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Testosterone and vasopressin in men's reproductive behavior

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TESTOSTERONE AND VASOPRESSIN IN MEN'S REPRODUCTIVE BEHAVIOR

by

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ABSTRACT

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One common practice used by researchers is to divide human reproduction into two major domains: mating and parenting. Adaptive problems men faced over the millennia may have produced evolutionary pressure for hormone responses and behavior that facilitate both mating and parenting, either separately or simultaneously. The sometimes competing domains of mating and parenting in men are often mediated by a number of the same hormones, such as testosterone (T) and arginine vasopressin (AVP). One aim of the current study was to examine differences in baseline levels of T and AVP between childless men who were not in an exclusive, romantic relationship and married fathers. Another aim was to examine differences in responses in these hormones as a function of relationship/parental status and mating versus parenting audiovisual stimuli. Sixty men, ages 21-44 years, completed the study. Thirty were single, childless men and 30 were fathers, 29 of whom were married. Participants provided saliva samples for T assay and urine samples for AVP assay before and after viewing one of two randomly assigned 15-minute videos. One video was aimed at mating efforts and included couples engaging in sexual activity. The other video was aimed at parenting efforts and included clips of babies/toddlers crying from receiving a vaccination needle. There was no significant difference in baseline T or AVP between the single, childless men and the married fathers.

Also, there was no significant difference in T or AVP responses as a function of relationship/parental status or video condition. Interpretation of the results and conclusions are discussed.

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CHAPTER 1

INTRODUCTION

Sexual selection is the process by which heritable, sex-specific characteristics that facilitate reproductive success get passed on to future generations by way of intrasexual competition and intersexual choice (Darwin, 1871; Geary, 2010). The reason for sex-specific adaptations is that males and females face different reproductive challenges. For example, female mammals are typically required to make a larger minimum parental investment (in gestation and lactation and so forth) for offspring to survive (Trivers, 1972). Sex-specific challenges place adaptive pressure for "solutions." For instance, males of many species aggressively compete with one another for access to a female mate; a larger male may have an advantage and thus larger male body size may aid reproductive success (Trivers, 1972). Often the result is sexual dimorphism in body size, in which males tend to be larger than females for species that mate polygynously. Humans exhibit modest sexual dimorphism in body size, which may suggest a polygynous ancestry. However, current mating systems across cultures usually reflect monogamy, even in societies that permit polygyny (Lancaster & Kaplan, 2009).

At the same time, there has been considerable flexibility across cultures and time in mating and parenting systems. The implications of these findings are significant as they challenge our attitudes about sexuality and conventions such as marriage. Some claim that our (human) approach to reproduction is too complex and varied to be categorized in the way that we categorize the reproductive strategies of other species. This complexity may be attributed to the size of our cortex which allows us to be flexible and adapt to various environmental contexts.

In specific relation to men, the question remains whether or not their behavior and hormone responses reflect the notion that they are physiologically primed to "spread their seed" as much as possible, to "settle down" at some point, or perhaps a little of both reflected in a flexible and opportunistic approach to reproduction. Reproduction encompasses the behaviors that are directly and indirectly involved in producing and caring for offspring. One common practice used by researchers is to divide reproduction into two major domains: mating and parenting (Clutton-Brock, 1991). Mating refers to the behaviors involved in courting a mate, and the act of sexual intercourse itself. Parenting refers to the investment that leads to an offspring's survival and its own reproduction. Mating and parenting can co-occur. For example, a father can be engaged in parenting behaviors, but can also be engaged in mating behaviors at more or less the same time. However, mating and parenting generally involve different and, at times, competing behavior sets, all of which are required for reproductive success. Both are necessary, but engaging in one can preclude engaging in the other. The different problems men faced during mating efforts versus parenting efforts may have produced evolutionary pressure for hormone responses and behavior that facilitate both mating and parenting, either separately or simultaneously. Our understanding of mating and parenting behaviors in men is in its nascence and requires focused empirical investigation to tease apart the dynamic between the two impulses.

The sometimes competing domains of mating and parenting in men may be mediated by a number of the same hormones. Examples of such hormones include testosterone (T) and arginine vasopressin (AVP). Both hormones are found in much higher concentrations in men than women, which may help explain some of the sex differences found in mating

and parenting. T and AVP may also help elucidate variations in mating and parenting behaviors among and within men and consequently provide several pieces of the puzzle to men's mating and parenting behaviors.

The investigation undertaken in this study aimed to examine differences in baseline levels of T and AVP, and their reactivity to both sexual (mating) and parenting stimuli in an attempt to tease apart the differential role these hormones might play in different dimensions of the reproductive effort. This reactivity was also investigated as a function of marital and parenting status to determine whether the hormonal response to these stimuli is contingent on individual reproductive circumstances. Finally, this study aimed to better understand the relationship between T and AVP under different reproductively relevant conditions.

The literature review leading to the description of the proposed study will begin with a brief primer on T and AVP. Following will be a socioevolutionary discussion of the potential roles of T and AVP in reproduction, a review of the behavioral correlates of T and then AVP as well as ways in which these relationships may be relevant to reproduction. Various questions that have been raised by the literature will then be presented in regard to the rigidity versus flexibility of male reproductive strategies, the extent to which mating or parenting impulses dominate, what hormones appear to be most implicated in each of the two aforementioned strategies, and the extent to which hormonal responses suggest that men lean toward or away from mating as opposed to parenting or vice versa. The literature review will end with the aims of our study, a study that will hopefully shed light on some of the questions that remain regarding male reproductive strategies and the hormones involved in their facilitation.

CHAPTER 2

TESOSTERONE AND VASOPRESSIN AND THEIR ROLE IN SOCIOEVOLUTIONARY THEORIES OF MALE REPRODUCTIVE BEHAVIOR

A Primer on Testosterone

The human endocrine system has four different types of hormones: (1) steroids, (2) proteins and peptides, (3) monoamines, and (4) lipid-based hormones. T is a steroid. In particular, it is the primary male sex steroid. Like all steroid hormones, T is processed from cholesterol. It is lipid-soluble and easily passes through membranes and the blood-brain barrier. T is not stored anywhere in the body, but is produced and secreted based on signals that originate in the hypothalamus. Almost all of men's T is produced and secreted from the testes; the remainder comes from the adrenal cortex. In women, approximately half of the T comes from the ovary, half from the adrenal cortex, and small amounts from peripheral tissue.

In men, T plays an important role in two developmental processes: (1) prenatal masculinization/defeminization, and (2) brain organization/activation that takes place prenatally and throughout the life course. Regarding masculinization/defeminization, male and female zygotes are sexually undifferentiated, both containing a Mullerian and Wolffian duct system. In a female zygote, the absence of testicular hormones results in the degeneration of the Wolffian duct system, and the development of the Mullerian duct system into the fallopian tubes and uterus. The beginning of sexual differentiation begins with the expression of the SRY gene in the Y chromosome. Hormone secretions from the testes promote the development of the Wolffian duct system into the seminal vesicles and vas deferens. In male embryos, the testes also secrete Mullerian Inhibitory Hormone to

cause the Mullerian duct system to degenerate. Thus, no hormones are needed for normal female development in utero, but normal male development requires two hormonal processes. The development of the Mullerian duct system and the regression of the Wolffian duct system in females is known as the feminization/demasculinization process, respectively. The development of the Wolffian duct system and the regression of the Mullerian duct system in males is known as the masculinization/defeminization process, respectively.

The organizational/activational hypothesis predicts that time-sensitive effects of certain steroid hormones are responsible for many sexually dimorphic behaviors in mammals. There are critical periods of time when early, irreversible effects of steroid hormones organize neural substrates. These neural substrates are located in the hypothalamus, and are presumably responsible for sexually dimorphic behavior (Forest, Sizonenko, Caithiard, & Bertrand, 1974). The same steroids that organize these neural substrates will activate these neural substrates later in life. In contrast to organizational effects, activational effects are reversible. For example, sexual desire is an activational effect that can be manipulated by increasing or decreasing T in adulthood (e.g. Regan, 1999). As such, simply measuring and comparing individuals' baseline levels of T in adulthood for inferences on behavior yields an incomplete picture because differences in the organization of neural substrates are not taken into account.

An example of an organizational effect is the ratio of the index finger to the ring finger (2D:4D), which is an indicator of prenatal estrogen:testosterone proportion (Lutchmaya, Baron-Cohen, Raggatt, Knickmeyer, & Manning, 2004), or just prenatal androgen exposure (Brown, Hines, Fane, & Breedlove, 2002; van Anders, Vernon, &

Wilbur, 2006). Men typically have a longer 4D than 2D which would reflect a lower prenatal estrogen-to-testosterone proportion, whereas women typically have a longer 2D than 4D which would reflect a higher prenatal estrogen-to-testosterone proportion (Manning, 2002).

Male T involves three major life-course increases and decreases. T increases substantially a few weeks after conception, remains elevated until a few days after birth, and then decreases to a low level for a few days. Then it increases and remains elevated for a few months, and then decreases to very low levels until puberty. These early rises in T are believed to be responsible for important, sexually dimorphic organizing effects of neural substrates (Nelson, 2005). T rises again with puberty and peaks in late adolescence or early adulthood. Then it begins the slow and gradual decline with age over several decades (Dabbs, 1990a).

The regulation of T in the body is carried out by way of a negative feedback loop in the hypothalamic-pituitary-gonadal (HPG) axis. The hypothalamus secretes gonadotropin-releasing hormone (GnRH) which signals the anterior pituitary to release luteinizing hormone (LH). This, in turn, stimulates the secretion of T from the testes. For men, total daily output is 6-7mg (Coffey, 1988). T secretion has a circadian rhythm whereby it peaks in the morning, decreases significantly in the midmorning, and continues to decrease at a more gradual rate throughout the remainder of the day (Dabbs, 1990b).

T is involved in numerous bodily functions including the development and maintenance of sex characteristics and musculature, the production of red blood cells and sperm, and the regulation of the release of various neurotransmitters. In some instances, T

exerts its physiological effects immediately after binding to an androgen receptor. In other instances, T functions as a prohormone, whereby it exerts its effects after being converted into another steroid. An example includes the conversion of T to dihydrotestosterone (DHT) by the enzyme five-alpha-reductase. DHT plays a key role in genital development.

T levels can be measured from blood, saliva, urine, and feces, but levels will vary depending on the method used. For instance, T is 10 to 20 times higher in blood than in saliva samples. Unbound T is the portion that is considered to be biologically available, and constitutes approximately 2% of total T. The rest of T is bound to sex hormone-binding globulin (SHBG) and albumin. The portion of T that is bound to albumin can become unbound, and thus makes it difficult to obtain reliable measures of free T. Average levels of free T in healthy adult men range from 300-1000 nanograms per deciliter (ng/dL) of serum. Women tend to have eight to ten times less T than men.

A Primer on Vasopressin

In contrast, AVP, also known as antidiuretic hormone (ADH), is a peptide hormone that is water-soluble and unable to cross the blood-brain barrier. It is produced in the hypothalamus and stored in the posterior pituitary. AVP is involved in homoeostatic processes of the body's water and salt balance; one of the main functions of AVP is to retain water. For instance, diabetes insipidus is characterized by an AVP deficiency, or an inability of the kidney to respond to this hormone which results in frequent thirst and urination. AVP was originally described as a vasoconstrictor, but researchers explained how AVP also serves to reabsorb water (e.g., Mutlu & Factor, 2004). In either case, AVP

increases blood pressure and plays a role in the cardiovascular stress response (Ellison & Gray, 2009). A sudden loss of blood due to injury or hemorrhage will result in AVP secretion. Hypovolemia (low blood volume) or hyperosmolality (high concentration of solutes in the bodily fluids) increase AVP activity in different areas of the hypothalamus - magnocellular neurons of the paraventricular nucleus (PVN) and supraoptic nucleus (SON) (Caldwell & Young, 2006).

Baseline levels of AVP will vary depending on a number of factors, just of few of which include sex, neuronal/hormonal modulators, and time of day. AVP is found in higher concentrations in men than women, and is modulated by T (Carter, 2007). The glucocorticoid known as corticosterone (a steroid) is also involved in the modulation of AVP, decreasing its activity in the PVN (e.g., Tramu, Croix, & Pillez, 1983). Like T, AVP follows a circadian rhythm, increasing during the night and peaking in the morning (Forsling, 2000).

Many of the behaviors associated with AVP are controlled via AVP receptors found throughout the body. AVP receptors can be classified into two groups: AVPR1 and AVPR2. AVPR1 can be further divided into two types: AVPR1a and AVPR1b. Most of these receptors are located in various regions of the brain (Ostrowski et al, 1992; Lolait et al., 1995). AVPR1a is primarily linked with social behaviors, and AVPR1b is primarily linked with stress responses (Caldwell, Lee, Macbeth, & Young, 2008). It should be noted that this is a generalization with exceptions. For example, aggression, which is a social behavior, has been associated with AVPR1b, at least in mice (Wersinger, Ginns, O'Carroll, Lolait, & Young, 2002). AVPR2 is mostly located in the kidney (Ostrowski et

al., 1992), and is involved in AVP's anti-diuretic properties by regulating the body's water and salt balance.

Socioevolutionary Theories of Testosterone and Vasopressin

T and AVP have been implicated in socioevolutionary theories of reproduction. Specifically, these hormones are believed to be part of the physiological underpinning of social behaviors that have evolved to facilitate mating and parenting. T and AVP may potentially mediate, directly or indirectly, the processes of male reproduction across species that range in genetic similarity to humans: from vertebrates to mammals to primates. In light of the fact that vertebrates have existed longer than mammals which have existed longer than primates, this continuity portrays how well preserved these hormonal functions are in reproduction, and suggest significant evolutionary importance (Donaldson & Young, 2008). Yet relatively little is known about the relationship between T and AVP in human reproduction, or how these hormones vary with men's marital or parental status. The following socioevolutionary theories will help researchers form testable predictions in this regard.

