproductive Strategy, directly, and indirectly through Romantic Attachment (panel A and B). Panel C depicts the mediation analysis of Total Family Structure Index on Non-Sexual Reproductive Strategy, directly, and indirectly through Childhood Attachment Insecurity.

one-tailed test was considered appropriate. The results of the mediation analysis demonstrated that the constituent paths comprising the indirect effect (i.e., Adult T to Avoidant Attachment and Avoidant Attachment to Sexual Reproductive Strategy) were both in the anticipated positive direction, and each path was significant at $p < .01$. The indirect effect was significant at $p < .05$. By contrast, the direct effect of Adult T on the Sexual Reproductive Strategy was non-significant ($p > .05$), indicating mediation.

For CAG RL, the indirect effect of CAG RL through Anxious Attachment on Sexual Reproductive Strategy had to be evaluated using a two-tailed significance test, as the literature is silent on the importance of the androgen receptor per se. The indirect effect was significant at $p = .03$, 95% CI [-.130 to -.006], indicating that Anxious Attachment mediated the relationship between CAG RL and Sexual Reproductive Strategy. Again, the direct effect of CAG RL on the Sexual Reproductive Strategy was non-significant ($p > .05$).

Testing the two specific indirect pathways that supported the theories of Belsky et al. (1991) and Del Giudice (2009) showed that the indirect effect of Childhood Attachment Insecurity through Avoidant Attachment on Sexual Reproductive Strategy was significant at $p = .02$, 95% CI [.023 to .255], indicating the presence of mediation. The indirect effect of Childhood Attachment Insecurity through Anxious Attachment on Sexual Reproductive Strategy was also significant at $p = .01$, 95% CI [-.188 to -.022]. The direct effects were non-significant at $p > .05$.

Finally, the indirect pathway of Total Family Structure Index through Childhood Attachment Insecurity on Non-Sexual Reproductive Strategy, as outlined by Chisholm (1999), was tested for mediation. The indirect effect was significant at $p = .04$, 95% CI [.003 to .246], indicating that attachment insecurity in childhood mediated the relationship between early family environment and engagement in a reproductive strategy characterized by aggression, impulsivity, and risk-taking.

Subgroup Follow-Up Analysis. Recent evidence in the literature has begun to suggest that the most frequently occurring CAG repeat lengths in the population may

confer stronger androgen receptor functionality compared to short or long repeat lengths (Buchanan et al., 2004; Nenonen et al., 2010a; 2010b). This view differs from the commonly assumed negative linear association between CAG length and androgen receptor function that formed the basis for the present study. To investigate this emerging possibility, exploratory correlations were computed in SPSS.

Review of the frequency distribution of CAG RL in the current sample revealed a mean of 21.80 (*SD* = 2.66) and a mode of 21. A modal range of 21±1 (20-22) therefore was used, as this encompassed approximately 50% of the sample (N = 94). Pearson correlations were then computed for the modal subsample between Adult T and any variables it was hypothesized to predict. For the latent variables of Avoidant Attachment, Sexual Reproductive Strategy and Non-Sexual Reproductive Strategy, as well as the single indicator Anxious Attachment, factor scores were first computed using the formula: $F_{ji} = \beta_{j1}z_{i1} + \beta_{j2}z_{i2} + \ldots + \beta_{jk}z_{ik}$, where z = the standard score of each observed variable caused by the latent construct and β = the standardized regression weight of the latent factor on the observed (indicator) variable.

Results showed that the relationship between Adult T and Avoidant Attachment was stronger within the modal CAG group, with $r = .31$, $p < .01$. Similarly, the correlation between Adult T and Non-Sexual Reproductive Strategy was larger in size compared to the standardized regression coefficient between these two variables in the SEM analyses, with $r = .28$, $p < .01$. By contrast, the correlations between Adult T and Anxious Attachment and Adult T and Sexual Reproductive Strategy remained weak and non-significant ($r = .05$, $p > .05$ and $r = .07$, $p > .05$, respectively), consistent with the pattern seen in the structural analyses. Overall, these findings support the possibility that a CAG repeat range that covers the lengths most people carry is associated with optimal androgen receptor functionality.

4. General Discussion

4.1. Overview of Research Goals

In the past several decades, researchers have begun to understand individual differences in human reproductive strategies. Life history-based approaches suggest a critical role for attachment processes, in both childhood and adulthood (e.g., Belsky et al., 1991; Chisholm, 1999; Del Giudice, 2009). Attachment insecurity (*vs.* security) has been proposed to lead to early reproductive effort, a short-term mating orientation, and associated characteristics of increased aggression, impulsivity, and risk taking, among adult men. Furthermore, theories by Belsky (1997), as well as Del Giudice (2009), have hypothesized differential reproductive consequences of the different insecure attachment styles. In particular, avoidant patterns have been associated with short-term, opportunistic, uncommitted mating, and are suggested to be characteristic of insecure men (Del Giudice, 2009).

These theorists, as well as Miller and Pasta (2000), have also speculated about the role of sex hormones within LHTs of early environment, attachment, and reproduction, with hormonal effects suggested to occur prenatally and/or in adult life when reproductive behaviours are of direct relevance (Belsky, 1997). The biological plausibility of this suggestion is based on a large body of literature showing that androgens in particular, and especially testosterone, are capable of influencing the structure and/or neurochemistry of the brain at these same time points (Breedlove & Hampson, 2002; Wallen, 2009), with exposure during critical periods in early development having enduring consequences for behavioural predispositions. Chisholm (1999) specifically implicates testosterone as a causal factor for increased male engagement in risky activities that adaptively maximize current reproductive opportunities (i.e., the "Young Male Syndrome"), while Belsky et al. (1991) and Miller and Pasta (2000) discuss the role of pubertal maturation, characterized in males by a significant increase in androgen concentrations, in the development of reproductive strategies. Because puberty ushers in adult-like levels of testosterone, it opens the door to a new class of hormonal action, the so-called activational effects of the hormone (Eckel

et al., 2008). Activational effects are not possible in childhood when testosterone production is negligible, because they involve changes in the CNS that are sustained by the ongoing current presence of a hormone. The fact that the avoidant style is hypothesized to be a "male-biased" strategy is consistent with studies that have found that on average, men have higher attachment avoidance and lower attachment anxiety than women (e.g., Del Giudice, 2011; Bartholomew & Horowitz, 1991; Scharfe & Bartholomew, 1994; Schmitt et al., 2003; Brassard et al., 2007). A possible proximate mechanism underlying the sex difference may be differential levels of sex hormones, including androgens.

The goal of the present research was to formulate and empirically test a LHT-based model of attachment and reproductive strategies in men, integrating the potential effects of androgens. Support for the basic tenets of a LHT-based model would be demonstrated by finding that a less stable early family environment positively predicted childhood attachment insecurity, and that in turn attachment insecurity positively predicted a more opportunistic reproductive strategy in adulthood, characterized by a shorter-term mating orientation and more avoidant and less anxious adult romantic attachment style. The relationship between testosterone and attachment was investigated by incorporating measures of adult testosterone, as well as an indirect estimate of prenatal differences in testosterone (2D:4D ratio), and of androgen receptor sensitivity (indexed by CAG repeat length) into the model in an effort to evaluate whether any association with androgens was supported (and if so, whether effects occurring during very early development or in adulthood were implied). Although the LHTs are neither uniform, nor very specific, about the *timing* of androgenic effects, the testosterone-related indices chosen in the present study had the potential to provide insights into this important question.

The discussion below is organized as follows. I will begin by summarizing the overall findings from the research study. Following this, I will discuss the pattern of results obtained within the context of the existing theory and literature. I will then discuss the role of androgens within the LHT-based model, and what, if any, type of effect androgens have on attachment-related processes in men. The chapter will conclude

with a discussion of the limitations of the present research, followed by a review of the study's contributions and some directions for future research.

4.2. Summary of Research Findings

The present research represents the first empirical study to test and support a LHT-based model of attachment and reproductive strategies in young men. To my knowledge no studies before it have investigated the role of attachment processes within evolutionary-developmental models of reproduction. Structural analyses demonstrated that a less stable family structure in childhood positively predicted childhood attachment insecurity (assessed retrospectively), which then positively predicted a more opportunistic sexual reproductive strategy, via greater levels of avoidant attachment. By contrast, the sexual reproductive strategy was negatively predicted by levels of adult anxious attachment. These findings highlight the differential significance of adult romantic attachment styles on the development of men's reproductive strategies, and support the theoretical models proposed by Belsky (1997) and Del Giudice (2009), who have hypothesized that avoidant attachment is associated with opportunistic, uncommitted mating behaviours. The findings also provide new evidence that within men, anxious attachment may be associated with more investment-oriented and less opportunistic sexual behaviours.

Another novel contribution of the present study was that it demonstrated that childhood attachment insecurity mediated the relationship between quality of early family structure and engagement in non-sexual evocative behaviours (i.e., Young Male Syndrome) believed to be associated with a more opportunistic male reproductive strategy (Chisholm, 1999). This finding again highlights the centrality of attachment processes in the development of mating strategies in men. Furthermore, it provides the first empirically-based support for Chisholm's model (1996, 1999), which focuses on the role of *childhood* attachment configurations in the expression of reproductive strategies in adulthood.