Testosterone

The Challenge Hypothesis (Wingfield, Hegner, Dufty, & Dall, 1990) can potentially be used as a theory to explain the relationship between T and men's mating and parenting practices. Derived from avian research, this theory has since been applied to humans as a way to synthesize the vast literature on the behavioral correlates of T. The Challenge Hypothesis predicts that an avian male's androgen responses to territorial aggression, mating, and parenting stimuli are related to the male's mating and parental investment

system. Specifically, the Challenge Hypothesis suggests that monogamous male birds that provide paternal care will show an increase in T at the start of the breeding season, with further increases when challenged by another male for access to territory and mates. On the other hand, when these monogamous birds provide parental care, such as incubation, their T will decrease. It is predicted that promiscuous male birds that do not provide paternal care will not exhibit these context-specific changes in T because their T is close to a maximum level throughout the breeding season. A review of the social modulation of androgens in a number of vertebrates including various avian and fish species, with exceptions such as the male St. Peter's fish, has generally supported the Challenge Hypothesis (Oliveira, 2004). The Challenge Hypothesis was also successfully applied, with some modifications, to chimpanzees (Muller & Wrangham, 2004). The authors noted that male chimps mate with females that have never given birth (nulliparous) at the same rate as they do with females that have given birth one or more times (parous). Furthermore, rises in male T and aggression are only seen during mating with parous females showing maximum sexual tumescence, and not nulliparous maximum sexual tumescence. Consistent with the original Challenge Hypothesis is that increases in male chimpanzee T and aggression are most associated with reproductive contexts. In contrast to the original Challenge Hypothesis which predicts that males of promiscuous bird species will not show T responses to mating contexts because their T is already close to maximum, the males of the promiscuous chimpanzee species will portray T responses to mating contexts.

Archer (2006) provided a review of the relevant human data which further supported a modified version of the Challenge Hypothesis. The author found evidence on a broad

level for several predictions derived from the Challenge Hypothesis as applied to humans: (1) There is no increase in male aggression during puberty. The original prediction was based on the finding that male birds providing paternal care do not show a rise in aggression, despite a rise in T, at the start of the breeding season. This led to the conclusions that T levels, in and of themselves, do not predict aggression and that the relationship between T and aggression is context-dependent and, more specifically, reproductive competition dependent. In support of this conclusion in humans, puberty in boys is associated with a rise in T, but we do not witness a rise in boys' aggression with the onset of puberty because reproductive competition is not perfectly correlated with the onset of boys' puberty. (2) Men respond to sexual arousal with a rise in T. One of the two T-behavior relationships that the Challenge Hypothesis predicts is that T facilitates mating. Archer's review of studies investigating the effect of sexual activity, sexual stimuli, or the interaction with a potential female mate on T responses all provided some support for a rise in T in these contexts. (3) Men respond to competition with a rise in T. The other T-behavior relationship that the Challenge Hypothesis predicts is that T facilitates competition in reproductive contexts. Archer's summary of experiments that measured the effect of various types of human competition on T responses showed that, in general, T increased for both winners and losers, or especially so for winners. Furthermore, sport competitions showed greater effect sizes than contrived laboratory-type competitions. Although the competitions in these studies admittedly did not involve "reproductive contexts," men's evolved T responses may not make that distinction. (4) T levels are lower among paternal men. If T facilitates mating, then a decrease in T may be an adaptive hormonal response that accompanies fatherhood, since humans are a species

that engage in paternal investment. Archer found support for the prediction that fathers have lower T than fatherless, age-matched men. (5) There is a correlation between aggressive dominance and T in men. This prediction was derived from the Challenge Hypothesis as it was applied to chimpanzees in which aggressive dominance, and not just aggression, was associated with higher T (Muller & Wrangham, 2004). Archer qualifies, however, that non-aggressive forms of dominance in humans, such as those found in various occupations, are not linked with higher T. (6) Higher T is linked with life history approaches that are geared more towards mating than parenting. For example, Archer cites evidence for a link between antisocial behaviors, such as a frequent change in sex partners, with higher T. These types of behaviors, often involving the prioritizing of short term goals over long term ones, generally reflect a life history approach that is geared more towards mating than parenting. When support for all of these predictions are considered in unison, a reasonable conclusion to be drawn is that the function of sex steroids such as T is to influence behavior in a manner that ultimately brings the sperm and the egg together (Nelson, 2005).

Vasopressin

AVP is predicted to be part of the hormonal underpinning of monogamy and paternal investment in men. However, a socioevolutionary theory of AVP as it applies to mating and parenting in humans is largely unexplored as many of the predictions about the relationship between AVP and social behavior emanate from rodent research. Young, Wang, and Insel (1998) predicted that AVP and oxytocin are the endocrine bases of monogamy in different vole species. Most of their discussion focuses on comparing the monogamous prairie vole (Getz, McGuire, Pizzuto, Hofmann, & Frase, 1993), which

exhibits biparental care, to the promiscuous montane vole (Jannett, 1980), which does not exhibit bipaternal care. In male prairie voles, mating supports the development of partner preference (Winslow, Hastings, Carter, Harbaugh, & Insel, 1993) and paternal investment (Bamshad, Novak, & DeVries, 1994). In the absence of mating, the administration of AVP to unmated male prairie voles, in comparison to controls, enhanced partner preference for cage mates (Winslow et al., 1993). Administering AVP has also been shown to enhance paternal care in male prairie voles in the absence of mating (Wang, Ferris, & DeVries, 1994). In sum, rodent research suggests that the act of mating facilitates partner preference and paternal investment, at least in part, through an AVP response. In particular, Young et al. (1998) predict that it is the V1a receptor distribution and the binding action of AVP to this receptor type that is partially responsible for differences in male mating and parenting patterns among vole species.

In human males, the relationship between AVP and mating and parenting contexts is unclear, in part because relatively little research has been conducted. In the context of mating, one study investigating the effect of sexual stimuli on AVP responses in 13 men found an increase in AVP with sexual arousal, but not with orgasm, and then a decrease to basal levels at the time of ejaculation (Murphy, Seckl, Burton, Checkley, & Lightman, 1987). However, another study that tested the effect of sexual stimuli on AVP responses in 10 men did not find a relationship between AVP and sexual arousal or orgasm (Krüger et al., 2003).

In the context of parenting, one study examining the potential relationship between various hormones and father-child interactions in a Jamaican-based study found no difference in AVP between 28 fathers and 15 non-fathers (Gray, Parkin, & Samms-

Vaughan, 2007). However, the authors did find a significant inverse correlation between a man's AVP and the age of his youngest child. This may be important. If AVP facilitates paternal investment, higher AVP in a father may be adaptive when the offspring is younger rather than older. Typically, a woman is more vulnerable shortly before and after giving birth. The offspring's vulnerability is also inversely related to its age. An AVP response in men to facilitate childcare when it is most needed may be an evolved adaptation. In sum, evidence is leading to a prediction that AVP plays a mediating role in both mating and parenting contexts for men. In the parenting role, AVP is conceivably geared towards male monogamy and paternal investment.

To conclude, T is the principle male steroid and AVP is the principle male peptide. The effects of these hormones are not limited to physiology, but also manifest themselves in behavioral differences between the sexes, and within the male sex. Moreover, higher levels of T and some threshold level of AVP have been implicated in mating efforts, whereas lower levels of T and some threshold level of AVP have been implicated in parenting efforts. Both of these hormones may work in tandem to support reproductive success. An examination of the behavioral correlates of these two hormones may provide insights as to how they may mediate or moderate mating and parenting efforts.

CHAPTER 3

BEHAVIORAL CORRELATES OF TESTOSTERONE

Although T has been linked with numerous contexts, characteristics, and traits, methodological concerns suggest caution in proposing links between T and a great many variables (e.g., Zitzmann & Nieschlag, 2001). However, certain variables have been empirically linked with T, and may have relevance for men's reproductive success. Examples of such variables linked with higher T include competition, aggression, and dominance/status. Conversely, examples of variables that have been linked with lower T include pair-binding and fatherhood. All of these variables, perhaps, reflect more indirect relationships with reproductive success. Other variables that have been linked with T may reflect a more direct or proximal relationship with reproductive success. For instance, T is known to impact sexual function, and sexual activity/stimuli are known to impact T responses. Each of these behavioral correlates will be discussed in the following sections, beginning with T and competition.

Testosterone Responses to Competition

Research on the effect of competition on T responses in humans appears to have begun in earnest in the 1980s. Related research had been conducted prior to that time on nonhuman primates. For example, Rose, Bernstein, and Gordon (1975) described how successful attempts by rhesus monkeys to maintain or increase status seemed to promote a rise in T, whereas unsuccessful attempts seemed to decrease T. Almost 30 years after the Rose et al. (1975) study, Muller and Wrangham (2004) described how male

chimpanzees showed increases in T when competing with other males for access to ovulating females.

Mazur and Lamb (1980) published the first study on the effect of competition on T in humans investigating the effect of doubles tennis matches on serum T responses in four men. Two of the matches ended with a decisive victory and the winners showed a higher rise in T than the losers. However, the third match ended with an indecisive win and the winners and losers showed no significant difference in T. Elias (1981) examined the effect of wrestling matches on serum T responses in 15 men. T rose significantly for both winners and losers, but significantly more so for winners than losers. Gladue, Boechler, and McCaul (1989) tested the effect of a computer-based mock reaction time task on salivary T responses in 39 men. Participants competed in twos and were unaware that they were randomly assigned to win or lose. These individuals also could not see how well their competitors were performing. In addition, one participant from each pair was randomly assigned to win decisively or by a narrow margin. Winners had significantly higher levels of post-competition T than losers in both the decisive win and narrow win conditions.

There are several examples of non-physical competitions as well where winners show a greater increase in T than losers. Mazur, Booth, and Dabbs (1992) investigated the effect of chess competitions on changes in salivary T. Sixteen males participated in one or both of two chess tournaments. Eleven males participated in the first chess tournament, and eight participated in the second tournament. Generally, winners showed higher levels of T than losers. McCaul, Gladue, and Joppa (1992) measured the effect of a chance-controlled task on salivary T responses in two studies, the first of which included 28 men.

A coin was tossed 60 times. If it turned up “heads” more than 30 times, participants won $5. If the coin turned up heads 30 times or less, they did not win the $5. These individuals were told to guess on each toss whether it would turn up heads or tails, although this had no bearing on whether they would win the $5. In this sense, participants were not competing against another person, but competing against chance. Only the second post-task sample approached significance, where winners had higher T than losers. The second study included 101 men. This study was the same as the first one except: (1) some participants were in a neutral condition where the $5 possible prize was removed, and (2) a sixth post-task saliva sample was taken. In the second study, winners had significantly higher T than losers in the first post-task sample.

One study is unique in that it portrays how winners can show higher increases in T than losers even though they are not directly involved in the competition. Bernhardt, Dabbs, and Fielden (1998) examined the effect of vicariously winning or losing through a favorite sports team on men’s salivary T responses in two studies, the first of which included eight participants. These individuals watched a college basketball game, four were in support of one team and four were in support of the opposing team. In the second study 21 fans watched a televised World Cup of Soccer match. Twelve of these individuals supported one team, and fourteen supported the opposing team. In both studies, there was a significant interaction where T increased for those who “won” and decreased for those who “lost.”

Two more examples of competition-induced T increases are included in this section, even though a distinction between winners and losers is not made. Guezennec, Lafarge, Bricout, Merino, and Serrurier (1995) measured the effect of pistol shooting competition

on serum T in 20 men. The result was a significant increase in T. As well, Kivlighan, Granger, and Booth (2005) tested the effect of rowing competition on salivary T responses in 23 males and 23 females. During the competition, men experienced a significant rise in T, but women did not.

If winners experience a higher increase in T than losers, and winning is linked with an increase in status, then the T response may be a reflection of an individual's perception or internalization of his own rise in status. This view may place more importance on the outcome of the competition because it suggests that the higher rise in T is not due to the competition itself, but due to winning. In addition, common sense indicates that a competitor's T cannot influence the outcome of a competition that is entirely determined by chance, yet winners in these types of competitions may experience higher post-competition T, as shown by Gladue and Joppa (1992). This leads the reader to conclude that the outcome of a competition is at least partially responsible for influencing T.

Not all studies have shown that the rise in T associated with competition is exclusive to winners of these competitions. There are several examples of physical competitions where T increased for all competitors, with no difference between winners and losers. Booth, Shelley, Mazur, Tharp, and Kittok (1989) tested the effect of tennis matches on salivary T responses in six males. Although T increased for winners and decreased for losers during the match, there was no significant difference between winners' and losers' T immediately after the match. Suay et al. (1999) investigated the effect of judo competition on serum T in 26 males. T increased significantly for winners and losers, with no difference between the two. Bateup, Booth, Shirtcliff, and Granger (2002) examined the effect of rugby competition on salivary T responses in 17 women. There

was a significant rise from pre-game to post-game, with no difference between winners and losers. Edwards, Wetzel, and Wyner (2006) measured the effect of soccer on salivary T responses in men and women. Three soccer games were observed: one for the men, which ended in victory, and two for the women, one of which ended in victory and one of which ended in defeat. The 13 males who played, and won, showed a non-significant increase in T. The 15 women who played in the game that they won showed a significant increase in T. The 11 women who played in the game that they lost also showed a significant increase in T. Hasegawa, Toda, and Morimoto (2008) investigated the effect of *shogi* (Japanese chess) on salivary T responses in 41 men. Winners and losers alike showed a significant increase in T, with no difference between the groups. Also, Steiner, Barchard, Meana, Hadi, and Gray (2010) examined the effect of a poker competition on salivary T responses in 32 males. There was a significant rise in T for all participants as a whole, but no difference between winners and losers.

It remains important to note that not all competitions seem to elicit a T response, and indeed, several studies using physical competitions have shown no significant increase in T for either winners or losers. Salvador, Simon, Suay, and Llorens (1987) investigated the effect of judo competition on serum T responses in 13 males. The result was a decrease in T with no significant difference between winners and losers. Mazur, Susman, and Edelbrock (1997) measured the effect of a video game contest on salivary T responses in 28 males and 32 females. There was no significant difference between winners' and losers' T responses. González-Bono, Salvador, Serrano, and Ricarte (1999) examined the effect of winning or losing a basketball game on salivary T responses in 15 men. Seven participants were from the winning team, and eight participants were from

the losing team. Although T increased for winners and decreased for losers, there was no significant difference between the two groups. Passelergue and Lac (1999) tested the effect of wrestling competition on salivary T responses in 15 men. There was no difference in T between the competitive and the resting days, although post-competition T levels on the second day of the competition were significantly higher than post-competition T levels on the first day of the competition. As well, no differences were found in T between winners and losers. González-Bono, Salvador, Ricarte, Serrano, and Arnedo (2000) measured the effect of basketball competition on salivary T in 17 men. Participants were divided into two teams, and each team won a game against another opponent. As such, there were no losers in this study. Saliva samples showed a non-significant increase in T for one team, and no change in T for the other team. Serrano, Salvador, González-Bono, Sanchis, and Suay (2000) investigated the effect of a judo competition on salivary T responses in 12 males. T increased for winners and decreased for losers, although the change was not statistically significant. Filaire, Maso, Sagnol, Ferrand, and Lac (2001) examined the effect of winning/losing a judo competition on salivary T responses in 18 men. T increased for losers and decreased for winners, but the changes were non-significant. Urhausen and Kindermann (1987) measured the effect of a triathlon competition (swimming, cycling, and running) on serum T responses in 8 men. No significant effects for T were found from before to after the competition.

Non-physical competitions have also yielded a lack of group differences in T responses. Mazur and Lamb (1980) measured the effect of winning/not winning a $100 lottery on serum T responses in 14 men. Seven participants won $100, and seven did not. No significant differences in T were found between the winners and losers. Wagner,

Flinn, and England (2002) tested the effect of dominoes competition on salivary T responses in eight men. Competition did not cause a rise in T, nor was there a difference between winners and losers. Mehta and Josephs (2006) measured the effect of salivary T responses to winning/losing a competition on visual processing speed in 57 men. The competition involved a series of six puzzles called the Number Tracking Task. Unbeknownst to the participants, the competition was rigged so that who would win and lose was randomly assigned. T decreased for both winners and losers. Finally, van Anders and Watson (2007) investigated the effect of a computer-based verbal meaning competition on salivary T responses in two studies. In the first study, which included 37 men and 38 women, the outcome of the competition was determined by ability. Individuals competed against the computer, not against other individuals. For the men, losers' T decreased significantly more than winners' T. For women, there was a significant decrease in T from before to after the competition, but no significant differences in T between winners and losers. The second study included 31 men and 43 women, and involved the same procedures, but the participants were randomly assigned to win or lose. Thus, competition outcome was determined by chance. There were no significant changes in T responses, or significant differences between winners and losers, in either males or females.

Conclusions on the Relationship between Testosterone and Competition

From 1980 to the present, investigations on the effect of competition on T responses have involved many different paradigms. Some competitions were physical, while others were not. Some competitions involved an outcome that was determined by skill or chance or some combination of the two. Some competitions involved a one-on-one design, others

involved team efforts, and some competitions involved a different design altogether, such as competing against a computer, as shown by van Anders and Watson (2007). As a whole, the findings are mixed, to say the least. It appears that despite the many studies linking T to competition, there is a substantial number of other studies in which T is not implicated.

There are many potential reasons for such inconsistent results. One concerns the variable timing of obtaining T samples. Steiner et al. (2010) explains how T can rise significantly and then fall to baseline levels within minutes. Studies such as the one conducted by Passelergue and Lac (1999) may have missed any significant change in T, due to timing. Another reason concerns psychological differences among competitors that may have mediated or moderated the effects of competition on T responses. In her review of the studies on the effect of competition on T responses, Salvador (2005) states that the importance of the competition to the competitor, and the degree of perceived control that the competitor has over the outcome of the competition are examples of such psychological differences. In a similar vein, Edwards (2006) suggests personality differences as a possible moderator.

Yet another possible explanation for the mixed results concerns anticipatory rises in T before a competition, and how differences in these rises would alter the effect of competition on T responses because not all competitors are beginning the competition with similar baseline T levels. Booth and Mazur (1989), Mazur, Susman, and Edelbrock (1997), and Bateup, Booth, Shirtcliff, and Granger (2002) all found anticipatory rises in T before a competition. In contrast, Salvador, Suay, González-Bono, and Serrano (2003) measured the effect of judo competition on anticipatory T responses in 17 men, but there

was only a non-significant increase in T before the competition. As an aside, these results indicate that not only does competition itself have the potential that cause a change in T, but that even thinking about an upcoming competition can elicit a T response. Internalizing the prospect of an increase in status, by winning, or the threat of a decrease in status, by losing, could cause a spike in T.

A final potential reason for the mixed findings relates to the complexity of the dynamic reciprocal determinism framework (Bandura, 1978) within which the relationship between T and competition exists. This framework can be viewed as three points on a triangle: (1) the environment, (2) internal factors (such as T), and (3) behavior (such as competing). Each point has a bidirectional relationship with the other two points. In this framework, hormones can affect behavior, behavior can affect hormones, and these relationships may depend upon specifics of the competitive environment. In short, the reciprocal determinism framework argument points to a host of potentially confounding variables in the competition studies reviewed.

Despite mixed findings, there is accumulating evidence for several conclusions: (1) Competition often, but not always, causes a rise in T. (2) T increases for both winners and losers of a competition, or the increase is more pronounced in winners. There is no published study in which losers' T increased significantly more than that of winners. (3) Psychological differences may influence the relationship between winning/losing and T responses, as explained by Salvador (2005). (4) Competition-induced T increases are brief, typically lasting minutes versus hours, as shown by Elias (1981). There also appear to be gender differences that point toward the role of T in reproduction.

In the study involving rowing competition by Kivlighan, Granger, and Booth (2005) and the study involving video game competition by Mazur, Susman, and Edelbrock (1997), T decreased for women, but not for men, indicating that T may play a different role for men and women in competitive contexts. Men and women faced different evolutionary pressures during the ancestral past, and sex differences in T responses during competitions may be a reflection of these different pressures. Women's reproductive lifespan is shorter than that of men's, as they can only produce one child at a time (or two in the case of twins) whereas men can theoretically produce dozens of children at a time. Moreover, women need to make a much greater physiological investment to reproduce, in the form of gestation and lactation, than men. During gestation and lactation, women were more dependent on help for obtaining food and resources. For these types of reasons, as Nelson (2005) explains, women's reproductive success is ultimately constrained by access to resources, whereas men's reproductive success is ultimately constrained by access to mates. Among mammals, these differences in constraints are reflected in different physiologies between the sexes, one part of which may include a different sensitivity in T to competition, as discussed by Ellison and Gray (2009).

However, conclusions about sex differences for the role of T in competitive contexts are still unclear. There are cases of women's competition that resulted in significant T increases, as shown by the study involving rugby by Bateup, Booth, Shirtcliff, and Granger (2002), and the study involving soccer by Edwards, Wetzel, and Wyner (2006). Conceivably, a rise in women's T from the threat of a decrease in status by losing a competition, or the potential of an increase in status by winning, elicits the same

physiological response as it does for men, and that this response was perhaps adaptive for both sexes in the same way.

How may competition be related to reproductive efforts? The notion of competition may have more salience to mating than parenting. From an evolutionary perspective, men likely competed with other men for access to mates. The competitions were likely in the form of hunting or obtaining resources that would make them attractive as mates to females. That said, competitions in hunting for example, may have been carried out far from the presence of females, and may not have involved a direct declaration that the "winner" would obtain a mate. Thus, competition-induced T responses may have been very salient to mating, even if the competition itself seemed far removed from mating. In this regard, competitions that seem to have little, if any, evolutionary significance, like playing poker in a lab on campus as shown by Steiner et al. (2010), may still be able to trigger T responses that were geared towards mating.

Testosterone and Aggression

T has long been associated with human aggression, and dozens of studies have sought to elucidate the relationship between the two. This relationship has been well established in other mammals (e.g., Turner, 1994), but the link is less clear in humans. The following section will focus on meta-analyses of T-aggression research and then review a number of studies that have manipulated either T or aggression to investigate their effect on each other. The discussion closes with a description of some of the limitations of T-aggression research, conclusions reasonably drawn from the literature, and how aggression may be related to reproductive efforts.

From several months postpartum until puberty, a boy's T is barely measurable. As such, this section begins with adolescence. Olweus, Mattsson, Schalling, and Löw (1980) examined the relationship between T and aggression in 58 boys, 15-17 years of age. A correlation coefficient (*r*) of .44 was observed between serum T and self-reported physical and verbal aggression. Several years later, these same authors performed a path analysis to investigate a potential causal relationship and found a direct link between serum T and self-reported physical and verbal aggression (Olweus, Mattsson, Schalling, and Löw, 1988).

In contrast, a number of studies have failed to confirm a link between adolescent T and aggression. Schaal, Tremblay, Soussignan, and Susman (1996) examined this link in 178 boys, 6 to 12 years of age. Salivary T was collected at 13 years of age, and aggression was assessed by the teachers of these students when they were 6 to 12 years of age. The result was an inverse correlation between T and history of aggression. Tremblay et al. (1998) examined the relation between salivary T and other-reported physical aggression in 57 boys, 12 to 13 years of age. T did not predict aggression, but did predict dominance. The authors hypothesized that in cases in which T is linked with aggression, it may be limited to contexts in which dominance is best attained and expressed by aggression. In a typical school or workplace setting, the authors claim, aggression would not be an effective route to dominance because aggression is not typically permitted in these settings. Hence the T-aggression link may not be found under these circumstances. In the ancestral past, T was perhaps a better predictor of aggression because the cultural environment did not suppress aggression to the same extent and aggression was the primary way for dominance to be conveyed.

In a longitudinal study that examined T, aggression, and dominance, van Bokhoven et al. (2006) measured salivary T in 96 boys, from the age of 12 to 21. Aggression was measured via self-and other-report questionnaires. As expected, T increased over the adolescent years, but aggression decreased over this time frame. Contrary to Tremblay et al.'s (1998) findings, dominance was not correlated with T. The relationship between T and adolescent aggression thus remains unclear.

In adulthood, the T-aggression link is, arguably, only somewhat more apparent. Archer (1991) provided a review of the literature via meta-analyses on the association between T and aggression. Overall, he concluded that there is a low but direct relation between T and aggression, whereby the correlation coefficient is .38 when aggression is rated by others, but lower when rated via self-report. Noting that violent men had higher T than less violent men, Archer also made a point of emphasizing that social experiences can moderate the link between T and aggression, even in animals. Considering that hormones are often less predictive of behavior in humans than in animals (Nelson, 2005), the relationship between T and human aggression can be a challenging one to elucidate.

Archer, Birring, and Wu (1998) examined the relationship between serum T and self-report of aggression in 101 men, 18 to 27 years of age. They did not find an effect for either free or total T. The authors also conducted a meta-analysis of 18 studies and found a moderate weighted mean effect size (d = .40) for T on aggression. No difference was found in studies involving students and those involving populations more likely to engage in aggression such as violent criminals. In sum, the authors' review evidenced mixed results for the relation between T and aggression.

Harris (1999) also reviewed studies on the relation between T and aggression and considered several reasons for the mixed findings on the T-aggression link. She noted that many studies had used relatively small sample sizes which may have produced null results, especially when considering that the expected effect size would be small to moderate. Measurements taken at different times of the day or year also may have introduced variability into the data. Harris also proposed that the use of prisoner samples may have introduced a set of confounds related to their lack of representativeness of the population, the general effects of being in prison, and self-report bias related to participants' concern of parole board access to their responses. Variability and methodological concerns notwithstanding, Harris concluded that there is a weak to moderate relation between T and aggression.

Book, Starzyk, and Quinsey (2001) conducted a meta-analysis of 45 studies on the relation between T and aggression while cautioning that the "file-drawer" problem may have skewed the results. The "file drawer" problem relates to the fact that null results tend to not get published, leading to a potential overestimation of the effect of T on aggression. The authors also focused on two moderator variables; age and time of day that T was sampled. They found the link between T and aggression to be strongest in 13 to 20 year old males, and in afternoon T samples. The mean weighted correlation between T and aggression was .14, which is generally in line with previous meta-analyses.

Sometimes, however, T has not been found to have an association with aggression. For instance, Campbell, Muncer, and Odber (1997) did not find a relationship between salivary T and self-report aggression in 119 men, 16 to 43 years of age. Johnson, Burk, and Kirkpatrick 's (2007) study on T, aggression, and dominance with 72 men and 67

women (mean age of 19 years) found that dominance was positively related to self-reported aggression, but that T was not related to either dominance or aggression.

The mixed results of the aforementioned correlational research is mirrored by experimental designs that have involved two general approaches: manipulating aggression and measuring T, or manipulating T and measuring aggression. The following three studies involve the former approach. Berman, Gladue, and Taylor (1993) examined the relationship between salivary T and aggression in 38 men, 18 to 24 years of age. To avoid the limitations of self-report, aggression was measured in terms of how much electric shock a participant would deliver to another participant. A significant relationship was found between T and overt aggression. Klinesmith, Kasser and McAndrew (2006) conducted an experiment on the effect of handling a pellet gun versus handling a children's game on salivary T in 30 men, 18 to 22 years age. After handling either item, participants added hot sauce to a cup of water, believing that another individual would have to drink it later. The amount of hot sauce added was used as a measure of aggression. The authors found that T increased significantly more for those who handled the pellet gun, and that these individuals also added more hot sauce to the cup of water. McDermott, Johnson, Cowden, and Rosen (2007) conducted a study on the link between T and aggression in a simulated crisis game. The study included 78 women and 102 men. Ages ranged from 18 to 65 years of age. Participants competed one on one, each representing a different country. Players could invest in industrial production or military armaments, and could win by negotiation or winning a war. Going to war was riskier because there was always the chance of losing. Salivary samples were taken before, during, and after the game, but there were no differences in T across time. However, males were more

likely to make unprovoked attacks than women. Studies that have used aggression as an independent variable have found that aggression, can, but will not necessarily cause a rise in the dependent variable T.

In contrast, the following studies involve treating T as an independent variable to learn of its effect on aggression. Pope, Jr., Kouri, and Hudson (2000) examined the effect of T cypionate administration, increasing up to 600mg per week, on aggression. Total T was measured to determine if the T administration did indeed create a rise typically higher than what is found in normal, healthy men. Forty-seven men, 20 to 50 years of age, completed all parts of the study. The design was a placebo-controlled, cross-over study. Aggression was measured by the Point Subtraction Aggression Paradigm (PSAP). PSAP involves a computer game in which a participant believes he is competing against another person, but is actually competing against the computer. When participants intentionally deprive the "other participant" of points based on retaliation, this is interpreted as a measure of aggression. Increases in T in this study were associated with aggression. Dabbs, Karpas, Dyomina, Juechter, and Roberts (2002) measured the effect of micronized T administration or placebo on aggression in 16 men and 17 women with a mean age of 20 years. T was administered in a gel in an amount that equaled 40mg/day for men, and 10mg/day for women although it was not confirmed whether T really did increase with administration. Participants provided written reports of their experiences from the experiment, and then judges evaluated mood characteristics. Those taking T described significantly more hostility (aggression, anger, irritability, etc.) than those taking the placebo. Furthermore, the effect was stronger for women. The authors

concluded that the physiological and psychological effects of T are similar for men and women.