Support for the integration of androgenic factors within a LHT-based model of attachment and reproduction was also demonstrated—the first empirical evidence of its kind. Levels of testosterone in adulthood were found to independently and positively predict levels of avoidant attachment, as well as the non-sexual reproductive strategy. Integration of testosterone into the model was further expressed by the identification of avoidant attachment as a mediator variable in a significant pathway connecting adult testosterone levels to the sexual reproductive strategy. In addition, weaker androgen receptor responsivity to testosterone predicted higher levels of anxious romantic attachment and anxious attachment was found to be a significant negative predictor of a short-term reproductive strategy. Mediation analysis showed that anxious attachment was a significant mediator in a pathway connecting responsivity to adult testosterone levels and the sexual reproductive strategy. Thus, adult romantic attachment was found to be an important mediator of associations observed between levels of androgen activity and the sexual reproductive strategy.

Overall, the findings from this study highlight the pivotal role that attachment processes play in evolutionary-developmental models of mating in men.

4.3. The Integrated Life History Theory-Based Model

I will now turn to a more complete interpretation of the core findings from the structural analyses, within the context of the LHT framework. The core set of relationships, as described in Section 4.2, is summarized schematically in Figure 6. As can be seen in the Figure, childhood attachment insecurity had three separate, direct effects: on adult anxious attachment, adult avoidant attachment, and non-sexual reproductive strategies (as represented by higher levels of aggression, risk-taking, and impulsivity). In other words, men's retrospective self-reports of their level of attachment insecurity to caregivers in childhood seems to predict degree of self-acknowledged attachment insecurity in adulthood, as well as predicting engagement in evocative non-sexual behaviours characteristic of opportunistic mating.

Evidence of temporal continuity of insecure attachment patterns is consistent with certain LHT-based models of attachment and reproduction (i.e., Belsky, 1997; Del Giudice, 2009) that suggest that early attachment prototypes should influence the development of corresponding adult, romantic attachment styles, which are used to guide reproductive strategies. As proposed by Bowlby (1982), attachment relationships formed early in life represent internal working models of individuals and their social worlds that can be stable across significant portions of the lifespan. Empirical study has supported this claim, finding stability in insecure attachment patterns from infancy to young adulthood (e.g., Hamilton, 2000; Fraley, 2002), and that exposure to negative life events over the developmental course seems to increase the stability of attachment insecurity (Hamilton, 2000). Furthermore, and consistent with the current results, retrospective studies have found overlap in levels of attachment security to parents in childhood and to romantic partners in adulthood (e.g., Hazan & Shaver, 1987; Levy, Blatt & Shaver, 1998, J. Steele as cited in Fraley, 2002). These findings support the view that attachment is an enduring trait that shapes the kinds of interactions a person experiences and facilitates personality stability within a given environment (Fraley, 2002).

Consistent with this view, confirmatory factor analysis in the current study did not find that measures of romantic attachment style loaded strongly onto the sexual reproductive strategy latent variable, but instead suggested that they may represent separate, yet correlated entities (i.e., avoidant and anxious attachment) which *predict* the sexual reproductive strategy. As Hill and colleagues (1994a) have suggested, romantic attachment style may act as a mediator between early environmental factors (including childhood attachment) and adult reproductive strategy (which was empirically supported in the current investigation). Identifying that romantic attachment predicts reproductive strategy is of relevance, as it helps to clarify the ambiguities about where romantic attachment fits within LHT-based models (i.e., Belsky, 1997; Del Giudice, 2009). It is important to note, however, that the existence of stability of attachment prototypes into adulthood does not preclude the possibility that men may adjust their reproductive strategies later in development (Del Giudice, 2009). In fact, biological factors, including

sex hormones, may contribute to adaptive reproductive plasticity in adulthood (Del Giudice, 2009). More is said about this in Section 4.4.

Within the current model, romantic attachment avoidance was not a single indicator, but rather it was a component of a multi-indicator latent construct. As outlined in Section 3.2.5, CFA found that the indicators of ECR Avoidance, RQ Dismissing-Avoidance, RQ Insecurity, and RQ Fearful loaded most strongly together, while the two measures of anxious attachment only weakly loaded onto the same factor. The finding that overall attachment insecurity (computed by reverse coding the scores on the RQ Secure Attachment scale) was more closely associated with attachment avoidance, than anxiety, has been supported in the literature. In a factor analytic study of several romantic attachment measures, Brennan and Shaver (1995) identified an *Insecurity* factor, defined by high loadings on self-reliance, frustration with partners, proximity-seeking (in a negative direction), and low loadings on jealousy and anxious clinging to partners, and a *Preoccupation with Attachment* factor, defined by high loadings on anxious clinging to partners, jealously, frustration with partners, and low loadings on self-reliance. The insecurity factor was found to correlate strongly and positively with attachment avoidance (.67), as measured by Hazan and Shaver's (1990) rating-scale of attachment style, and not at all with anxiety (.03), while the Preoccupation factor correlated positively with anxious-ambivalence (.59), and not at all with avoidance (.09). Similarly, Simpson (1990) factor analysed the 13 items of Hazan and Shaver's (1987) attachment measure and found that 2 factors emerged: a *secure-avoidant* dimension (made up of the 5 secure and 4 avoidant items, and reflecting level of insecurity/avoidance), and an *anxious-nonanxious* dimension (made up of the 4 anxious items, and reflecting level of anxiousness).

As introduced in Section 3.2.1 (see Appendix D), fearful attachment has been described as a special case of dismissing-avoidance (what has been referred to here as avoidance), in which the deactivating defences characteristic of dismissing-avoidant individuals (i.e., lack of proximity-seeking) are not fully operative (Shaver & Mikulincer, 2002). Consequently, fearfulness is considered to be inherently linked with dismissing-avoidance, and fearful individuals remain capable of employing behavioural strategies

consistent with deactivation (Shaver & Mikulincer, 2002). As such, it is conceptually appropriate that levels of fearfulness loaded more strongly on the avoidant than the anxious attachment latent variable.

Romantic attachment configurations were found to directly and differentially predict men's sexual reproductive strategy, such that avoidant attachment *positively* predicted men's sexual behaviour and anxious attachment *negatively* predicted sexual behaviour. These results corroborate the existing empirical evidence that suggests that romantic attachment avoidance is associated with more opportunistic sexual behaviour (e.g., Simpson, 1990; Brennan & Shaver, 1991,1995; Feeney & Noller, 1992; Paul et al., 2000; Schmitt, 2005; Jackson & Kirkpatrick, 2007, Schindler et al., 2010, DeWall et al., 2011), while anxious attachment may be associated with behaviours indicative of less interest in short-term mating (e.g., Gentzler & Kerns, 2004; Kirkpatrick & Davis, 1994; Schmitt, 2005, Jackson & Kirkpatrick, 2007). Furthermore, the current findings are in support of lifespan attachment models (i.e., Belsky, 1997; Del Giudice, 2009), which suggest that avoidance in men is associated with short-term, uncommitted mating.

Interestingly, a double-dissociation in how child and adult attachment predicted sexual and non-sexual reproductive strategies was found. Attachment insecurity in childhood directly predicted the non-sexual reproductive strategy, and not the sexual reproductive strategy, while adult romantic attachment configurations directly predicted the sexual reproductive strategy, and not the non-sexual reproductive strategy. Because juveniles cannot reproduce, it has been suggested that the adaptive consequence of insecure attachment in childhood may be to increase male coercive tactics (i.e., increased aggressiveness and impulsiveness) that characterize alternative reproductive strategies (Chisholm, 1996; 1999). By contrast, attachment insecurity early in life only predicted adult sexual behaviour through men's adult romantic attachment configurations. This finding supports the notion proposed by Del Giudice (2009) that it is *adult* attachment that takes on the mature function of regulating relationships and sexual mating strategies. Empirically, a substantial literature base exists to support the association between adult, romantic attachment and sexuality (e.g., Simpson, 1990; Brennan & Shaver, 1991,1995; Feeney & Noller, 1992; Paul et al., 2000; Gentzler & Kerns, 2004; Schmitt, 2005;

Jackson & Kirkpatrick, 2007, Schindler et al., 2010). At present, however, no research has been conducted on the association between childhood attachment patterns and adult sexual behaviour. Although the lack of such study within a rich and long-standing research traditional like child attachment is intriguing, and raises questions about researchers' beliefs about the existence of a direct relationship between these variables, it remains possible that future studies, if conducted, could find a significant association between early attachment and later sexual behaviour. Nevertheless, the current findings reconcile Chisholm's theory (1996; 1999), which discusses the consequences of *childhood* insecurity/security on later reproductive behaviour, with those of Del Giudice (2009) and Belsky (1997), which highlight the relevance of attachment in adulthood in the development of sexual behaviour preferences. Overall, the findings from the model highlight the importance of attachment processes, in both childhood and adulthood, in the development of male reproductive strategies.