Not all studies involving T administration have produced a rise in T. Yates, Perry, McIndoe, Holman, and Ellingrod (1999) examined the effect of either 100mg (n=10), 250mg (n=10), or 500mg (n=11) of T cypionate administrations for 14 weeks in a double-blind study of men, 21 to 40 years of age. The 500mg group reached T levels that were four times their baseline levels but no significant effects were found for self-reported aggression. O'Connor, Archer, Hair and Wu (2002) examined the effect of T administration on self- and other-reported aggression over an 8 week period in 3 groups: 30 eugonadal men, 19 to 45 years of age (15 for an experimental group, and 15 for a placebo group), and 7 hypogonadal men, 23 to 40 years of age (also an experimental group). The two experimental groups received administration of 200mg of T enanthate weekly or biweekly for 8 weeks. Serum T was measured to ensure supraphysiological levels were obtained. There was no increase in aggression in any of the groups. O'Connor, Archer, and Wu (2004) examined the effect of T administration on aggression and sexual behavior in 24 eugonadal men, 22 to 44 years of age. The study involved a double-blind cross-over design in which one group received 1000mg of T undecanoate (TU) and the other group received a placebo at the beginning of an 8 week session. Both groups then underwent an 8-week normalizing session, and then the groups switched treatments at the start of the third 8 week session. Plasma samples confirmed that T levels reached supraphysiological amounts in their participants. In a behavioral assessment, no effects were found for self- and other-reported aggression. In a mood assessment, a rise in T was linked with anger hostility. It may be surprising to note that even supraphysiological rises

in T, as the preceding three studies have used, did not elicit an increase in aggression. It is possible that T has a limited role in aggression, or that T is, in part, only as effective as the number of receptors that are available for T binding.

Conclusions on the Relationship between Testosterone and Aggression

Research on the T-aggression link has numerous limitations, some of which have already been alluded to in this review. First, self-report measures of aggression may not be valid because of social desirability concerns. Second, lab simulations of aggression may not reflect real-world settings and thus lack ecological validity. Although this limitation is shared by most lab research, it is especially salient for aggression research because ethical restrictions limit the ability to truly create an aggressive scenario in the lab, one that is relevant to the evolutionary past that researchers are attempting to elicit. Third, most aggression research fails to distinguish between defensive and offensive aggression, which may have implications for T results. Kalin (1999) differentiates between defensive aggression, which is based in fear and correlated with cortisol, and offensive aggression which is related more to impulsiveness and involving lower cortisol and higher T. Fourth, T may influence aggression in ways that are not captured by simple T levels extracted during an aggressive act. For example, vom Saal (1983) proposed an Organization/Activation Model of T and aggression in which T organizes neural substrates relevant to aggression prenatally and then activates these substrates in adulthood. In other words, the real effect of T may be in prenatal development. He proposed that those exposed to low levels of T prenatally may require more T in adulthood to elicit or activate aggressive behavior, and vice versa.

Despite the methodological limitations of T-aggression research and the mixed findings of dozens of studies, T appears to have a small but significant positive correlation with aggression more often than not. Also worth noting are the differences in aggression between the sexes, the changes in men's aggression across the lifespan, and how both of these are generally correlated with T. Specifically, males have higher T than females, and are typically more aggressive (Bettencourt & Miller, 1996; Eagly & Steffen, 1986). Also, male-male physical aggression is highest in young males (Daly & Wilson, 1988), a developmental stage when male T is at its lifetime highest level (Read & Walker, 1984). Finally, aggression declines with age, as does T (Dabbs, 1990a).

Within a theoretical evolutionary framework, it is imperative to investigate how aggression may be related to reproductive efforts. There are a number of examples, albeit speculative, of how a certain level of male aggressiveness could have been adaptive during the ancestral past. Aggression may have facilitated hunting in some contexts, making the male more attractive as a potential mate. Aggression may also have provided an advantage in protecting oneself and family and community from predators or other humans, again making a man more attractive as a potential mate. Archer (1994) provided an evolutionary perspective on the link between T and aggression, and noted that during the ancestral past a certain level of aggression was likely adaptive as males competed with other males for access to females, and also prevented other males from mating with a particular female. Daly and Wilson (1994) suggested that aggression is an adaptive response to threats to one's reproductive success. In this manner, aggression is adaptive for obtaining mates, resources, and status. Daly and Wilson (1988) also suggested that

during the ancestral past, status conflicts were almost always solved via physical means or threats of physical force.

Testosterone, Dominance, and Status

Dominance can be defined as having power over another individual, and status can be defined as one's position or standing in relation to others. A dominant position is often characterized as having a higher status relative to someone else. Dominance and status are combined in this section because of the close association between these two terms. Considerable research has been conducted on the relationship between T and dominance/status. The human T-dominance/status link is perhaps an inherited characteristic from nonhuman primates, and therefore this link is briefly discussed in the latter context before moving on to the human research. The discussion will then continue by reviewing correlational studies on the link between T and dominance, and T and status. Next, a review of some key experimental studies on the relationship between T and dominance/status will be provided. The discussion ends with a description of some of the limitations of T-dominance/status research, how dominance/status may be related to reproductive efforts, and a short note on the relationship among competition, aggression, and dominance/status as they relate to T within an evolutionary perspective.

The T-dominance relationship has been well established in the nonhuman literature. For the sake of brevity, only a few of the nonhuman primate studies will be covered here. As mentioned earlier, Rose et al. (1975) described how successful outcomes of dominance encounters are linked with a rise in T in male rhesus monkeys, and unsuccessful outcomes are linked with a decrease in T. Moreover, Bernstein, Gordon, and

Rose (1983) found that baseline levels of T did not predict who would win or lose a dominance encounter in male rhesus monkeys. However, the outcome of the encounter (winning versus losing) did predict T where winning was associated with higher T. Wallen (1996) noted that social variables in rhesus macaques have a bigger impact on dominance behaviors than do hormones. Muller and Wrangham (2004) described how dominance was correlated with afternoon T, but not morning T in male chimpanzees. The authors stated that this was perhaps the result of morning T being almost entirely influenced by the nightly circadian rhythm while the afternoon measure was influenced by the events of the day in addition to biologically-determined hormone cycling. These preceding examples illustrate how dominance encounters can influence T, but does the relationship hold up in the opposite direction where T influences dominance encounters? Mazur's (1985) Biosocial Model of Status among primates suggests that it can. The model posits that status is established among members of a primate group by way of face-to-face interaction. In addition, T is related to one's motivation to increase status within that group. Those with high or increasing T are more likely to compete than those with low or decreasing T. Success at increasing status causes an increase in T; failure causes a decrease in T. Hence, T and dominance appear to have a reciprocal relationship.

More than a decade after Mazur's Biosocial Model of Status was published, Mazur and Booth (1998) provided a proposal of the relationship between T and dominance in humans. Their main points included: (1) T facilitates dominant behavior, and this behavior can be aggressive or non-aggressive. (2) Basal T, which is fairly stable, can predict certain types of behavior, including dominant behavior. This is what Mazur and Booth call the basal model. The authors noted that basal T may reflect the combined

effect of genes and a stable social position. (3) T and behavior have a reciprocal relationship, in what they call a reciprocal model. Mazur and Booth argue that aggression may be a poorer predictor of T than dominance, unless aggression is used as a means to assert dominance. The authors mention that there is stronger evidence for the effect of dominant-related encounters on T, than vice-versa. Finally, they note that there is relatively little empirical evidence on the relation between T and aggression or dominance in women. In response to Mazur and Booth's (1998) article, Dabbs (1998) stated that the T-dominance relationship may be better elucidated by examining basal T versus T responses to behavioral encounters such as a dominance contest. He argued that Mazur and Booth need a broader perspective on dominance, and that researchers need to think of dominance not just within a competitive framework, but as a trait that produces "admiration and deference in others." Clearly, the operationalization of dominance is a challenge in this line of research, making this construct difficult to measure with accuracy.

In another theoretical article, Mazur (2006) discussed how male T facilitates violent dominance contests. Again he asserts that T and dominance have a reciprocal relationship, and that when a non-aggressive dominance contest causes a rise in T, this in turn can facilitate dominance behavior which escalates to aggressive dominance contests. Mazur uses inner city "honor cultures" as an example to support his argument. He states that honor cultures involve environments of constant challenge from other individuals and cause men to be hyper-vigilant and reactive to disrespectful behavior. These types of environments may contribute to a rise in T, facilitating dominance contests that lead to violent outcomes. From an evolutionary perspective, the T-dominance relationship may have more salience in cases where physical violence is involved. However, as the

following studies will show, most research on T and dominance/status has not focused on physical violence.

A number of correlational studies have found a positive link between T and dominance, and T and status. The following three studies portray this link in adolescents. Schaal et al. (1996) measured the relationship between salivary T and social dominance in 178 boys who were 13 years of age. Participants' dominance was assessed by raters who were unknown to the boys. To control for the potential confound that raters would rate participants as being more dominant simply because of greater physical size (earlier pubertal development), various bodily measurements were entered as covariates. A significant positive correlation was found between T and social dominance. Tremblay et al. (1998) tested the relationship between salivary T and dominance in adolescents. Their study involved 57 boys, 12 to 13 years of age. Again, dominance was assessed by peers who were unknown to the participants. These peers observed participants' behavior in a 15-minute bean bag throwing contest that involved several individuals. Once more, T predicted dominance. The authors made a general speculation that a potential T-dominance link would be present in boys from infancy onwards. Rowe, Maughan, Worthman, Costello, and Angold (2004) examined the relation between blood T and self- and other-reported dominance in 713 boys, 9 to 15 years of age. T predicted dominance in those who did not have deviant peers, but T did not predict dominance in those who only *may* have had deviant peers, or *possibly* had deviant peers. T also did not predict dominance in those who definitely did not have deviant peers. The authors interpret this finding by stating that high T may not be related to dominance in general, but to dominance characteristics that are desired in pro-social settings.

The positive link between T and dominance also extends to adulthood. Ehrenkranz, Bliss, and Sheard (1974) examined the relationship between plasma T and dominance in 36 male inmates, 18 to 45 years of age. The men were divided into three groups: aggressive, non-aggressive, and dominant, based on observations of inmates' behavior over several years by one of the authors and a psychologist. Each group included 12 men. The dominant group had significantly higher T than the non-aggressive group, and the aggressive group had significantly higher T than the non-aggressive group as well as the other two groups combined. Interestingly, there was no significant correlation between T and self-reported data on various psychological data, including aggression data.

Most T-dominance research, however, has not involved inmates. Christiansen and Knussmann (1987) examined the relationship between androgens and dominance in 117 men, 30 to 40 years of age. The authors found a significant correlation between serum T (as a measure of total T) but not salivary T (as a measure of free T) and self-reported dominance. Gray, Jackson, and McKinlay (1991) investigated the relationship between serum T and self-reported dominance in 1679 men, 39 to 70 years of age, and found a significant correlation between T and dominance. Neave, Laing, Fink, and Manning (2003) examined the relationship between 2D:4D ratio and salivary T in 48 men, 18 to 33 years of age, and women's perception of the men's attractiveness, masculinity, and dominance. The findings of the Neave et al. study revealed that the lower the ratio, the higher the women's ratings of the men's dominance and masculinity. Salivary T was not related to digit ratio, or perceived dominance, masculinity, or attractiveness. This suggests that prenatal T may have more of an impact on dominance than adult T, at least in terms of perceived dominance.

Not all studies have uncovered a positive correlation between T and self-reported or perceived dominance. Johnson et al. (2007) conducted a study in which 43 men with a mean age of 19 years provided salivary samples for T measurement and self-reported measures of dominance. T was not related to dominance. Indeed, researchers should not overestimate the T-dominance link, as it is likely that numerous studies, or aspects of studies, have not been published because they obtained null findings.

If an individual's occupation can be used as a measure of status, and T and status are at least somewhat linked, can an individual's T be predicted based on his occupation, or vice versa? Perhaps. Mazur and Lamb (1980) measured the effect of medical school graduation on serum T responses in five men who were 35 years of age at the most. Graduation was on a Sunday. One serum sample was collected on each day for five days in the afternoon: on the Wednesday before graduation (on Thursday for one of the participants), the next day (Friday), on Sunday after the graduation, on Monday, and on Tuesday. There was no significant difference in T from before graduation levels to immediately after. However, all five subjects showed an increase in T on Monday, the day after the graduation. The authors did not specify if this increase was significant.

Dabbs, de La Rue, and Williams (1990) examined salivary T differences in 92 men who were grouped into one of eight occupational categories. The occupations in order from least to most T were ministers, salesmen, firemen, professors, physicians, football players, and actors. Unemployed men had much greater variance than the other occupations. Sample sizes were small, ranging from 6 to 16 men. Actors and football players had significantly higher T than ministers. Two subsequent studies, also with small sample sizes, confirmed that actors or entertainers had higher T than ministers. Several

years later, Dabbs, Alford, and Fielden (1998) compared salivary T levels of lawyers, other professionals, and blue collar workers under the age of 50. Blue-collar workers (N = 2195) had significantly higher T than non-lawyer professionals (N = 928). There was no significant difference in T between these professionals and lawyers (N = 28). Blue-collar workers had non-statistically significant higher T than lawyers. In a subsequent study, male trial lawyers (N = 35) were found to have significantly higher T than male non-trial lawyers (N = 31), and female trial lawyers (N = 13) were found to have significantly higher T than female non-trial lawyers (N = 18). Dabbs argued that these T differences represent traits, and not states, because circumstantial changes in T tend to be temporary. Dabbs also concluded that T has similar behavioral effects in men and women. The studies on the link between T and occupational status reveal that, at a very broad level, there is some merit to the argument that baseline levels of T influence one's occupation, and thus one's status. However, it seems contradictory that blue-collar workers have higher T than white-collar workers, if T has a positive correlation with status. Perhaps T has a positive relationship with status in short-term scenarios, as shown by the graduating medical students (Mazur & Lamb, 1980), or the nonhuman primate studies described earlier in this section. In the long-term, however, at least in modern societies, T may predict a behavioral repertoire that motivates individuals to pursue blue-collar jobs. Conceivably, the evolved T-status link selected for a combination of physical and mental characteristics, whereas today's white-collar environment is almost entirely focused on mental variables. This line of reasoning makes feasible an inverse relationship between T and occupational status.

In recent years, several experimental studies examining the relationship between T and dominance/status, usually within a competitive context, have also been conducted. This highlights the link between dominance and competitions, and the relevance of T-dominance links to competitive situations. Schultheiss, Campbell, and McClelland (1999) measured the effect of one's power motive (the desire to have an impact on others) on salivary T responses to winning or losing a competition. The study included 42 males, with an average age of 20 years, who were randomly assigned to win or lose a pen and paper visuospatial number tracking competition. Power motive was assessed by the short stories that the participants were asked to construct about various pictures they were shown. Participants could score high or low on none, one, or both Socialized Power (which measures altruistic-type behavior) and Personalized Power (which measures a desire for dominance over others). T was measured three times: near the beginning of the study for a baseline measure (T1), after imagining winning a contest (T2), and after the visuospatial competition (T3). Personalized power approached a significant correlation with baseline. At both T2 and T3, only those scoring high in Personalized Power and not high in Socialized Power had significantly higher T than the others. The results suggest that T reactivity to a competition has a stronger link with a desire for dominance than basal T's link with a desire for dominance.

Schultheiss et al. (2005) tested the relationship between salivary T and implicit power motive (the unconscious desire to have an impact on others) in a face-to-face competition. Ninety-five men, with an average age of 20 years, were unknowingly randomly assigned to win or lose a competition that involved a pen and paper visuospatial number tracking task. Again, power motive was assessed by the short stories that the participants provided

about various pictures they were shown. There was a significant negative correlation between T change and power motivation among losers, and a non-significant positive correlation among winners. Contrary to Schultheiss et al.'s (1999) findings, the outcome of a competition does play a role in the relationship between T and dominance. But consistent with their earlier study, T responses, rather basal T, appear to be relevant to dominance.

Josephs, Newman, Brown, and Beer (2003) measured the relationship among status, salivary T, and performance on a math task that was administered under one of two different sets of instructions. One set of instructions described how the test identifies those who are exceptional in math (exceptional ability math test), and one set of instructions described how the test identifies those who are weak in math (weak ability math test). The study involved 51 male introductory psychology students. High T males outperformed low T males on the math task that offered the opportunity to enhance one's status (exceptional ability math test), but not on the math task that did not offer such an opportunity (weak ability math test). High T males also performed significantly better on the exceptional ability math test than on the weak ability math test. Thus, higher T may facilitate maintaining or increasing status.

Newman, Sellers, Guinn, and Josephs (2005) examined an interaction effect between salivary T and social status on performance on a mental rotation and verbal fluency task in 36 males and 52 females. Participants were randomly assigned to one of three conditions: a high status position (leader), a low status position (follower), or neither, which served as a control. Leaders and followers were deceived into believing that the assignment to a position was based on a pretest, and not random assignment. When the

high T participants were in the low status position, they performed significantly worse than the participants with low T on both tasks. Also, participants with high T performed significantly better in the high status condition than in the low status condition, for both tasks. The control condition showed no difference in performance between low and high T, for either task. The authors suggested that the reason for better performance in participants with high T when they were in the high status position is that their high status needs were satisfied, and so negative arousal and cognition did not impair performance. Conversely, high T participants in the low status position had negative arousal and cognition that hindered performance.

Mehta, Jones, and Josephs (2008) examined the relationship between basal levels of salivary T taken before a competition and cortisol changes that occurred in response to the competition. The authors were interested in how differences in the relationship between baseline levels of T and changes in cortisol may predict dominance. The competition involved handling a dog in an agility contest, and included 83 men, 43 winners and 40 losers, all of whom were 20 to 65 years of age. High T winners experienced a drop in cortisol, and low T winners experienced a significant increase in cortisol. Also, low T winners and losers showed no difference in cortisol responses: both showing a non-significant decrease in cortisol. The authors concluded that high T men who lost had experienced a rise in cortisol because of the stress associated with failing to rise in status, and the high T men who won had experienced a drop in cortisol because they succeeded in increasing their status and thus lowering their stress.

Maner, Miller, Schmidt, and Eckel (2008) examined the relationship between salivary T, social anxiety, and dominance in 23 men and 35 women with a mean age of 19 years.

Participants competed in a pen and paper visuospatial number tracking task competition, and unbeknownst to them, were randomly assigned to win or lose. There were no significant changes in T in the female winners or losers, whether they were low or high in social anxiety. The male winners also did not show a significant change in T, nor did the male losers who were low in social anxiety. But the male losers who were high in social anxiety experienced a significant drop in T. The authors speculate that it is these individuals' concern about their status or place within a dominance hierarchy that is linked with a drop in T associated with losing the competition. It seems that dominance does indeed have a weak to moderate link with T, and that the link is emphasized in competitive contexts. However, conclusions that are drawn to explain some the effects obtained in the preceding studies are arguable at this stage.

One study has examined the T-dominance link within a context that was not competitive, but rather involved a man interacting with a woman. van der Meij, Buunk, van de Sande, and Salvador (2008) investigated the effect of a five minute casual conversational interaction with a young woman in her twenties on a man's salivary T responses. Fifty-nine male participants, 18 to 27 years of age, were split into two groups: some interacted with a woman, others interacted with a man. Those who interacted with a woman experienced a significant rise in T, but those who interacted with a man did not. Self-reported aggressive dominance was marginally, but not significantly, related to a T increase when the participant interacted with a woman. Self-reported social dominance did not show a significant relation with T changes. Those with higher than average aggressive dominance (among the sample of participants) had higher baseline T than

those with lower than average aggressive dominance. Social dominance was not linked with baseline levels of T.

Conclusions on the Relationship between Testosterone, Dominance, and Status

The research on the T-dominance/status link is subject to a number of limitations, many of them similar to those that pertain to the T-aggression research. Self-report measures of dominance, are subject to inaccurate self-perception, social desirability bias, and deception. Dominance is often not exclusively an overt process of imposing one's will over another, but frequently plays out in subtle ways, which makes dominance challenging to capture via self-report. Another limitation is related to the type of T measurement obtained. For example, Christiansen and Knussmann (1987) found a link between total T and self-reported dominance, but not between free T (as measured by salivary T) and self-reported dominance. To further complicate matters, Higley et al. (1996) found that plasma T and CSF free T are significantly correlated with one another. However, cerebrospinal fluid T may have a different relationship with dominance than salivary T. Finally, one study reviewed in this review (Neave et al., 2003) distinguished between organizational and activational effects of T on dominance. More studies are needed to disentangle the measurement contingent effects of T. Despite these limitations, it appears there is a small but significant correlation between T and dominance/status. This seems to be especially true when dominance and status are being actively established among individuals, such as in competitive contexts.

How may dominance and status be related to reproductive efforts? It is not difficult to imagine how a dominant man would enjoy reproductive advantages over a subordinate one. In addition, women tend to find dominant-looking men more attractive than non-

dominant-looking men (Townsend & Roberts, 1993). Conceivably, dominance/status, and part of its hormonal underpinning, T, are geared to play a larger role in men's mating behaviors than in their parenting ones.

To conclude, the behavioral domains of competition, aggression, and dominance/status may be related to one another in that they all can be envisioned as facilitating mating efforts, and all are linked with T. Competitions can be likened to stages in which dominance and status are established among a group of individuals. Winners of these competitions have higher status than the losers. Winning can be perhaps facilitated by some measure of aggression. Indeed, aggressive dominance may have more relevance in mating contexts than other types of dominance, such as social dominance, as described earlier with van der Meij et al. (2008) where a rise in male T from an interaction with a woman was linked more with aggressive dominance than with social dominance. Moreover, Mazur and Booth (1998) argue that aggression may be a poorer predictor of T than is dominance, unless aggression is used as a means to assert dominance. It becomes evident that competition, aggression, and dominance/status are domains that overlap, and the common denominator among them may be that they are all involved in reproductive fitness. This is especially true for men who, during the ancestral past, increased fitness by mating with as many women as possible. When all men share that goal, competition ensues.

Testosterone, Pair-bonding, and Fatherhood

The previous sections presented part of a growing body of evidence indicating that men's T facilitates mating. If this is indeed the case, then researchers might expect single,

romantically unattached men to have higher T than those in committed, romantic relationships, assuming most of the former as seeking to be paired. Furthermore, researchers might expect fathers to have lower T than non-fathers, if high T is at odds with the physiological underpinning and behavioral imperatives of paternal investment.

The findings of several studies have suggested that pair-bonding may be linked with lower T. Perhaps the most convincing evidence comes from Booth and Dabbs (1993) who examined the relationship between serum T and marriage/divorce in a very large sample of U.S. army veterans, about half of whom served in the Vietnam War. Data was collected from interviews that took place in 1985-1986. Participants' demographic information was comparable to the U.S. census data on men 30 to 44 years of age. There was a response rate of approximately 60% from 4462 veterans. The authors found that high T men had a significantly higher probability of not getting married than low T men. Also, high T men had a significantly higher chance of getting divorced compared to low T men.

In a similar vein, Mazur and Michalek (1998) investigated the relationship between blood T and marriage and divorce from data on 1881 men who served in the Air Force during the Vietnam War. Participants provided blood samples and data in 1982, 1985, 1987, and 1992. In 1982, the ages ranged from 32 to 68 years. Men who were married from 1982 to 1992 (N = 1336) had significantly lower T than the divorced/never married group (N = 139). Furthermore, T was higher for divorced men around the time of divorce, which the authors argued was likely attributable to divorce-related competitive effects such as couples fighting with one another, struggling to gain custody of children, and re-entering the dating arena.

Given these results, one may predict that high T men are less likely to have high marital quality. This is not necessarily the case. Rather, marital quality is the product of several variables, just one of which is the interaction of T with factors such as "role overload." Booth, Johnson, and Granger (2005) define role overload as "the perception of being overwhelmed by multiple commitments and not having enough time to meet them." These authors measured the relationship between T and marital quality, and whether role overload moderated this relationship in 307 couples. The average age was 40 years for the wives and 42 for the husbands. T was not directly correlated with marital quality for either wives or husbands. For the men, high T was linked with low marital quality when role overload was high, but high T was linked with high marital quality when role overload was low. The authors explained this effect by suggesting that when role overload is high, high T primes negative emotions and perceptions which facilitate negative behavior in the marriage, such as infidelity and substance abuse. Conversely, when role overload is low, high T primes positive emotions and perception which facilitate positive behavior in the marriage, such as being more attentive to the wife. There was no interaction effect for T and role overload in women. This may suggest a different T-behavior relationship for women, at least regarding marriage, and possibly within the broader domain of reproduction.

Differences in men's T have been found not only within the domain of marital status, but also within the more general domain of relationship status. This is shown by Gray et al. (2004) who examined the link between salivary T and relationship status in 107 men, 17 to 26 years of age. The participants were divided into four groups based on their romantic relationship status and time of T collection: unpaired men who provided a

morning sample of saliva (N = 50), paired men who provided a morning sample of saliva (N = 24), unpaired men who provided an evening sample of saliva (N = 21), and paired men who provided an evening sample of saliva (N = 14). Only the paired men who provided an evening sample showed significantly different (lower) T than the other three groups. The authors suggested that morning T may reflect effects of circadian rhythm, and that evening T may reflect effects of social stimuli relevant to relationship status. Moreover, among the unpaired men, those without prior committed, romantic relationship experience (N = 22) had significantly lower T than those with relationship experience (N = 47). The authors suggested that this result may be indicative of lower T individuals' lower success at, or interest in, pursuing a committed, romantic relationship. Further support is provided by Maestripieri, Baran, Sapienza, and Zingales (2010) who examined salivary T responses to psychological stress in over 500 males and females, 24 to 38 years of age. The authors found that single men had significantly higher T than paired men (i.e. those who were married or were in a stable romantic relationship).

Not all studies obtained results consistent with the latter two studies. For example, Sakaguchi, Oki, Honma, and Hasegawa (2006) investigated the relationship between salivary T and relationship status in 87 men who were University of Tokyo students. The mean age for the single men was 22 years and the mean age for the paired men was 23 years. Only two of the men were married. The impetus behind the study was the notion that T is the physiological underpinning of men's competitive effort in scientific and creative productivity, where T and competitive effort increase with adolescence and decrease with age throughout the remainder of the lifespan. Like Gray et al. (2004), the authors suggested that diurnal patterns should be linked with daily behavioral patterns.

However, there was no statistically significant difference between the two groups in morning, evening, or diurnal change of morning-evening T levels. If we combine the results of the latter three studies, it appears that the difference in T between single men and paired men is small.

To further complicate matters, there are moderating variables, such as extrapair sexual interest, that may influence the relationship between T and relationship status, as shown by McIntyre et al. (2006). In Study 1, 102 men, 17 to 26 years of age provided a saliva sample, demographic information, and completed the Sociosexual Orientation Inventory (SOI; Simpson and Gangestad, 1991). A low score on the SOI represents a restricted sociosexual orientation whereby the individual is uncomfortable with sex outside of a committed relationship; a high score indicates an unrestricted sociosexual orientation, whereby sex outside of a committed relationship does not produce discomfort. The study included 65 unpaired men and 37 paired men. There were no main effects for relationship status or SOI. However, in paired men, high SOI scores were linked with higher T, but the relationship was only marginally significant. When relationship length was factored in, the relationship was significant such that longer relationship length was associated with lower T. In Study 2, 69 men, 17 to 33 years of age, underwent a similar procedure, but also answered two additional questions about extrapair sexual interest. Single men (N = 43) had significantly higher T than paired men (N = 26). In paired men, but not single men, extrapair sexual interest predicted T. The authors suggested that the unpaired men's answers to extrapair interests may carry less weight because they did not have a partner that they could/would cheat on. Across the two studies, the results give a

more refined illustration of the link between T and relationship status by demonstrating that other variables may influence this link.

One such variable may be commitment. van Anders and Siciliano (2010) examined salivary T-pair-bonding links in 120 men with a mean age of 23 years, and 115 women with a mean age of 22 years. Single men and men in a casual romantic relationship each had significantly higher T than men in a committed, long term relationship, but there was no significant difference in T between single men and men in a casual relationship. Hence, differences in T may be a function of commitment to a relationship, rather than just relationship status.

If T does indeed facilitate mating more than parenting, then researchers may expect lower T level in fathers versus non-fathers. Several studies support this hypothesis at a broad level. Gray, Kahlenberg, Barrett, Lipson, and Ellison (2002) measured the relationship between salivary T (morning and evening T levels) and marital/parental status in 58 men, 20 to 41 years of age. Most were graduate or professional students at Harvard University. Participants were divided into 3 groups: married with children (N = 15), married with no children (N = 14), and not married (N = 29). Married men without children had significantly lower T than unmarried men, but only with regard to evening T levels. Fathers had significantly lower T than unmarried men, but again only with evening T. Also, fathers did not have significantly lower T than married men with no children. The authors supported the general consensus among researchers in this line of inquiry that the lower T of the married men is associated with less mating effort, and that this may facilitate paternal investment.

In another study by some of the aforementioned authors, Burnham et al. (2005) investigated the relationship between salivary T and relationship status in 122 Harvard Business School graduate students, all in their late twenties. The participants were divided into 4 groups: married with children (N = 9), married without children (N = 34), in a committed, romantic relationship or "paired" (N = 38), and unpaired (N = 41). Paired men had significantly lower T than unpaired men. As well, the average T of married men was very similar to that of paired men. The two groups of married men combined with the group of paired men had an average T level of 21% lower than the unpaired men. Finally, the T of fathers, all of whom were married, was 42% lower than that of unpaired men.