LHTs of attachment and reproduction hypothesize that early childrearing experiences should predict the development of corresponding psychological attachment styles in childhood. In support of this, current results showed that less stable, and supposedly more stressful, family structure from birth to age 16 years, predicted greater levels of childhood attachment insecurity. Early family composition itself, however, did not directly predict sexual or non-sexual reproductive strategies. Draper and Harpending (1982) posit that early experiences concerning fathering and marital relationships influence the reproductive strategies that individuals develop in adulthood. While there exists some limited evidence of an association between father absence during early life and increased sexuality in men in young adulthood (e.g., Alvergne et al., 2008; Kim & Smith, 1998), most studies focus only on women, and James and colleagues (2012) have suggested that the unique role of father presence/absence on sexual development (i.e., *paternal investment theory*, see Ellis (2004)) may be more specific to women than men. Furthermore, the total family structure index included in the current study was not purely a measure of father presence/absence, and instead assessed family composition (and associated stress) from infancy to adolescence, which could help to account for the lack of relationship with mating strategy. A less father-centric perspective is consistent with

the theories proposed by Belsky et al. (1991), Chisholm (1999), and Del Giudice (2009), which suggest that the stress of the early family environment (which may derive in part from family composition) affects reproductive strategies via the attachment system (also see Hill et al., 1994a). In support of this, Miller and Pasta (2000) found that various measures of early family stress (e.g., level of family affection, exposure to abuse, father absence) failed to predict self-reported levels of aggression in young adult men.

4.4. The Role of Androgens Within an Integrated Life History Model

The most novel contribution of this study is that it provides some of the first empirical evidence in support of a predictive association between androgen action and romantic attachment in young adult men. Circulating levels of testosterone (T) in adulthood were found to positively predict an avoidant form of attachment. Higher T predicted a more avoidant approach. In addition, the length of the CAG repeat sequence in the androgen receptor (AR) gene, which has been suggested to be inversely related to the degree of responsivity of the AR to T following binding (e.g., Choong et al., 1996; Ding et al*.,* 2004), predicted anxious attachment. In other words, lower activation of genomic processes by T at the receptor level was found to predict greater anxious attachment.

Although this study is the first to systematically investigate the link between T activity and adult romantic attachment, these results are supported by a number of related observations. Previous studies have shown that romantically partnered men have lower circulating T levels compared to single men (e.g., Burnham et al., 2003; Gray et al., 2004), and that men's T levels may remain stable even with changes in partnering status (i.e., low T men are more likely to become and stay partnered than high T men; van Anders & Watson, 2006). Across several cultures, the level of caregiving that fathers provide their children, as assessed by self-report, partner-report, or interview, has been found to be negatively correlated with T levels (Gettler et al., 2011; Alvergne et al., 2009; Muller et al., 2009; Kuzawa et al., 2009). One investigation has reported a reduction in T levels subsequent to new fatherhood (infants aged 1 month or less) (Gettler et al., 2011). Weisman, Zagoory-Sharon, and Feldman (2014) recently demonstrated that lower basal T

levels in fathers of infants were associated with greater engagement in father-infant bonding behaviours (i.e., affectionate touch, "motherese", positive affect, and gaze towards infant), as coded by the experimenters. Collectively, these findings are consistent with the hypothesis that lower T in men may promote more committed, nurturing behaviour (Gettler et al., 2011). Finally, in an investigation of young men's interpersonal styles, adult T levels were negatively correlated with degree of communion, assessed in part by levels of attachment-related avoidance (Turan et al., 2014).

Low T has been associated in other studies with higher levels of internalizing symptoms including anxiety (e.g., Granger et al., 2003) and depressive symptoms (e.g., Sankar & Hampson, 2012; Schmidt et al., 2004). This converges with studies showing that romantic attachment anxiety is related to higher levels of self-reported depression, as well as state and trait levels of anxiety, compared to the avoidant style (e.g., Simonelli et al., 2004; Williams & Riskind, 2004). Within the current study too positive correlations were found between self-reported trait anxiety and measures of romantic attachment anxiety. The present study, however, is the first to show a link between a genetic marker of T-related activity and level of attachment anxiety.

Although not explicitly tested until now, several life history theorists have speculated about the possible role of T in evolutionary-developmental models of attachment and reproduction. For example, accelerated pubertal timing, a variable that is a proxy for the relative levels of circulating T in males, has been hypothesized to have consequences for sexual behaviour profiles (i.e., Belsky et al., 1991; Miller & Pasta, 2000). In addition, Chisholm (1999) views T as part of the mechanism for motivating young men to engage in behaviours that maximize current reproduction, based on the fact that T is implicated in each of the core features of the Young Male Syndrome. The current findings demonstrated that adult T directly predicted the non-sexual reproductive strategy, in line with Chisholm's (1999) proposition. Furthermore, in the present study androgen variables directly predicted romantic attachment style, and via the mediation of romantic attachment, also predicted the sexual reproductive strategy. This speaks to the centrality of attachment processes in the development of sexual behaviours/reproductive orientations in men. As Del Giudice (2009) suggests, it is attachment in adulthood that

takes on the mature function of regulating relationships and sexual mating strategies, and it is possible that increased androgen action may contribute to reproductive plasticity in adulthood by serving to amplify romantic attachment-dependent effects on mating strategies.

Of the limited empirical research conducted on life history models of mating and reproduction, no studies to date have assessed attachment either in childhood or romantically in adulthood. Based on the current findings, it appears that attachment configurations are indeed important in linking early family experience with reproductive behaviour in adulthood, and for accounting for how androgens are integrated within LHT-based models. In fact, the mediating role of romantic attachment may help to explain why existing evolutionary-developmental studies have not found a significant predictive association between pubertal timing, a variable that is a proxy for the relative levels of circulating T, and later sexual behaviour in males (i.e., Meckelmann et al., 2013; James et al., 2012). No evidence was found in this study, however, to support a direct predictive relationship from childhood attachment (or early family structure) to adult T, as might be expected by Belsky et al. (1991) or Miller and Pasta (2000). Although consistency would be expected between an individual's levels of pubertal T and adult T (e.g., Gesquiere et al., 2005), it is conceivable that stronger associations may have been seen presently if we had used a measure of T taken at puberty. Nevertheless it is possible, and perhaps more plausible, that T concentrations in adulthood independently predict attachment-related behaviour, once reproduction and mating become relevant concerns, as the current analyses suggest.

Although romantic attachment mediated the relationship between T or CAG RL and the sexual reproductive strategy, a direct predictive association between the androgen variables and the same latent construct was not found. This is somewhat unexpected given that previous literature has generally found positive associations between adult T, measured in either serum or saliva, and engagement in sexual behaviour, assessed experimentally or in correlational studies (e.g., van Anders & Goldey, 2010; Alvergne et al., 2009; Peters et al., 2008; van Anders et al., 2007; Schmidt et al., 2004). It is doubtful that the reason for the lack of relationship is due to T-related measurement error; the

mean and standard deviation for adult T in the present work were comparable to those found in most other studies of young adult men, and the internal consistency estimate showed a high reliability between the two T measurements obtained during testing.

Given that many of the indicators of the sexual reproductive strategy were single items that depended on self-report (e.g., total number of partners, typical relationship length, age at 1st intercourse), it is possible that the inherently weaker reliability of single item or limited item measures could have reduced the size of the associations. Stronger relationships may have been seen if multi-item measures were used as indicators. In addition, the results from recent studies investigating the relationship between T and the SOI (the source of several of our indicators) are mixed. For example, several studies have found that SOI scores are positively correlated with T in partnered but not single men (e.g., Puts et al., 2015; Edelstein et al., 2011; McIntyre et al., 2006). Given that nearly half of the study sample (N = 98) self-identified as single, this may have weakened the associations. Other studies have not found significant associations between T and the SOI (e.g., Charles & Alexander, 2011; van Anders et al., 2007). Although age at first intercourse was not significantly correlated with adult T levels, it was significantly correlated with CAG repeat length, in the anticipated direction (i.e., older age at first intercourse associated with longer CAG repeat sequence). It remains, however, that the results at this level of the model are weakened by the fact that the expected association between T and the sexual reproductive strategy was not found.

Adult T did, however, positively predict the non-sexual reproductive strategy, which is consistent with much existing literature on adult T and externalizing behaviours in men that points to a positive correlation between circulating T levels and aggression and risk-taking (e.g., Archer, 1991; White et al., 2006). The direction of association between adult T and impulsivity is less clear, partly due to the limited number of studies conducted on this topic in human males, although some studies suggest a positive correlation (e.g., O'Connor et al., 2002; Schmidt et al., 2004). Chisholm (1999) proposed that the so-called Young Male Syndrome, defined by the hypermasculine behaviours of increased aggression, risk-taking, and impulsiveness, is caused, in part, by T, which he viewed as the "drug" for engaging in risky activities. Within the current data, the

individual correlations between adult T and aggression, risk-taking, and impulsivity were all in the expected positive direction, although stronger for aggression and impulsivity than for risk-taking. The relationship between adult T and risk-taking, as assessed by paper-and-pencil measures, is not as well established in the literature, with most studies tending to assess risk-taking through laboratory-based gambling tasks. Such measures were not employed in this study because of the interest in assessing risk-taking more globally, rather than restricted to the financial domain. Nevertheless, such differences in the constructs assessed may help to explain the weaker association between risk-taking and adult T seen in the current data. Interestingly, when correlations between adult T and the non-sexual reproductive strategy were conducted within the *modal* CAG subgroup (see Section 3.2.6), comprising the range of repeat lengths that recently have been speculated to confer the strongest androgen receptor functionality (Buchanan et al., 2004; Nenonen et al., 2010a; 2010b), the association became stronger (r = .28), providing additional support for the role of adult T in the display of non-sexual evocative behaviours in men. Finding the expected relationship between adult T and the non-sexual reproductive strategy makes it all the more surprising that no significant association was found between adult T and sexual behaviours. The fact that the measures used to assess aggression, risk-taking, and impulsivity were made up of multiple items (range of 16 to 34 items), again reinforces the possibility that the better reliability of multi-item measures may help to strengthen the size of the associations with adult T.