Gray, Yang, and Pope Jr. (2006) examined the relationship between salivary T (morning and afternoon samples) and relationship status in 126 men, 21 to 38 years of age. Participants were divided into groups: unmarried (N = 66), married non-fathers (N = 30), and married fathers (N = 30). Unmarried men had non-significantly higher T than married non-fathers. The fathers had significantly lower morning and afternoon T than the other two groups. The authors concluded that fathers' lower T reflects lower mating effort and greater paternal investment. Among the 66 unmarried men, 15 were in a committed relationship, and 51 were not. There was no difference in T between the two groups, which is consistent with the findings of Sakaguchi et al. (2006). This suggests that T differences between unmarried paired men and unmarried unpaired men may be small.

In an attempt to catch parenting in action, Gray et al. (2007) investigated the hormone levels and responses of Jamaican fathers after a 20 minute interaction with their partner

and youngest child. The experiment involved three groups: fathers who lived with their partner and youngest child, fathers who lived apart from their partner and youngest child, and single men. The latter did not engage in a behavioral interaction. Visiting fathers had significantly lower T than single men, and co-residential and visiting fathers collapsed into one group had significantly lower T than single men. There were no significant T responses to the behavioral interaction.

Kuzawa, Gettler, Muller, McDade, and Feranil (2009) examined morning T (via saliva and plasma samples), and evening T (via saliva samples) in 890 men, 20.5 to 22.5 years of age, in the Philippines. Among the non-fathers, there was no difference in T between the single men and the paired men (i.e. married or living with a partner). However, T was significantly lower in fathers than non-fathers, suggesting that parental status may have a larger impact on baseline T than relationship status.

Once again, not all studies point to a clear difference in T based on marital/parental status. Gray (2003) investigated the relationship between salivary T and marital/parental status in 97 Kenyan Swahili men, 29 to 52 years of age. Participants were divided into 3 groups: 17 single men, 57 monogamously married men, and 14 polygynously married men who each had two wives. In contrast to the author's hypothesis, polygynously married men had significantly higher morning and evening levels of T. Gray explains that 11 out of 17 of these men were divorced, and 8 were fathers, and that these factors may account for the unexpected findings. He also suggested that higher rates of mate guarding, sexual activity, and a different "developmental path" for polygynously married men may be the cause of their higher T. With regard to developmental path, Gray suggested that perhaps less stress at the time of puberty may set a higher "setpoint" or baseline level of

T, and that this setpoint may be related to being more attractive to women. In addition, higher T may be linked with a physiology that is better enabled to accumulate resources which facilitates the marriage of more than one wife.

Three studies have investigated the relationship between men's T to the birth of their child, or other infant stimuli. Storey, Walsh, Quinton, and Wynne-Edwards (2000) examined the relationship between blood T and stage of fatherhood: 25-40 year old new dads and soon-to-be-new-dads. Thirty-one couples provided a blood sample at one of four times before or after birth. In addition, more frequent blood sampling was obtained from three other couples before and after birth. Among the four groups of early prenatal, late prenatal, early postnatal, and late postnatal groups, the 8 men in the late prenatal group had significantly higher T than the 9 men in the early postnatal group. This points to a drop in a man's T that comes with the birth of his child, possibly enhancing paternal childcare.

Also in this study, participants were asked to hold a doll on their shoulder (or to hold their newborn child if they had one), to watch a 5 minute recording of baby cries, and a 6 minute video of a baby trying to breastfeed. All groups except the early postnatal group experienced a decrease in T. The early postnatal group experienced a significant rise in T. It may be perplexing why this particular group showed an increase. The authors speculated that this increase in T may be a "challenge response" in the fathers where physiological resources are engaged to protect the new baby. Overall, however, the authors suggested that a decrease in T is associated with the provisioning of paternal care. They argued that hormonal responsiveness is more important than baseline hormone levels in impacting paternal behavior.

Berg and Wynne-Edwards (2001) examined changes in salivary T in 23 men from several months before to 3 months after the birth of their child. These data were compared to non-fathers who served as controls. Half of the control participants were in a committed, romantic relationship. All participants were 22 to 46 years of age. Dads had significantly lower T than controls, but only for evening samples and not morning samples. These time-of-day effects were the same as in two other studies mentioned earlier (Gray et al., 2002; Gray et al., 2004), and suggests that a relationship between T and marital/parental status is more pronounced in the later part of the day. Also, a subgroup of 13 dads, who provided frequent salivary samples, was found to have low T immediately following the birth of their child. This is consistent with Storey et al. (2000) who found lower T in men shortly after birth versus before birth.

Fleming, Corter, Stallings, and Steiner (2002) compared T and emotional responses to infant cries in 20-50 year old fathers and non-fathers. Fathers were found to have lower T than non-fathers. Also, fathers and non-fathers with lower T experienced greater sympathy to the infant cries, as measured by self-report. Thus, lower T may enhance paternal investment by increasing responsiveness to infant needs.

Conclusions on Testosterone, Pair-bonding, and Fatherhood

In conclusion, it seems that paired men have lower T than unpaired men. Two reviews that addressed the hormonal correlates of human pair-bonding have also drawn this conclusion (van Anders & Watson, 2006; van Anders & Gray, 2007). Furthermore, husbands who are fathers tend to have lower T than husbands who are not fathers. These links are not unlike those found in mammals in general despite inter-species differences in the role of T in paternal behavior (Wynne-Edwards, 2001).

For obvious reasons, men cannot be randomly assigned to different marital/parental conditions and have their T measured. As such, it is difficult to ascertain if the lower baseline T that is associated with pair-bonding or fatherhood is a "state" or "trait" phenomenon, as described by van Anders and Gray (2007). If lower T is a state, then marriage would lower T. If lower T is a trait, then men with lower T would be more likely to get married. So what is the answer? The low T-pair-bonding/fatherhood link is probably both a trait and a state, but especially the latter. For example, as noted earlier, Mazur and Michalek (1998) found evidence for a reciprocal model of T as men's T appears to be highest around the time of divorce.

But fatherhood is different from simply producing offspring. Fatherhood implies paternal investment, which is not something that all "fathers" engage in. Recall from McIntyre et al. (2006) that high T men showed a marginally significant relationship with extrapair sexual interest. In light of this, are high T men more likely to have children than low T men, when relationship status is not taken into account? Questions such as these might be partially elucidated by turning to the more proximal role of T in reproduction. That is, the relationship between T and sexual function, to which we now turn.

Testosterone and Men's Sexual Behavior

Testosterone and Sexual Function

For the purposes of this review, men's sexual function can be characterized as having three major components: sexual desire, sexual arousal as evidenced by erectile function, and ejaculation. Sexual desire is the motivation to engage in sexual activity, and has a number of synonyms such as sexual drive, sexual interest, sexual appetite, sexual

motivation, and libido. Erectile function is the ability to develop and maintain an erection sufficient for vaginal or anal penetration and is generally considered the main indicator of physiological sexual arousal in men. Ejaculation is the process of climaxing or having an orgasm, and has been studied in terms of intensity, ejaculate volume and spurt strength.

Although the association between the testis and sexual function has been recognized for thousands of years as shown by the castration of men and animals, T itself was not isolated as a separate hormone until the 1930s. Since that time, animal research has clearly established that T influences sexual behavior and is necessary for male reproduction (Nelson, 2005). On the other hand, human research is limited insofar as the design of experiments to specifically ascertain the role that T plays in male sexual function. Hence, the specific role of T in sexual desire, erectile function, and ejaculation remains an active area of research.

Correlational Research on Testosterone and Sexual Function

Two correlational studies involving healthy men have supported the contention that T is associated with men's sexual function. Knussmann, Christiansen, and Couwenbergs (1986) conducted a study on the relationship between hormones and sexual activity, where they obtained serum for a measure of total T, and saliva for a measure of free T in 33 men, 19 to 31 years of age. Samples were taken in the mornings, 48 hours apart on Monday, Wednesday, and Friday on two consecutive weeks. Participants kept a daily record of how much sexual stimulation they received by fantasizing, viewing pornography, seeing attractive individuals etc., sexual activities leading and not leading to orgasm, and amount of sexual arousal. The authors found a significant correlation between total T and frequency of orgasms. Also, there was a closer link between T and

frequency of orgasms between individuals than within individuals. This may lead to the conclusion that at the population level, but not the individual level, T is correlated with sexual function and possibly desire. In another correlational study, Nilsson, Moller, and Solstad (1995) examined the relationship between psychosocial stress and gonadal function in a group of 439 men, all of whom were 51 years of age. The authors found that low serum free T had a significant correlation with low sexual interest. These two studies point to the notion that T is linked with sexual function and desire in young men as well as in middle-aged men, and that these relationships may hold true for both free and total T.

However, among the population of healthy men, there appears to be more evidence that disconfirms the T-sexual desire/function link.. Monti, Brown, and Corriveau (1977) examined the relationship between serum T and sexual behavior in 101 healthy men, 20 to 30 years of age. Participants recorded sexual interest and frequency of sexual behavior in terms of orgasm, sexual intercourse, and masturbation. T was shown to be in the eugonadal (normal) range, and did not correlate with sexual interest. Persky, Lief, Strauss, Miller, and O'Brien (1978) obtained results that were consistent with Monti et al. (1977) when they conducted a study on the relationship between plasma T and sexual activity in 11 couples 21 to 31 years of age. T did not have a correlation with intercourse frequency. Additional null results were found by Brown, Monti, and Corriveau (1978) who measured the relationship between serum T and sexual desire and behavior in 101 men, 20 to 30 years of age. Participants were healthy and had normal levels of T. The authors found no correlation between T and sexual desire, sexual intercourse, or masturbation. Another confirmation is provided by Mantzoros, Georgiadis, and Trichopoulos (1995)

who tested the relationship between sex steroids and frequency of orgasms in 92 healthy men, 18 to 22 years of age. Serum T did not predict orgasm frequency. These types of results appear to indicate that T may not be needed for sexual functioning. However, the study of older and clinical populations reveals a different story.

Studies with the elderly and men with abnormally low T (hypogonadal), erectile dysfunction (ED), and low sexual desire (hypoactive sexual desire disorder) have provided evidence that T is indeed necessary for sexual function, and most pointedly, sexual desire. For instance, Raboch and Starka (1972) compared frequency of sexual intercourse and plasma T in 61 healthy men and in 50 sterile men, 21 to 40 years of age. The sterile men had significantly lower T than the normal men. In the 21-to-30-year age group, the normal T men engaged in significantly more sexual intercourse than the sterile men. In the 31-to-40-year age group, there was no significant difference between the two groups in frequency of sexual intercourse. The authors concluded that a certain minimum level of T (approximately 3ng/ml) is necessary for typical frequencies of sexual intercourse to occur, and that beyond this level there is no link with frequency of sexual intercourse. Further support was added by Travison, Morley, Araujo, O'Donnell, and McKinlay (2006) who used a much larger but older sample of men (40 to 70 years of age). Free T, which was calculated from serum total T, and total T both correlated significantly with sexual desire at the population level. At the individual level, however, low sexual desire was a poor predictor of T level. Yet more support was provided by a study that addressed not only sexual desire, but also erectile function (Schiavi, Schreiner-Engel, White, and Mandeli, 1988). These authors examined T and nocturnal penile tumescence (NPT) in 17 men with hypoactive sexual disorder (HSD) and 17 healthy non-

dysfunctional men, ranging in age from 27 to 55 years. The HSD men had lower total T than the control group. There was also a correlation between T and sexual behavior (intercourse attempts and masturbation) within the HSD men. In addition, the HSD men with ED had lower NPT values than the control group. The findings were mixed. Although a link between T and sexual desire/activity was found, the authors concluded that men with HSD may be a heterogeneous group in which some with HSD and low T had normal NPT while others with normal T had impaired NPT. Finally, in a study that also examined erectile function, but not sexual desire, Carani, Bancroft, Granata, Del Rio, and Marrama (1992) added more support for the T-sexual function link. These authors compared eugonadal men to hypogonadal men aged 21 to 64 years in terms of NPT and erectile response to a 15-minute erotic film. The eugonadal men had greater tumescence and rigidity in erections during sleep than the hypogonadal men, but there was no difference between the two groups in terms of tumescence and rigidity in erections to the erotic stimuli. The authors concluded that nocturnal erections depend on serum T, but erections to erotic stimuli do not. The authors also noted that T is necessary for seminal production, and thus ejaculation.

It thus appears that the T-sexual function link is more evident in special populations than in young, healthy men. However, there are also several studies with special populations that found little support for the T-sexual function link. Schwartz, Kolodny, and Masters (1980) compared plasma T levels in 341 sexually dysfunctional men with 199 healthy men aged 20 to 81 years, all of whom went through an intensive sex therapy program. It is unclear why the healthy men underwent the therapy program. Sexual dysfunction included ejaculatory incompetence, ED, and premature ejaculation. The

authors found no difference between the two groups' T, but made noteworthy points: (1) When comparing healthy men to sexually dysfunctional men it is important to consider the confound of stress and abstinence differences which may produce different levels of T. (2) Some men with low T exhibit sexually-typical behavior. Another example is given by Sadowsky, Antonosky, Sobel, and Moez (1993) who examined the relationship between blood T and sexual intercourse in 60 men, 65 to 80 years of age. Among these men, 11 were hypogonadal. No significant relationship between T and sexual intercourse was found. A third example is given by Ansong and Punwaney (1999) who measured free and total T from serum in 108 men, 33 to 79 years of age. All of the men had ED. Among these men, 15 had high sexual desire, 38 had medium sexual desire, and 55 had low sexual desire. Sexual desire and function (including erection and ejaculation) scores were significantly different among these desire groups, but T levels were not. In sum, correlational studies have provided modest support for the necessity of T for sexual function.

Experimental Research on Testosterone and Sexual Function

Using T as an independent variable in research on hormones and behavior has been mostly conducted on animals, for obvious ethical and practical reasons. The importance of the experimental nature of such research, however, is twofold: it adds validity to the notion that T is needed for sexual function, and adds support for the direction of causality from T to sexual behavior. Among the few studies using T administration in humans, only a handful have used healthy men who were free of hormonal or sexual abnormalities as participants. For instance, Carani, Scuteri, Marrama, and Bancroft (1990) tested the effect of T administration and erotic stimuli on NPT in 8 healthy men, 20 to 28 years of

age. In one part of the study, 4 participants were given 150mg of T enanthate or placebo, and two nights later NPT was recorded. A month later the conditions were reversed for participants. T administration significantly increased rigidity but not frequency or tumescence of NPT. Anderson, Bancroft, and Wu (1992) investigated the effect of T administration on sexual behavior in 31 men, 21 to 41 years of age. Participants had normal levels of T, and were split into two groups: one group received 200mg of T undecanote (TU) weekly for eight weeks, and the other group received a placebo for four weeks followed by four weekly doses of 200mg of TU. Blood samples collected after each four week period indicated that T did in fact increase substantially from administration. Both groups (except during the placebo portion of the second group) experienced a significant increase in sexual desire. However, there was no increase in masturbation, sexual intercourse, or morning erections. Hence there is evidence, albeit limited, that T administration facilitates sexual desire and some aspects of erectile function in healthy men.

One study that weakened the notion that administering T to normal men increases sexual function was provided by Bagatell, Heiman, Matsumoto, Rivier, and Bremner (1992). Of the 19 healthy men, 19 to 42 years of age, in their study, 10 participated in the experimental condition, and 9 in the placebo condition. T administration involved weekly doses of 200mg T enanthate for 20 weeks. Serum sampling showed that T did in fact increase significantly with administration. However, no significant increases in sexual desire or behavior (masturbation, sexual intercourse, fondling, kissing, spontaneous erections, or arousal) were observed. Another study that weakened the belief that administering T to healthy men increases sexual function was provided by Buena et al.

(1993). These authors suppressed endogenous T production, and then administered 2 different T levels to 11 men, 18 to 49 years of age. All participants were given a gonadotropin-releasing hormone agonist to lower T into the hypogonadal range, an effect shown to last for 35 to 40 days. Participants were then divided into two groups: one group received a T microcapsule formulation that released 4mg of T per day, and the other group received a formulation that released 8mg per day. These two dosages represent low and high levels, respectively, but within the normal range for men. The authors noted that such formulations were previously shown to increase T for 10-11 weeks. There was no significant difference between the groups in sexual desire, sexual activity, or NPT. A growing body of evidence seems to suggest that T variations within the normal range in healthy men do not have differential impacts on sexual function.

But what about the effect of T administration on sexual function in special populations? Some research seems to confirm the beneficial effects of T on sexual function in men with ED. O'Carroll and Bancroft (1984) examined the effect of administering Sustanon (which includes 100mg of TU) on sexual desire and ED in 20 men, 19 to 64 years of age. One group involved 10 men with low sexual desire and another group involved 10 men with ED. T was administered for 6 weeks, as was placebo for 6 weeks in a double-blind, cross-over method. The first group experienced a significant rise in sexual desire, but the second group did not. Also, neither group experienced a change in erectile function. The authors concluded that T affects sexual desire and ejaculation, but not erections. Carani et al. (1990) added support to the idea that T facilitates sexual desire, but unlike O'Carroll and Bancroft (1984), Carani et al. found a positive effect for erectile function. The authors examined the effect of T

administration on ED among 14 men with a mean age of 37 years who had mildly low levels of serum free T. The control group consisted of 57 men with a mean age of 38 years, 18 of whom provided sexual behavior data. Among the experimental group, half were given 80mg of TU twice a day for 6 weeks, followed by a placebo for 6 weeks. The conditions were reversed for the other half of the participants. T was measured at the end of each 6-week period. Sexual desire, sexual intercourse, masturbation, and frequency of morning erections improved significantly in the low free T group who were administered T, but not in the normal free T group. The authors concluded that there may be a threshold level for when T administration improves sexual function, and that free T may be a better predictor of ED than total T. Further support, albeit modest, was provided by Morales, Johnston, Heaton, and Lundie (1997) who examined the effect of 120mg/day of TU administration for at least two months on hypogonadal men with ED. Participants included 23 hypogonadal men, 30 to 72 years of age. An improvement in sexual desire and vaginal penetration was seen in 61% of them. In contrast, Schiavi, White, Mandeli, and Levine (1997) obtained no support for T administration's positive effect on ED. These authors conducted a study involving 12 eugonadal men, 45 to 74 years of age with ED who were given biweekly administration of 200mg of T enanthate for 6 weeks. Ejaculatory frequency was higher during T administration, but other variables were not: frequency of sexual desire, masturbation, NPT, sexual activities with partner, penile rigidity, and sexual satisfaction. Null or marginal findings were also provided by Benkert, Witt, Adam, and Leitz (1979) who investigated T administration on erectile function in 29 men, 45 to 75 years of age, all of whom had ED. Among these men, 13 were given daily doses of 120mg of TU for 8 weeks, and the others were given a placebo. After 8

weeks, all men were given a placebo for 2 weeks. Several participants from both groups reported an increase in erectile function, but there was no significant difference between the two groups. Among the components of sexual function, erectile function seems to respond the least to T administration. That is not to say that T is not necessary for erectile function, but that perhaps erectile function is subject to more variation in terms of a T threshold level, reactivity to T, and psychological factors.

In addition to men with ED, hypogonadal men in general could be considered a special population in this area of research. The following studies provided broad support for increases in both sexual desire and erectile function in hypogonadal men receiving T administration. Davidson, Camargo, and Smith (1979) examined the effect of administering T enanthate (100mg, 400mg, and placebo) once per four week period for five months. The study included six hypogonadal men, 32 to 65 years of age. All participants received each of the three treatments which were randomly varied over the five months. Blood was sampled every week or two for determination of T level. Overall there was a significant increase in frequency of erections and sexual intercourse, when the 400mg dose was compared to placebo. However this effect was not found for masturbation or orgasms. Luisi and Franchi (1980) administered 120mg/day of TU to 12 hypogonadal men, 21 to 41 years of age. Participants experienced a significant increase in sexual desire, erections, and ejaculations when compared to 14 men who received 150mg/day of mesterolone (the most widely used androgen at the time). Skakkebaek, Bancroft, Davidson, and Warner (1981) tested the effect of T administration in 12 hypogonadal men, 22 to 50 years of age. The methods included a cross-over design: 2 months of daily 160mg of TU administration and 2 months of placebo. Overall, there was

a significant improvement in sexual desire and behavior (sexual intercourse, masturbation, and ejaculations per week) from the T administration. Salmimies, Kockott, Pirke, Vogt, and Schill (1982) found similar results. Their study involved biweekly administrations of increasing levels (from 25-250mg) of T enanthate - each dose for 4 weeks to 15 hypogondal men, 18 to 53 years of age. One treatment period included a placebo injection. All participants with plasma T below 2ng/mL of blood showed an improvement in sexual desire and frequency of erections and ejaculations. Four of those with pretreatment levels of 2-4.5 ng/mL reported relatively high frequency of erections that did not change with T treatment. Four others in the same pretreatment range did have reduced sexual behavior that was improved with T treatment. The authors suggested that the minimum level of T needed for normal sexual functioning varies among individual and lies between 2-4.5 ng/ml. One limitation with this study is that they did not control for a placebo effect.

Seftel, Mack, Secrest, and Smith (2004) gathered additional evidence of T administration's positive effect on sexual function in a study with a relatively large sample size of late-middle-aged men. The authors examined the effect of T administration on sexual function in 406 hypogonadal men whose average age was in the late 50s. Participants were randomly assigned to receive one of 50mg or 100mg of T gel, a T patch, or a placebo over a 90 day period. Those in the 100mg condition experienced a significantly higher increase from baseline in sexual desire and NPT when compared to the other three groups, and a significantly higher increase from baseline in sexual intercourse when compared to the T patch and placebo groups. These authors also

concluded that a threshold level of T must be reached for significant increases in sexual function to occur.

In sum, it appears that the positive effect of T administration on sexual function is much clearer from studies involving hypogonadal men, versus men with ED. It should be noted that some men with ED are hypogonadal, but not all men who are hypogonadal have ED. The percentage of men with ED who have low T ranges from 7% (Buvat & Lemaire, 1997) up to 35% (Isidori et al., 2005). The overall effects of T administration on sexual function are perhaps best portrayed by Isidori et al. (2005). These authors conducted a meta-analysis on T's effect on sexual function (nocturnal and daytime erections, sexual desire, frequency of intercourse, and general sexual satisfaction) in men. The review covered 17 studies that included a total 656 male participants, 19 to 75 years of age. Isidori et al. found that T administration provided a moderate increase in all of these variables in men with low or hypogondal levels of T.

Conclusions about Testosterone and Sexual Function

In conclusion, T is geared toward mating by promoting sexual desire, and playing a proximate role in facilitating semen production, erection, and ejaculation. Most of the studies discussed in this section addressed sexual desire, some addressed erectile function, and none directly addressed ejaculation, although some researchers posit that T is probably necessary for ejaculation (Carani et al, 1992; Bancroft, 1984). At the population level, there is a significant correlation between T and sexual desire. T, like sexual desire, increases in males at puberty and declines with old age. Moreover, men typically have higher sexual desire than women (Baumeister, Catanese, & Vohs, 2001; Regan & Atkins, 2006), as well as higher T. Given that T probably has similar effects on sexual desire in

both sexes (Regan, 1999), large samples of T could theoretically predict sexual desire within men, and between the sexes.

At the individual level, though, these relationships are less clear. One reason is that, as Regan (1999) points out, a minimum level of T is necessary but not sufficient for sexual desire to occur. This is because sexual desire is the product of several variables, where T is just one factor. Other factors include age, health, psychological factors, relational variables, social situation, and gender, as discussed by Levine (2003). As well, changes in T within the eugonadal range, which is often characterized as being between 300ng/dl to 1000ng/dl of blood for men, have little if any effect on sexual function. This can be seen in the studies described above in which a restorative increase in T to a threshold level is associated with a substantive increase in sexual desire in hypogonadal men only. Increases in T in healthy men seem to have marginal effects. A similar relationship may characterize erectile function.

The adaptive nature of sexual desire is obvious because it provides the motivation to engage in sexual intercourse which is necessary for reproduction. Men having more sexual desire than women is probably also adaptive, but in a less obvious way. During the ancestral past men presumably maximized their reproductive success by mating with as many women as possible, which is a process that is facilitated by sexual desire. Women maximized their reproductive success by choosing the best mate, and by engaging in high levels of maternal investment. Both of these processes may have been hindered by excessive sexual desire. Furthermore, women can typically only produce one child at a time, and thus the beneficial nature of sexual desire may have a ceiling effect for women. Indeed, excessive sexual desire may not just have a null effect on women's reproduction,

but may have a maladaptive effect if it leads to high sexual activity with various men, after which none are willing to invest in the offspring. Finally, sexual desire is necessary for men to reproduce because it is linked with physiological arousal necessary for penetrative sex. Technically, neither female sexual desire nor orgasm is required for reproduction. This evolved sex difference is perhaps part of the reason why at every age group men report more sexual desire and reach orgasm during sexual activity much more consistently than women (Laumann, Gagnon, Michael, & Michaels, 1994).

The aforementioned studies investigated the relationship between T and sexual function primarily by focusing on how T influences sexual function. The focus on this one direction is logical given that a similar direction of effect has been firmly established in the animal literature (Nelson, 2005). Yet researchers are aware that T and behavior have a reciprocal relationship (Beach, 1975; van Anders & Watson, 2006), and hence this raises questions about the effect of external events on T responses. For instance, how do sexual activity and mating stimuli affect T responses? Addressing such questions may help illuminate the relationship between T and sexual function, and might shed more light on the role of T in mating behavior.

The Effect of Sexual Activity and Mating Stimuli on Testosterone Responses

If men's T is geared to facilitate mating behavior, then researchers might expect sexual activity and mating stimuli to be associated with increases in men's T. For the purpose of this review, sexual activity refers to masturbation and sexual intercourse, and mating stimuli refers to erotic films and conversational interactions with a woman. Whereas sexual activity may involve sexual intercourse, mating stimuli may serve as a mental or physiological prime for sexual intercourse, both of which may be associated

with a rise in T. An analysis of the relationship between T and sexual activity and mating stimuli may provide insight into how this steroid ultimately promotes reproduction.

The Effect of Sexual Activity on Testosterone Responses

A number of studies conducted in the last few decades have supported the hypothesis that sexual activity causes increases in T. The first study of its kind was conducted by Fox, Ismail, Love, Kirkham, and Loraine (1972). One man, 38 years of age, collected blood samples over the course of several weeks, and then the samples were analyzed for plasma T. Blood samples were taken during sexual intercourse before orgasm, and less than five minutes after ejaculation. Blood samples were also collected in the absence of sexual intercourse to serve as controls. There was no significant difference between T samples taken during and after sexual intercourse. However, both of these sets of values were significantly higher than the participant's control values. In addition, the authors measured the effect of masturbation on T levels in 7 men, 20 to 38 years of age. Blood samples were taken five to ten minutes before masturbation, and less than five minutes after ejaculation. No significant difference was found in T levels between the two times. There may be a differential effect between sexual intercourse and masturbation on T responses but no study has systematically separated the effects.

Purvis, Landgren, Cekan, and Diczfalusy (1976) who measured T from blood and semen samples taken before and after masturbation in 34 men, 18 to 20 years of age. All samples were collected immediately before and after masturbation. Time between samples ranged from 9 to 40 minutes. A significant increase in T was found from pre- to post-samples. Two months later, 11 of these individuals participated in a control study. They were made to believe that they would masturbate during the experiment, but

actually no masturbation took place. Blood samples were taken before and after this period of expectation. This experimental condition was used to separate the possible effect of "expecting to masturbate" from actually masturbating on T responses. No significant change in T was observed. However, not all studies examining the effect of masturbation have found an increase in T. Evans and Distiller (1979) investigated the effect of administering luteinizing-hormone-releasing hormone versus placebo on sexual arousal in 6 men, 20 to 22 years of age. Participants took part in both conditions on different days, and were exposed to audiovisual erotic stimuli, and then they masturbated to orgasm. Five blood samples were obtained before, during, and after this process. Although the primary purpose of the study was not to test the effect of masturbation or erotic stimuli on T responses, the authors' results showed that no significant change in T was detected.

Most studies on the effect of sexual activity on men's T responses have examined orgasmic frequency, rather than the differentiating effects of masturbation and sexual intercourse. The first published study in this regard was by Kraemer et al. (1976) who investigated the relationship between orgasmic frequency and plasma T levels in 20 men, 20 to 28 years of age. The authors measured T every second day between 8:00am and 9:00am for a two month period. All participants had a regular sexual partner throughout the study. As well, participants kept a daily record of all sexual activity that led to orgasm. Within participants, T was higher during times of orgasmic activity. Between participants, T was higher for those with less orgasmic frequency. The authors predicted that these findings may be the result of a mechanism where low T stimulates sexual activity as a way of raising T. Thus, low T men may engage in more sexual activity, and high T men

are less stimulated to engage in sexual activity. This effect may be in contrast to what a researcher might predict: if T facilitates mating, then high T might be predicted to be linked with greater orgasmic frequency.