No direct association was found between CAG repeat length and either the sexual or non-sexual reproductive strategy. To date, only limited research has been conducted on the relationship between CAG and androgen-related psychological traits, and the existing data are mixed (e.g., Jönsson et al., 2001; see Section 1.7). Conceivably, weaker relationships for CAG could reflect the fact that CAG length must be considered in conjunction with individual differences in adult T concentrations, as the receptor does not act on its own. However, in a different context, CAG recently has been found to independently predict symptoms of depression in men (Sankar & Hampson, 2012) or other traits (Hampson & Sankar, 2012a), showing that such relationships are theoretically possible. Nevertheless, further study of the association between CAG repeat length and

externalizing behaviours, as well as sexual behaviours, in men is merited in order to understand the nature of these relationships.

Recall that T is known to exert its effects on the brain by binding to ARs located in neurons throughout the central nervous system, and that the neuronal effects of such binding can occur either during fetal or neonatal development or during adult life (Rubinow & Schmidt, 1996; Swerdloff et al., 1992). These are regarded as two different classes of T-induced effects, because the types of changes induced in the nervous system during early brain development and in the adult brain are quite different. As such, the effects of androgens may be *organizational*, whereby the actions of T occurring as a result of exposure during specific windows of sensitivity in early brain development *permanently* alter the structural organization or functional potential of the nervous system (Phoenix et al., 1959; Breedlove & Hampson, 2002; Wallen, 2009), and/or *activational*, referring to *reversible* changes in brain function brought about by current levels of circulating T acting upon neural substrates that may or may not also be organized by T exposure early in life (Eckel et al., 2008). The activational effects of T often consist of changes at the neurochemical level, such as changes caused by T in the synthesis or metabolism of particular neurotransmitters, or changes in the numbers of neurotransmitter receptors present in defined regions of the brain. The T-related findings in the current model were consistent with the possibility of an activational effect, whereby circulating levels of T in adulthood independently influence romantic attachment avoidance and in turn the sexual reproductive strategy, as well as influencing the expression of non-sexual externalizing behaviours.

It should be noted that the neural mechanisms that underlie attachment are expected to be exceedingly complex, like any higher-level integrated pattern of behaviours, and likely includes affective, motivational, and cognitive dimensions that cannot be pinpointed to a particular part of the brain. Contemporary studies are only just beginning to identify pathways in the brain that are involved in romantic attachment (for review see Coan, 2008). The present study points toward the possibility that adult T can modify one or more processes involved in romantic attachment but do not permit any insights into which particular processes are regulated by T.

The 2D:4D digit ratio, the proxy measure of individual differences in prenatal androgen exposure used in the present study, was not significantly associated with any of the attachment-related variables, nor did it significantly correlate with any of the behavioural characteristics it was hypothesized to relate to in the model. A smaller ratio has been argued to reflect greater T exposure *in utero,* when bone formation is laid down in the digits (Manning et al., 1998). The lack of associations is somewhat unexpected, as previous studies have found significant correlations between 2D:4D and some sex-related variables, as well as externalizing behaviours such as aggression and risk-taking (see Section 1.6.3 for a detailed review). Furthermore, null findings in this study occurred in spite of the high reliability of the 2D:4D measurement and in spite of finding a typical mean ratio very consistent with other published reports (e.g., Maner et al., 2014; Medland et al., 2010). An accumulating body of research, however, has begun to point to the possible fallibility of the 2D:4D finger length ratio as a valid marker of fetal T levels among *healthy* humans, even though an association with T has been found in clinical populations where variations in fetal T exposure are more extreme (e.g., Hampson & Sankar, 2012b; Breedlove, 2010; Berenbaum et al., 2009; McIntyre, 2006). It is possible that the 2D:4D ratio is not sufficiently sensitive in healthy individuals (for example, differences in the level of T action may not always be overtly reflected in the ratio), and correlations observed may be hard to replicate across studies because of the low signal-to-noise ratio associated with 2D:4D itself. For these reasons, the present data do not rule out the possibility of an organizational influence of prenatal T on attachment, as broadly speculated by Del Giudice (2009), even though no significant relationships were found in the present study. To investigate this question, future studies should incorporate a more refined and undisputed measure of prenatal T concentration, such as a direct measure of T taken from mid-trimester amniotic fluid.

The model findings revealed that T and CAG differentially predicted avoidant and anxious attachment; T positively predicted avoidant attachment, while CAG length positively predicted anxious attachment, suggesting that testosterone's influences on romantic attachment style in men may reflect either differences in adult T levels or differences at a receptor level. Interestingly, T and CAG were not significantly

correlated with one another, compatible with a number of previous reports suggesting they vary independently (Hampson & Sankar, 2012a; Goutou et al., 2009; Krithivas et al., 1999). In humans, most effects caused by T are thought to be mediated by T binding to the AR. Therefore possessing a less sensitive receptor ought to simultaneously be associated with higher anxious attachment, but also might be expected to attenuate the heightening effects of adult T on avoidance. In this respect, the effects of adult T on avoidant attachment could potentially be more potent than what is revealed by the model.

In considering why we did not find a significant path between CAG polymorphism and avoidant attachment, there is another possibility that must be considered. Although the possibility is more hypothetical, it is not altogether impossible that sex hormonal influences on the anxious *vs.* avoidant dimensions could occur through different receptor mechanisms. Data from laboratory animals has shown that under some circumstances T can also exert its effect through metabolic conversion to its aromatized metabolite 17β-estradiol. While this pathway has proven to be important in some species, evidence is slim that the 'aromatization route' is important in humans. Nevertheless, there is still a possibility that adult T might act to affect avoidant attachment via metabolic conversion to estradiol (with subsequent binding to the estrogen receptor), potentially explaining why no association was seen for CAG RL (polymorphism in the *AR*). In the present data we did find a significant association between anxious attachment and *AR* repeat length, which suggests that AR is involved. It is for the other form of adult romantic attachment, avoidant attachment, that our data could be taken to imply that a separate mechanism exists. Nevertheless, the overall importance of estradiol conversion as a mechanism by which T affects behaviour in men remains relatively unexplored, and represents an important direction for future investigation.

4.5. Limitations

Sample. Participants for this study were recruited from a university campus and the sample was primarily comprised of students. As mentioned in Section 2.1, university populations have been used in a multitude of studies assessing romantic attachment (e.g.,

Edelstein et al., 2010; Gormley & Lopez, 2010; Gillath et al., 2008; Gentzler & Kerns, 2004; Schachner & Shaver, 2004), and thus our recruitment sample was conventional for this type of research. One possible limitation of using a post-secondary student sample is its potential to show a restriction in range across certain demographic variables (e.g., SES, parent education). There is, however, evidence that Canadian university populations are demographically diverse (e.g., Clifton et al., 2008; Goonewardena, Rankin, & Weinstock, 2004), and inspection of the descriptive statistics from the current study revealed substantial range in scores across a number of the measures of interest (see Table 2 and Table 3). Nevertheless, it remains true that a university sample may be less diverse than the general population, and therefore could influence the scores seen on relevant parameters, including those pertinent to the development of attachment styles (e.g., SES, family composition). If anything, the use of a student sample may have weakened the correlations seen; that being said, significant correlations were still found in the sample studied here. Conclusions as to how the present findings may generalize to the wider population should be made with caution. Expanding recruitment into the greater community may be a beneficial next step.

Another potential limitation relates to the fact that our East Asian participants had to be excluded from the final analysis. This resulted in the reduction of our total sample size by 45 participants. In may be beneficial for future studies to test the integrated-LHT model within a larger subsample of East Asian men, preferably in their native community. This could also help to address the potential validity issue related to linguistic proficiency by allowing participants to complete self-report questionnaires in their native language.

Measurement Issues. Although the timing of pubertal maturation (advanced or delayed) has been speculated to connect early environmental experience with later relationship behaviour and choices related to mating (i.e., Belsky et al., 1991; Miller & Pasta, 2000), pubertal timing was not directly assessed in the present study. Because pubertal development in males lacks a salient and discrete event comparable to menarche in females, retrospective reports of the timing of puberty onset in men are susceptible to inaccuracy, and are not empirically well-established (Mustanski et al., 2004). In fact,

Dubas, Graber, and Petersen (1991) found only chance levels of stability in adolescents' self-reports of perceived pubertal timing, and cautioned readers that perceived timing should not be interpreted as actual timing. Given that males who mature earlier maintain higher circulating levels of T into adulthood compared with males who enter sexual maturity at a relatively later age (Gesquiere et al., 2005), individual differences in adult T concentrations are likely to reflect relative differences in pubertal timing, and have the advantage of being more objective than retrospective self-reports. As mentioned earlier, however, predictive associations from early family structure or childhood attachment to adult T were not found in the current study. Studies using prospective, *in vivo,* measurement of pubertal timing and associated T concentrations would provide the best and most accurate test of the role of pubertal maturation within LHT-based models of attachment and reproduction.

All participants in the present study were recruited and tested in young adulthood, and therefore measurement of attachment to parents/caregivers in childhood had to be retrospective. Few retrospective measures of attachment exist. The RAQ (Parkes, 2006) was selected because is the only measure that assesses attachment history according to the patterns of attachment described by Ainsworth and colleagues (1978), and is the only measure available to be used in more normative and less pathological samples (Crowell et al., 2008). It is, however, a relatively new measure that has not been widely studied in the literature, and its lack of procedure for how to handle missing data due to parental absence (i.e., single parenthood) needs to be formally addressed (although I did outline a sound method for addressing this issue; see Section 2.3.1). As more psychometric and substantive research is done on the topic of attachment history it is possible that more comprehensive retrospective measures of attachment will be developed, and their validity demonstrated. Nevertheless, one limitation of all retrospective reports, within the attachment domain or not, is that memory for or interpretation of past events has the potential to become distorted with increasing time lag since the occurrence of the event/experience (e.g., Baldwin & Fehr, 1995). Unfortunately, this is a limitation that cannot be circumvented without the use of a longitudinal design that would allow for parent-child attachment and other early life experience variables to be assessed directly in

childhood. It bears noting though that following children into young adulthood to study the development of their adult romantic attachment styles would be a rather difficult undertaking given the time spans involved.

Specific items from Part I of the RAQ were used to compute indices of Family Affection and Family Abuse. The nature of the items used to assess these constructs was consistent with those used in other studies to retrospectively assess early family environment in men (particularly for the abuse domain) (e.g., Miller & Pasta, 2000; Kim & Smith, 1998). Nevertheless, the estimates of internal consistency obtained for the Family Affection Index and the Family Abuse Index were low ($\alpha = .58$ and $\alpha = .48$, respectively), suggesting that the items comprising each of these indices may not be very closely related. Although employing more psychometrically robust measures might have been beneficial, the availability of measures, particularly in the affection domain, represents a challenge. It appears that few retrospective measures assessing perceived quality of early family life exist. For example, while Meckelmann et al. (2013) used the Relationship Context Scale (Scheffer et al., 2000) to retrospectively assess quality of parents' marital relationship and quality of child's maternal relationship, this scale has not been validated in English speaking populations.

4.6. Study Contributions and Directions for Future Research

Overall, the present study has begun to bridge the independent research traditions in attachment and neuroendocrinology, and has made novel contributions in each domain. I tested a life history-based model of reproductive strategies in men, and results provided some of the first empirical evidence linking childhood and romantic attachment configurations to differential mating strategies. No previous studies have assessed attachment within evolutionary-developmental models, and the findings highlight that both the level of retrospective attachment insecurity to parents/caregivers in childhood, as well as style of attachment to romantic partners in adulthood influence the degree to which men align with a short-term, opportunistic mating approach.

The results confirm the speculated, but to date directly untested, view that romantic attachment behaviours are modulated, in part, by androgens. These findings are theoretically important because they help to re-formulate the general understanding of the etiology of romantic attachment in men from a purely learned construct to one that is also hormonally-based. Adult T itself, and androgen function at the receptor level, predicted avoidant attachment and anxious attachment, respectively, and importantly, romantic attachment configurations mediated the relationship between androgenic variables and sexual behaviour. In addition, and consistent with expectation, the levels of adult T were a positive predictor of the evocative non-sexual behaviours that characterize the Young Male Syndrome, again providing support for a role for androgens in the development of male reproductive strategies/orientations.

These findings may inspire avenues for future research. The ultimate test of the integrated-LHT model would be to assess it through a longitudinal design, following a cohort of males from infancy through young adulthood, and even extending into fatherhood. Such a design would allow for relevant early environmental, psychological (i.e., early attachment style), and somatic (i.e., pubertal timing) factors to be assessed prospectively, thereby obviating the need for retrospective self-reports. Furthermore, T could be measured directly at multiple time points (i.e., perinatally, at various stages of puberty, in adulthood), allowing for a more detailed understanding of androgenic influences within the context of evolutionary-developmental models of early environment, attachment, and reproduction.

Another direction for future research is to test the LHT-based model in a broad community-based sample. Such recruitment may increase the proportion of participants coming from high-risk backgrounds, potentially serving to expand the range in scores across all psychological/behavioural variables of interest. Expanding the sample into the larger community could help to strengthen associations seen with the early family environment latent construct and to increase the number of indicators that could be used to characterize this construct (e.g., increased range in family SES, more variability in early family composition, family affection index, and family abuse index).

4.7. Conclusion

The conceptualization of attachment as an innate human tendency, one of evolutionary significance, lends itself to being characterized as not only a socially learned construct, but also by biological substrates. The role of androgens in the expression of attachment behaviours, specifically in adulthood, has been contextualized within the present study in models that outline the lifespan effects of early environmental experiences on the development of corresponding mating orientations, with attachment representing a figural mediating variable. The current study has empirically identified a conceptually plausible connection between androgenic variables and romantic attachment configurations that influence mating approaches, using structural modelling techniques. Through this work, a precedent is set for future research to continue to explore the biological, and sex hormonal, correlates of psychological attachment.

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Appendices

Appendix A: Poster for Recruitment from Western Campus

MALES Needed

for a study of
Testosterone, Personality, and Experiences in Close Relationships

Eligibility:

- Heterosexual **MALE** age 18 - 35
- Open to undergraduates and staff at UWO
- Must have had **at least** one romantic or sexual partner, either currently or in the past 1 year
- Fluent in English

The experiment will last approximately **1 hour**.

You will be compensated **$15.00** for your participation.

You will be asked to:

- Fill out questionnaires about your personality and relationships with romantic or sexual partners
- Fill out questionnaires about childhood experiences with parents/caregivers
- Provide saliva to measure testosterone levels
- Provide saliva to determine the genetic makeup of your hormone receptor

For further information or to make an appointment, please e-mail:
shipstudy@gmail.com

Appendix B: Order of Questionnaire Presentation

1) Part I - Composite JPI-R/PRF-E/MC-C Questionnaire
2) Demographics Questionnaire

3) ECR
4) SOI
5) Part II- Composite JPI-R/PRF-E/MC-C Questionnaire
6) RQ
7) SDI
8) Part III- Composite JPI-R/PRF-E/MC-C Questionnaire

Booklet 1

9) RAQ
10) RSE
11) AQ
12) Dating History Questionnaire

Booklet 2

13) POMS

Note. JPI-R = Jackson Personality Inventory Revised; PRF-E = Personality Research Form E; MC-C = Marlowe-Crowne Social Desirability Scale Form C; ECR = Experiences in Close Relationships Questionnaire; SOI = Sociosexual Orientation Inventory; RQ = Relationship Questionnaire; SDI = Sexual Desire Inventory; RAQ = Retrospective Attachment Questionnaire; RSE = Rosenberg Self-Esteem Scale; AQ = Aggression Questionnaire; POMS = Profile of Mood States

Appendix C: Demographics Questionnaire and Dating History Questionnaire

Demographics Questionnaire

Please provide the information requested below. If, for any reason, you wish not to answer a particular item, you are free to leave it blank. All information provided is strictly confidential and will be used for research purposes only. Your name or other identifying information will not appear anywhere on this questionnaire.

Subject Number: _____ Date: _____

Age: _____ Testing time: _____

1. In the 30 minute period before your appointment today, did you:

(a) have anything to eat?	YES	NO
(b) have a beverage other than water?	YES	NO
(c) have a cigarette?	YES	NO
(d) brush your teeth?	YES	NO
(e) chew gum?	YES	NO

2. In the past week before your appointment today, did you:

(a) have an acute illness (e.g., cold or flu)? YES NO

3. What time do you normally wake up in the morning?

On weekdays: _____
On weekends: _____

4. What time did you wake up today? _____

5. Has anything happened in your life over the past few days that made you feel unusually stressed? YES NO

6. What is your height? _____ (feet & inches) OR _____ (cm)

7. What is your weight? _____ (pounds) OR _____ (kg)

8. Do you attend/work at Western or Fanshawe? WESTERN FANSHAWE

9. Are you a smoker, non-smoker, or an occasional smoker?

SMOKER NON-SMOKER OCCASIONAL SMOKER

10. How often do you normally consume alcohol? (Circle one number from 0 to 4).

0	1	2	3	4
Never	1-2 times a **month**	1-2 times a **week**	3-4 times a week	Almost every day

11. What is the average number of drinks you have when/if you drink? (Circle one number).

0	1	2	3	4
None	one to three	four to seven	eight to twelve	more than 12

12. How long has it been since you last consumed an alcoholic beverage (e.g., beer, wine, spirit) of any kind? _____

13. Have you ever had any accidents with either of your hands that could affect the growth of your fingers?

_____

_____

14. Are you currently taking any prescription or non-prescription medications? YES NO

If so, please list the medications you are taking.

_____

_____

15. Do you currently have any physical condition(s) that might cause your hormone levels to be unusual? (e.g., diabetes, thyroid, etc.). YES NO

16. What is your ethnicity?

_____ White	_____ East Asian	_____ Middle Eastern
_____ Black	_____ South Asian	_____ Pacific Islander
_____ First Nations	_____ Hispanic	_____ Other

17. How many brothers do you have? _____ What are their ages? _____

18. How many sisters do you have? _____ What are their ages? _____

19. Up to age **16**, I was raised by (check all applicable answers and indicate ages):

_____ Both biological parents living together	From ages ___ to ___
_____ Both biological parents, living separately	From ages ___ to ___
_____ A biological parent and a step-parent	From ages ___ to ___
_____ One biological parent living alone	From ages ___ to ___
_____ Another family member (not a parent)	From ages ___ to ___
_____ Adoptive parents	From ages ___ to ___
_____ Foster parents	From ages ___ to ___
_____ Other	
(please specify: _____)	From ages ___ to ___

20. Is English your first language? YES NO

If no, what is your first language? _____

21. The following information should be filled out for the parents who raised you. If you grew up in a single-parent home, fill out the information only for the parent you lived with:

MOTHER

Mother's Usual Occupation or Job
(be very specific; e.g., Insurance adjuster): _____

Mother's Highest Education (check one):

_____ Grade 6 or less
_____ Grade 7 to 9
_____ Some high school
_____ High school graduate
_____ At least one year of college or other specialized training
_____ College or university graduate
_____ Master's degree, Ph.D., M.D., or other professional degree

Province or country where your mother went to elementary and high school: _____

FATHER

Father's Usual Occupation or Job:
(be very specific; e.g., Insurance adjuster): _____

Father's Highest Education (check one):

_____ Grade 6 or less
_____ Grade 7 to 9
_____ Some high school
_____ High school graduate
_____ At least one year of college or other specialized training
_____ College or university graduate
_____ Master's degree, Ph.D., M.D., or other professional degree

Province or country where your father went to elementary and high school: _____

22. What is <u>your</u> highest level of education (check one):

_____ Grade 6 or less
_____ Grade 7 to 9
_____ Some high school
_____ High school graduate
_____ At least one year of college or other specialized training
_____ College or university graduate
_____ Master's degree, Ph.D., M.D., or other professional degree

23. If not a student, what is your usual occupation? _____

Dating History Questionnaire

1. Your marital/partner status:

_____	Single	_____	Steady live-in partner
_____	Steady partner but living apart	_____	More than one steady partner at present
_____	Married	_____	Divorced
_____	Separated	_____	Widowed

2. How long did your most **recent** romantic or sexual relationship last? (Do not include your current relationship, if any):

_____

3. What is the **typical** length of a romantic or sexual relationship for you? _____

4. If you are sexually active, at what age did you first have sexual intercourse? _____

5. In total, how many romantic or sexual relationships have you had in your lifetime? (Please count all intimate relationships, whether or not they included sexual behavior)

_____

6. How many children do you have? (e.g., 0, 1, 2, unknown etc.) _____

7. Is there any reason why your answers today might not be typical?

_____

_____

_____

Appendix D: Detailed Description of Indicators of Latent Constructs in the LHT-Based Model

Early Family Environment

Because all the life history theories reviewed highlight the role of parental sensitivity as potentially important early environmental predictor of psychological and somatic development, measures of "family affection" and "family abuse" were included as indicator variables. Using items from Part I of the RAQ, which asks adults about their childhood relationships with parents (Parkes, 2006), the "family affection" index (α = .58) was defined as the sum of four items measuring the level of attention and affection the participant received from or felt towards his parents during childhood: Was your parent inconsistent, sometimes responding, and at other times ignoring your needs for attention and affection? Were you unusually close to your parent? Was either parent unable to show warmth or to hug or cuddle you? Did you have mixed feelings of love and hate, affection and resentment, towards either parent? Responses to these yes/no questions were summed for both parents, yielding a total of 8 items.

The "family abuse" index (α = .48) was made up of the sum of 12 yes/no items from Part I of the RAQ (6 for each parent), measuring the level of physical or psychological abuse in the participant's family: Did your parent ever assault or injure his or her partner? Did either parent obtain your obedience by threatening to leave you or give you away? Did either parent drink more alcohol than was good for them? Was either parent inclined to tease you or make you feel small? Did either parent beat you or physically punish you more than most parents? Did either parent sexually interfere with you or expect you to touch their genitals?

Because some researchers (e.g., Clarke-Stewart et al., 2000; James et al., 2012) have suggested parental psychopathology may influence the ecology of the early family environment, "Mother's Psychiatric Health" (α = .64) and "Father's Psychiatric Health" (α = .56) were included as manifest variables. Five items from the RAQ Part I made up each of these measures: Was either parent nervous, insecure or a worrier? Was your

parent subject to episodes of gloom or depression? Did your parent ever receive psychiatric treatment? Was your parent ever admitted to a hospital for psychiatric treatment? Did either parent threaten to kill themselves? The total score was the sum of the yes/no responses to each of these questions, computed for each parent independently.

Within their theories, both Belsky et al. (1991) and Chisholm (1999) suggest that the availability of financial resources may have an impact on the nature of the early family context, and empirical studies have provided further support for this viewpoint (e.g., Arim et al., 2011; Chasiotis et al., 1998; Hill et al., 1994a; James et al., 2012). Consequently, SES of the household was included as an indicator variable. Within the demographics questionnaire, participants provided occupation and education information for the parents who raised them from ages 0-16 years. Following Hollingshead (1975), the level of education attained by each parent was rated on a 1-7 scale, where 1 = "Grade 6 or less" and 7 = "Master's degree, Ph.D., M.D., or other professional degree", and occupational status was rated on 1-9 scale, categorized according to the earning potential of the profession, such that a more lucrative profession (e.g., Physician: score of 9) received a higher occupational status score than a less lucrative profession (e.g., Dishwasher: score of 1). Parents who were unemployed (including stay-at-home parents) received a score of 0. The list of professions falling into the different occupational categories was provided by Hollingshead (1975).

SES was computed according to the procedure outlined by Deonandan et al. (2000) where the highest occupation score in the household (which could come from either parent) was summed with the average of the education score for both parents. In this way, the influence of a parent who was not contributing financially to the participant's early environment (e.g., homemaker) but may have been contributing to the overall SES by way of their educational status (e.g., helping to provide an intellectually stimulating home environment) could be taken into consideration. If the participant indicated that he was raised by a single parent, then total SES was computed as the sum of the occupation and education score for that one parent. If the participant reported that he was raised in a divorced household where he lived with each parent separately, then SES = (sum of occupation and education of mother + sum of the occupation and

education of father)/2. For participants who reported that a parent and a stepparent raised them, SES was computed the same as for a two-parent household, since both adults were deemed to be contributing to the home environment.

Because the life history theories of attachment and reproduction appear to discuss the potential importance of financial stability in the early family environment, a second measure of SES based purely on employment was also computed, emphasizing financial resources. For two-parent households this translated into the sum of the occupation scores for each of the two parents; for one-parent households this was equal to the occupation score for the one parent who raised the participant; and for divorced households where both parents were raising the child independently this was equal to the sum of the employment score for both parents divided by 1.5. In this way, a two-parent (or parent and stepparent) household had the potential of receiving the highest score (highest level of financial resources), a one-parent household had the potential of receiving the lowest score (lowest level of financial resources), and a divorced household fell in between, as the child would only be able to gain exposure to each parent's financial resources independently, but would still have the possibility of being exposed to more resources than a child living in a single-parent home.

Parental presence/absence has been explored both theoretically and experimentally as a factor within the early family environment that may predict subsequent psychological (i.e., childhood attachment), somatic, and reproductive strategy development (e.g., Chisholm, 1999; Draper & Harpending, 1982; Hill et al., 1994a; James et al., 2012; Miller & Pasta, 2000). There is evidence, however, that not just parental absence, but also the nature of the family structure (i.e., two-parent household, divorced, single-parent) may affect attachment style, such that a less intact family structure is associated with higher levels of attachment insecurity in children (e.g., Nair & Murray, 2005; Clarke-Stewart et al., 2000). Children from divorced families, on average, have been found to experience more problems and have a lower level of well-being than children from continuously intact two-parent families (Amato & Keith, 1991), and these effects may extend into adulthood (e.g., Cherlin, Chase-Lansdale, & McRae, 1998; Hetherington, Bridges, & Insabella, 1998). Marital breakup may also have negative

psychological consequences by way of its effect on the child's access to financial resources and by potentially diminishing the capacity of the parent to rear the child due to the emotional and financial distress of the divorce (Clarke-Stewart et al., 2000). Young children from single-parent/never married households have also been found to be less securely attached than their two-parent household counterparts. Moreover, they display more negative interactions with mothers than children from separated/divorced homes (Clarke-Stewart et al., 2000) and are more economically disadvantaged than children from divorced households (e.g., Bianchi, 1995). With respect to families with a biological parent and a cohabiting stepparent, there is some evidence that biological mother-partner families are at higher risk of emotionally and physically maltreating children compared to biological two-parent households, but the maltreatment risk is higher in single parent (i.e., single mother) families, particularly if the mother works (Berger, 2004). By contrast, Gibson-Davis (2008) found that biological mothers with a cohabiting male stepparent rated their partners' level of involvement in family life (i.e., positive engagement, frequency of spanking, and instrumental family support) similarly to mothers married to the biological father.

Some research suggests that changes in family structure have greater developmental effects when the disruption occurs earlier in childhood (e.g., Allison & Furstenberg, 1989; Howell, Portes, & Brown, 1997), but other studies do not find any apparent age-related effect (e.g., Furstenberg & Teitler, 1994; White, Brinkerhoff, & Booth, 1985). McLanahan and Bumpass (1988) postulate that family structure disruption occurring in early as well as late childhood/early adolescence may be important. Consequently, three indicator variables measuring the effect of family structure on the quality of participants' environmental experience were included. The first variable encapsulated the ages of 0-4 years, the second variable ages 5-9 years, and the third variable ages 10-16 years. Based on participants' responses to a demographic item inquiring about the family structures in which they were raised across the ages of 0-16 years, participants received a score on a 1-4 scale for each of the 3 age ranges, where a higher score was indicative of being raised in a more stressful family structure. Thus for each of the age ranges a score of 1 was given for having two biological (or adoptive)

parents living together, a score of 2 was given for a biological parent and a stepparent, a score of 3 was given for both biological parents living separately, and a score of 4 was given for either one biological parent living alone, being raised by another family member who was not a biological parent, or for non-adoptive foster parents.

Because the presence/absence of a non-biological stepparent has been investigated in studies of the psychological and somatic outcomes of family antecedents (e.g., Arim et al., 2012), an indicator variable categorizing whether participants did or did not have a stepparent over the course of the first 16 years of their lives (0 = no stepparent; 1 = stepparent) was included. Finally, because the death of a parent during childhood can have serious emotional and physical consequences, and can certainly disrupt a growing child's family structure, an indicator variable categorizing whether or not participants had lost a parent to death during the first 16 years of their lives (0 = both parents alive; 1 = experienced a parent death) was included. Information regarding parent death was obtained from the second question on Part I of the RAQ, which asks if the participant's parents are alive, and if not, how old was the participant when his parent(s) died.

Each manifest (observed) variable was coded such that a higher score was indicative of a poorer quality early family environment. In the case of SES, where a higher score indicated better socioeconomic status, scores were reversed so that a higher score corresponded with a lower SES.

Retrospective Childhood Attachment

Although individual scores for the three insecure attachment patterns (i.e., anxious/ambivalent, avoidant, disorganized) can be separately computed, because Belsky et al. (1991) and Chisholm (1999) speculate about the causes and consequences of overall attachment insecurity (*vs.* security) without differentiating among the varieties of insecure attachment in their theoretical models of attachment and reproduction, the decision was made to only compute the RAQ total insecure attachment score as a single indicator of retrospective childhood attachment style.

Non-Sexual Reproductive Strategy

Although not discussed as a formal part of the Young Male Syndrome, the rationale for including self-esteem and trait anxiety as indicators of the non-sexual reproductive strategy is that higher levels of self-esteem and lower levels of anxiety may provide an advantage for young males who need to defend their social status in anticipation of early reproduction, and thus are conceptually similar to the other traits that comprise the Young Male Syndrome (Del Giudice, 2009). Because the opportunistic reproductive approach, which may run parallel to a more avoidant adult attachment style in men, may, in part, be characterized by more independent and less affiliative social behaviour, level of need for autonomy was also hypothesized to be an indicator of participants' non-sexual reproductive strategy.

Each manifest (observed) variable of the Non-Sexual Reproductive Strategy was coded such that a higher score was indicative of a more opportunistic non-sexual personality profile (i.e., more aggressive, more impulsive, less anxious). In the case of the anxiety subscale of the POMS, where higher scores indicated more anxiety, scores were reversed so that a higher score corresponded to a lower level of anxiety.

Sexual Reproductive Strategy

Data for the age at first intercourse, typical relationship length, and total number of lifetime partners indicator variables were obtained from responses to questions on the Dating History Questionnaire. Of note, because sexual experience was not a pre-requisite for study participation, some participants had not yet had sexual intercourse. Review of the frequency distribution for the "age at first intercourse" variable revealed that nearly all participants in the sample had had their first sexual experience by the age of 19 (89% of the sample). In order to not code as missing those participants who were sexually inactive, inactive participants who were aged 18 or 19 years at the time of testing were assigned a score of 19 years on this variable, given the data from the observed frequency distribution. For those participants who were older than 19 years and had never had sex,

they were assigned a score that corresponded to their current age. In total, only 7 data points (3.6% of the sample) had to be handled in this manner.

As mentioned in Section 3.2.1, a current partnering status observed variable was also included. Participants were scored on a 3-point scale ranging from 0-2. A score of 0 was given to participants who indicated on the Dating History Questionnaire that they had a steady partner but living apart, a steady live in partner, or were married. A score of 1 was given to participants who were single, divorced, or separated. A score of 2 was given to participants who indicated that they had more than one steady partner at present. Thus, a higher score corresponded to a conceivably more opportunistic mating status. Moreover, the coding also corresponded to what the testosterone literature predicts is a higher T partnering status (van Anders & Watson, 2007).

With respect to the set of core indicators derived from the SOI, although Item 2 ("How many different partners do you foresee yourself having sex with during the next five years?") and Item 3 ("With how many partners have you had sex on *one and only one* occasion, in your lifetime?") of the SOI were included as independent indicators, Item 1 ("With how many different partners have you had sex (sexual intercourse) within the past year?") was omitted because of its redundancy with the "total number of lifetime partners" indicator variable.

The SOI assesses both behavioural and attitudinal facets of sociosexuality (Webster & Bryan, 2007). Items 4-8 corresponded to the attitudinal portion of the SOI. One item, Item 7, was omitted from the computation of the attitudinal SOI indicator variable because of its long and complicated wording which has been found in previous work to lead to measurement problems with less attentive participants (Penke & Asendorpf, 2008). Within the current sample, many participants appeared to respond to Item 7 in a manner inconsistent with their responses on the remaining attitudinal items, possibly due to the fact that Item 7 is the only question on the SOI that is negatively worded (i.e., a higher score corresponds to a more restricted sociosexual orientation), making it semantically difficult to decode. A principal components analysis was conducted to confirm that the remaining 4 items loaded onto a single factor, and

participants' standardized factor scores became the indicator variable, a common procedure used to handle the different response scaling on some of the SOI items (Simpson & Gangestad, 1991).

As noted in Section 3.2.1, there is a lack of clarity in the life history models about the role of adult fearful attachment (e.g., Del Giudice, 2009). Many studies (e.g., Brennan & Shaver, 1995; Cooper et al., 1998; Feeney & Noller, 1992; Simpson, 1990) investigating the relationship between adult attachment and sexual behaviours have employed measures that prevent a distinction between the two avoidant attachment classifications (i.e., dismissing-avoidant and fearful-avoidant) (Shaver & Mikulincer, 2002; Simpson & Rholes, 2002). That being said, some research has found that fearful attachment is positively correlated with indices of short-term mating in men, as well as more out-of-control or addictive sexual behaviour (e.g., Schmitt, 2005; Carnes, 1991; Faisandier, Taylor, & Salisbury, 2012). It is believed that fearful-avoidants' motivation for avoiding intimacy is due to a lack of trust towards others and/or to prevent being hurt by partners (Bartholomew, 1990), which differs from dismissing-avoidants who adopt an avoidant orientation to maintain self-reliance and independence. Nevertheless, men with high fearful attachment may still be apt to engage in sex opportunistically and without commitment in an effort to avoid intimacy, regardless of the motive (but see Schachner & Shaver, 2004). For these reasons, participants' RQ continuous fearful score was included as an indicator variable in the Sexual Reproductive Strategy latent construct, along with the other continuous measures of romantic attachment avoidance, anxiety, and overall security.

Although a measure of commitment in a current romantic relationship was administered, and would certainly be a relevant indicator of the Sexual Reproductive Strategy latent construct, the Commitment Scale (Lund, 1985) by definition can only be completed by participants currently in a relationship. At the time of testing only N = 100 were in a current relationship and thus completed the Commitment questionnaire. The proportion of missing data on this variable was, therefore, too high to justify imputation of any sort, even though the data were considered to be missing at random (missingness that is not related to the missing value itself (i.e., commitment scale question), but is

related to the values of another variable in the data set (i.e., current partnering status) (Kline, 2011). Consequently, it was not possible to include level of actual relationship commitment as a manifest variable in the model.

Each manifest (observed) variable of the Sexual Reproductive Strategy was coded such that a higher score was indicative of a shorter-term reproductive strategy. Participants' responses to age at first intercourse and typical relationship length were reversed so that a higher score corresponded to an earlier age at first intercourse and a shorter typical relationship length. Similarly, the anxious attachment observed variables were reversed so that a higher score reflected lower levels of anxiety.

Appendix E: Ethics Approval Forms

Department of Psychology The University of Western Ontario
Room 7418 Social Sciences Centre,
London, ON, Canada N6A 5C1
Telephone: [redacted]

Use of Human Subjects - Ethics Approval Notice

Review Number	**12 02 15**	**Approval Date**	**12 02 16**
Principal Investigator	**Elizabeth Hampson/Janani Sankar**	**End Date**	**13 02 16**
Protocol Title	**Associations between testosterone, personality, and experiences in close relationships**		
Sponsor	**n/a**		

This is to notify you that The University of Western Ontario Department of Psychology Research Ethics Board (PREB) has granted expedited ethics approval to the above named research study on the date noted above.

The PREB is a sub-REB of The University of Western Ontario's Research Ethics Board for Non-Medical Research Involving Human Subjects (NMREB) which is organized and operates according to the Tri-Council Policy Statement and the applicable laws and regulations of Ontario. (See Office of Research Ethics web site: http://www.uwo.ca/research/ethics/)

This approval shall remain valid until end date noted above assuming timely and acceptable responses to the University's periodic requests for surveillance and monitoring information.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the PREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of research assistant, telephone number etc). Subjects must receive a copy of the information/consent documentation.

Investigators must promptly also report to the PREB:
a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to the PREB for approval.

Members of the PREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the PREB.

[redacted]

Clive Seligman Ph.D.

Chair, Psychology Expedited Research Ethics Board (PREB)

The other members of the 2011-2012 PREB are: Mike Atkinson (Introductory Psychology Coordinator), Rick Goffin, Riley Hinson Albert Katz (Department Chair), Steve Lupker, and Karen Dickson (Graduate Student Representative)

CC: UWO Office of Research Ethics

This is an official document. Please retain the original in your files

Department of Psychology The University of Western Ontario
Room 7418 Social Sciences Centre,
London, ON, Canada N6A 5C1
Telephone: [redacted]

Use of Human Subjects - Ethics Approval Notice

Review Number	**12 02 15**	**Approval Date**	**12 02 16** **Extension of end date approved on 13 01 31**
Principal Investigator	**Elizabeth Hampson/Janani Sankar**	**End Date**	**13 02 16** **New End Date 14 01 30**
Protocol Title	**Associations between testosterone, personality, and experiences in close relationships**		
Sponsor	**n/a**		

This is to notify you that The University of Western Ontario Department of Psychology Research Ethics Board (PREB) has granted expedited ethics approval to the above named research study on the date noted above.

The PREB is a sub-REB of The University of Western Ontario's Research Ethics Board for Non-Medical Research Involving Human Subjects (NMREB) which is organized and operates according to the Tri-Council Policy Statement and the applicable laws and regulations of Ontario. (See Office of Research Ethics web site: http://www.uwo.ca/research/ethics/)

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[redacted]
Clive Seligman Ph.D.

Chair, Psychology Expedited Research Ethics Board (PREB)

The other members of the 2011-2012 PREB are: Mike Atkinson (Introductory Psychology Coordinator), Rick Goffin, Riley Hinson Albert Katz (Department Chair), Steve Lupker, and Karen Dickson (Graduate Student Representative)

CC: UWO Office of Research Ethics

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Janani S. Sankar
Curriculum Vitae

Post-Secondary Education

2015 ***Doctor of Philosophy, Clinical Psychology***
The University of Western Ontario
Research Advisor: Elizabeth Hampson, Ph.D., C. Psych.
Dissertation: The Role of Androgens in Life History Theories of Attachment

2009 ***Master of Science, Clinical Psychology***
The University of Western Ontario
Research Advisor: Elizabeth Hampson, Ph.D., C. Psych.
Thesis: Influence of Testosterone and Androgen Receptor Polymorphism on Visual-Spatial Cognition in Adult Men

2007 ***Bachelor of Science, Psychology, First Class Honours***
McGill University
Research Advisor (U4): Barbara Sherwin, Ph.D.
Thesis: Verbal Memory Function during Pregnancy and the Early Postpartum Period
Research Advisor (U3): Frances Aboud, Ph.D.
Thesis: Peer Relations and Friendship Quality in Two-Way Immersion Programs

Publications and Presentations

Peer-Reviewed Publications

- **Sankar, J. S.**, & Hampson, E. (2012). Testosterone levels and androgen receptor gene polymorphism predict specific symptoms of depression in young men. *Gender Medicine, 9,* 232-243.
- Hampson, E., & **Sankar, J. S.** (2012). Hand preference in humans is associated with testosterone levels and androgen receptor gene polymorphism. *Neuropsychologia, 50*, 2018-2025.
- Hampson, E., & **Sankar J.S.** (2012). Re-examining the Manning hypothesis: Androgen receptor polymorphism and the 2D:4D digit ratio. *Evolution and Human Behavior, 33*, 557-561.
- Aboud F.E., & **Sankar J.** (2007). Friendship and identity in a language-integrated school. *International Journal of Behavioral Development, 31,* 445-453.

Conference Proceedings

- **Sankar, J.S.** on behalf of Advocacy through Action (2013, June), *Evaluation of a student-driven mental health literacy and advocacy initiative: The Finding Your Way public lecture series*. Poster session presented at the 74th Annual Convention of the Canadian Psychological Association, Quebec City, Quebec.
- **Sankar, J.S.** on behalf of Advocacy through Action (2013, June), *Increasing the footprint of psychology in the community: A conversation on grass-roots mental health literacy and advocacy initiatives*. Round-table conversation hour presented at the 74th Annual Convention of the Canadian Psychological Association, Quebec City, Quebec.
- **Sankar, J. S.,** Hampson, E. (2011, March), *Testosterone levels and androgen receptor gene polymorphism predict depressive symptomatology in young men*. Poster session presented at the 1st annual Rotman Research Institute and the Kunin-Lunenfeld Applied Research Unit Neuroscience of Emotion and Emotion-Related Disorders Conference, Toronto, Ontario.
- **Sankar, J. S.,** Hampson, E. (2010, February), *Associations between handedness and spatial reasoning in men: Possible influence of androgen receptor gene polymorphism.* Poster session presented at the 38th Annual Meeting of the International Neuropsychological Society, Acapulco, Mexico.
- **Sankar, J.S.,** Hampson, E. (2009, June), *Testing the link between the 2D:4D digit ratio and spatial orientation and visualization in adult men.* Poster session presented at the 13th Annual Meeting of the Society for Behavioral Neuroendocrinology, East Lansing, Michigan.

Published Abstracts:

- **Sankar, J. S.,** Hampson, E. (2011). Testosterone levels and androgen receptor gene polymorphism predict depressive symptomatology in young men. *Rotman-Baycrest and KLARU Neuroscience of Emotion and Emotion-Related Disorders Abstracts*, 32.
- **Sankar, J. S.,** Hampson, E. (2010). Associations between handedness and spatial reasoning in men: Possible influence of androgen receptor gene polymorphism. *Journal of the International Neuropsychological Society*, 16 (Suppl. 1), 214.
- **Sankar, J.S.,** Hampson, E. (2009). Testing the link between the 2D:4D digit ratio and spatial orientation and visualization in adult men. *Society for Behavioral Neuroendocrinology Abstracts*, P3.67, 194.

Recognition of Scholarship

Honours and Awards:

- *Queen Elizabeth II Graduate Scholarship in Science and Technology, 2012* ($10,000)

- *NSERC Alexander Graham Bell Canada Graduate Scholarship, 2009-2012* ($105,000)
- *Ontario Graduate Scholarship, 2009* ($15,000; declined)
- *Ontario Graduate Scholarship, 2008* ($15,000)
- *Western Graduate Research Scholarship, 2008* ($8,000)
- *CIHR Canada Graduate Scholarship, 2007* ($17,500)
- *Fond de Recherche en Santé du Québec, 2006* ($5,366)
- *Dow-Hickson Undergraduate Scholarship, 2006* ($2,000)
- *Emily Ross Crawford Undergraduate Scholarship, 2006* ($1,000)

Related Work Experience

Teaching Assistantships:

- *Abnormal Psychology—Tutorial Instructor (2012-2013)*
- *Exceptional Children: Developmental Disorders (2012)*
- *Neuropsychology and Cognitive Neuroscience (2009)*
- *Sex Differences in Human Brain and Behaviour (2008)*
- *Introduction to Psychology (2007-2008)*

Supervisory Roles:

- ***Independent Studies Research Advisor, The University of Western Ontario (2012)***
  Project Title: Do Experiences in Close Relationships Change Across the Seasons?

Professional Service

Professional Association Membership:

- *Canadian Psychological Association*, Student Affiliate (2012-present)
- *Ontario Psychological Association*, Student Affiliate (2011-present)
- *London Regional Psychological Association*, Student Member (2010-present)
- *Society for the Study of Clinical Psychology*, Student Member (2010-present)
- *Society for Behavioral Neuroendocrinology*, Student Member (2009-2012)