Kraemer et al.'s (1976) results were supported by three other studies. Knussmann et al. (1986), mentioned earlier, measured the relationship between serum T and sexual activity in 33 men 19 to 31 years of age. Six blood samples were taken over a two week period. Twenty-three of the men also provided salivary samples for free T analysis. Blood and salivary samples were obtained between 8am and 9am. The participants kept a log of sexual activities: degree of sexual stimulation (caused by fantasies and attractive individuals and so forth), arousal, masturbation, sexual intercourse, reaching orgasm, and the times of day that these events took place. Interindividually, there was a significant correlation between free T and frequency of orgasm. Intraindividually, there was a significant correlation between serum T and sexual stimulation the day before, but not on the day of the sample. This suggests T is more influenced by sexual activity versus having an influence on sexual activity. Also, free T and total T both had a significant correlation with frequency of orgasms in the 48 hours before and after the samples. Moreover, Dabbs and Mohammed (1992) analyzed four couples' salivary T levels before and after sexual intercourse. Participants were 21 to 30 years of age. Salivary samples were collected about 3 hours apart on 11 evenings when there was sexual intercourse, and 11 evenings when there was no sexual intercourse. Sexual intercourse occurred approximately two hours after the first salivary sample, and about one half hour before the second salivary sample. For men and women, T increased over the course of the evening when there was sexual intercourse, and decreased when there was no sexual

intercourse. T samples were log transformed so that men's and women's T samples could be collapsed. The only statistically significant finding was that T was lower in the late evening sample versus the early evening sample on the days in which no sexual intercourse took place. Furthermore, Hirschenhauser, Friderio, Grammer, and Magnusson (2002) conducted pattern analysis using Theme software to investigate the relationship between T and sexual behavior over a period of 3 months in 27 men, 23 to 47 years of age. To measure T, saliva was collected in the morning immediately after waking up. A daily record was kept to measure sexual activity, including masturbation. The study also compared the effects among single and paired men, fathers and non-fathers. Questions were asked about whether or not men wished to have children with their current partner as it may have influenced monthly patterns of T. A significant positive relationship was found between sexual activity and T. The authors proposed that the results should be interpreted as a bidirectional relationship, in which T affects sexual activity, and vice versa. No significant difference was found between single and paired men, or between fathers and non-fathers. These findings may be in contrast to predictions about differences in T responses based on the overall findings discussed in the previous section on T, pair-bonding and fatherhood. Perhaps men's relationship/parental status do not predict T responses to sexual stimuli as much as they predict baseline levels of T. It is premature to draw a conclusion at this stage.

A more convincing example of how sexual activity can increase T is provided by Escasa, Casey, and Gray (in press). The authors examined salivary T in 44 men, with a mean age of 40 years, who attended a swingers club. Men were grouped in terms of having viewed others engage in sexual activity, or having engaged in sexual activity

themselves. Both groups of men revealed a significant increase in T, but the men who actually engaged in sexual activity experienced a significantly higher increase in T than those who just viewed sexual activity. This study differed in potentially important ways from previous ones by having used a unique, naturalistic setting, samples that were collected very late in the day (between 11:00pm and 2:00am), and in-person social interactions with females that were possibly unfamiliar to the participants.

Despite the studies listed above, we cannot conclude that sexual activity necessarily causes a rise in T. For instance, Stearns, Winter, and Faiman (1973) measured the effects of sexual intercourse on hormones in six married couples. Participants were 21 to 41 years of age. Blood samples were obtained within the hour prior to sexual intercourse, and 10, 30, and 60 minutes after intercourse. No significant change in T was observed. Another example is provided by Lee, Jaffe, and Midgley, Jr. (1974) who measured the effect of sexual intercourse on various hormones in 11 cases of sexual intercourse in 8 men and 7 cases of sexual intercourse in 5 women. Blood samples were taken 10 minutes, 30 minutes, and every 60 minutes after sexual intercourse for 8.5 hours. Blood was taken again 24 and 48 hours afterwards. Among these participants, four men and four women provided blood every hour for 24 hours before intercourse to serve as controls. For the remaining participants, 1 to 3 blood samples were taken within 30 minutes before intercourse to serve as controls, too. Sexual intercourse produced no significant changes in T. In addition, one man, who did not participate in the study as described above, provided random samples of blood on 22 mornings over a 7 month period. Before and after a two month period of sexual abstinence, was a two month period in which the man engaged in sexual intercourse two or three times weekly. There were no significant

differences in T among the three time periods. In light of all the studies on the effect of sexual activity on T responses, it appears that masturbation and sexual intercourse often, but not always, produce a rise in T.

The Effect of Mating Stimuli on Testosterone Responses

Similar to sexual activity, mating stimuli such as erotic videos may produce a rise in T. The first published study on the effect of audiovisual erotic stimuli on T responses was conducted by Pirke, Kockett, and Dittmar (1974). The authors sampled plasma T from 16 men, 21 to 34 years of age, every 15 minutes for 3.5 hours. After the fourth sample, 8 participants watched a 30 minute erotic film, and 8 participants watched a cartoon film. Six of the eight participants in the experimental group showed a significant rise in T, and the overall increase for the group was statistically significant. The control group did not show a significant rise in T. Also worth noting is that two participants showed no rise in T from the erotic stimuli, even though they had erections as determined by plethysmography. Pirke et al's (1974) findings were supported by Hellhammer, Hubert, and Schürmeyer (1985) who tested salivary T levels in 20 men, 19 to 24 years of age, before, during, and after 5 films that were each 30 minutes in length. The content of the films were sexual, erotic, aggressive, stressful, and neutral. Each participant viewed a different film every day for five days. (Only with this study is a distinction made between "erotic and "sexual." Elsewhere the terms are used interchangeably.) After a 10 minute habituation session, participants provided a saliva sample before viewing a film. Fifteen minutes into the film, a second saliva sample was taken. A third sample was taken 15 minutes after the film was over. There was a significant increase in T fifteen minutes into the sexual and erotic films, and a significant decrease in T 15 minutes into the stressful

film. There was no difference in T from before to after any of the five video clips. Further support for the latter two studies was demonstrated by Stoléru et al. (1999) who collected blood samples to determine the effect of emotionally-neutral (N), humorous (H), and sexual (S) film clips on various brain region activation and T levels in 8 men (21 to 25 years of age). All film clips were silent. Two 10 minute clips of each film type were used, and the order was the same for all 8 participants: N1, N2, H1, H2, S1, and S2. As soon as a film clip was over, a blood sample was taken. In between film clips, questionnaires were completed, a five minute neutral film was shown, and a four minute relaxation phase was used to normalize any physiological change that may have occurred from the previous ten minute film clip before showing the next ten minute film clip. T levels were significantly higher after the sexual film than after the neutral and the humorous film. The previous three studies, in addition the study by Escasa et al. (in press) noted earlier in which observers of sexual activity at a swingers club increased T, seem to point to a conclusion that erotic stimuli are indeed associated with a rise in men's T.

It is noteworthy, however, that there are five studies that challenge the conclusion that erotic stimuli are associated with a rise in men's T. The study by Evans and Distiller (1979) mentioned earlier provides one example. A second example is provided by Rowland et al. (1987) who measured hormonal, psychological, and genital responses to sexual arousal in 16 men, 18 to 40 years of age. Hormone assays were derived from continuous blood sampling; sample values were averaged over 10 minute intervals. Thirty minutes after the start of the session, eight participants were shown an 18 minute sexually explicit tape, and eight were shown a neutral tape. All of those who watched the sexually explicit tape showed physiological and self-reported arousal, as did one

participant who watched the neutral tape. These nine participants comprised the experimental group. The remaining seven who viewed the neutral tape served as the control group. Eighty minutes later an 18 minute sexually explicit tape was shown to both groups. There were significant changes in T throughout the 170 minute session for both groups, but no significant difference between the groups. However, the only time that T was significantly higher than baseline was near the end of the session for the control group. This result appeared to coincide with the viewing of the second erotic tape. This finding perplexed the authors. Other null findings were obtained by Carani et al. (1990) who investigated the effect of audiovisual erotic stimuli on hormone responses in eight men, 20 to 26 years of age. The study took place over two days: on one day an erotic film was shown, and on another day a 30 minute neutral film was shown. The erotic film was made up of erotic scenes for the first 10 minutes, then neutral scenes for the next 10 minutes, and then more erotic scenes for the last 10 minutes. Each of the eight subjects saw the two films, the order of which was balanced. Blood was sampled at 15 minute intervals. No significant change in T was found. More null results were provided by Krüger et al. (1998) who measured hormone and cardiovascular responses to audiovisual erotic stimuli that involved masturbation to orgasm in ten men, 23 to 46 years of age. The study took place over two days: on one day the participants watched a 60 minute neutral documentary, and on the other day these same participants watched a 60 minute video where the first and last 20 minutes were neutral and the middle 20 minutes were erotic. The order of the two films was balanced. Ten minutes into the erotic portion of the experimental condition, participants were asked to masturbate to orgasm while watching the video. Blood was sampled continuously for the 60 minute duration of the videos, and

grouped into ten minute intervals. No significant changes in T were detected. A fourth example involving null results was provided by Krüger et al. (2003) who examined the effect of sexual arousal leading to orgasm during the presentation of erotic audiovisual stimuli on blood T and AVP. The study included 10 men, 18 to 30 years of age, who each completed both the experimental and control condition. The experimental condition involved watching a 40 minute film: 10 minutes of a documentary, 20 minutes of an erotic film, followed by 10 minutes of further documentary film. Ten minutes into the erotic film, participants began to masturbate, leading to orgasm 2 to 8 minutes later. A continuous blood draw allowed the assessment of hormones at 2 minute intervals. The control condition involved a 40 minute documentary. There was no significant effect between the experimental and control conditions, nor within the experimental condition, for either T or AVP. (This was the first study to examine AVP in such a context, and will be discussed again in a later section.) In sum, the findings on the effect of erotic stimuli on T responses are mixed. In some individuals, or some cases, erotic videos are linked with a rise in men's T, and in other individuals or cases this effect is not found.

Yet mating stimuli for heterosexual men can also be envisioned in terms of a simple conversational interaction with a woman. A man's physiology may interpret the act of talking with a woman as the initial stages of a potential mating relationship. For instance, Roney, Mahler, and Maestripieri (2003) tested the effect of interacting with a man or a young woman for 5 minutes on men's salivary T responses. Nineteen men, 18 to 36 years of age interacted with a young woman and 18 interacted with a man. Participants in the former condition experienced a significant increase in T, but the others did not. These findings were later supported by Roney, Lukaszewski, and Simmons (2007) who

investigated the effect of conversing with a young woman on men's salivary T responses. In Study 1, there were 113 participants, with an average age of 19 years, who either interacted with a young woman for 15 minutes (experimental condition), or sat alone for 15 minutes (control condition). Men experienced a significant increase in T from interacting with a woman, but only in the later afternoon experimental condition. Men who sat alone did not experience a significant change in T. In Study 2, there were 94 participants, with an average age of 19 years, who either interacted with a young woman or another young man for 15 minutes. Men who interacted with a woman experienced a significant increase in T, but men who interacted with another man did not. The authors concluded that the findings represent a hormonal courtship response. van der Meij et al. (2008), discussed earlier, provided further support a for T-courtship response. They found that men who interacted with a female experienced a significant rise in T, but those who interacted with a male did not. In sum, it seems that mating stimuli have the capacity to elicit a T response.

Conclusions on the Effect of Sexual Activity and Mating Stimuli on Testosterone Responses

Overall, it appears that mating stimuli and sexual activity, often but not always, produced rise in T. As of yet, little can be said about the duration or consequence of these effects. Moreover, a couple of methodological issues may be responsible for the mixed results in these areas, such as the timing of salivary and blood samples that may have missed a change in T. As well, the invasive procedure of drawing blood instead of collecting saliva samples may have had a dampening effect on T responses. Also unknown are how marital/parental status may differentially influence T responses to

sexual activity and mating stimuli. To date, only Hirschenhauser et al. (2002) have investigated the relationship between hormone responses and sexual activity while noting information on marital and parental status. The area remains wide open for inquiry. Furthermore, examining only one hormone in these contexts may limit the insights that can be gleaned from this line of research. Investigating a second "male" hormone might provide novel and important findings on men's mating and parenting behavior. This may be especially true when that second hormone is often modulated by T, such as AVP.

CHAPTER 4

BEHAVIORAL CORRELATES OF VASOPRESSIN

Research on AVP is a much newer area of inquiry than that on T; this is especially true regarding the behavioral correlates of AVP. Moreover, there seems to be more AVP research conducted with rodents than humans, although the increasing use of human participants in AVP studies can be seen in comprehensive reviews on the relationship between AVP and behavior in Caldwell and Young (2006) and Caldwell et al. (2008). Such reviews portray AVP as being linked with a great number of physiological, cognitive, and behavioral constructs. The present chapter is mostly concerned with the behavioral components of AVP, and will review the literature on AVP, or AVP receptor activity, as they relate to aggression, affiliation, and sexual behavior.

Vasopressin and Aggression

One study by Delville, Mansour, and Ferris (1996) was particularly instrumental in portraying the facilitative effect of AVP on aggression and on the modulating role of T in AVP receptors. The authors described how AVPR1 receptors binding in the ventrolateral hypothalamus (VLH) were absent in castrated golden hamsters that did not receive T treatment, but present in castrated hamsters that did receive T treatment. Also, injections of AVP in the VLH lead to a quicker aggressive response in the T treated castrated hamsters. AVP injections were also less likely to facilitate aggression in non-T treated castrated hamsters. Additional support for an AVP-aggression link was found by Coccaro, Kavoussi, Hauger, Cooper, and Ferris (1998) who examined the relationship between CSF AVP and aggression in 18 men and 8 women averaging 32 years old and diagnosed

with a personality disorder. Aggression, which was assessed via interview and self-report, was positively correlated with CSF AVP, which was assessed via lumbar puncture. Thompson, Gupta, Miller, Mills, and Orr (2004) found similar results with a population of healthy men. They tested the effect of AVP administration on a heart rate, skin conductance, and electromyographic (EMG) activity in response to the viewing of photos of faces displaying different emotional expressions in 27 men, 18 to 22 years of age. Approximately half of these men received an intranasal administration of about 50μg (50 micrograms) of AVP, and the other half received a saline solution. The pictures of faces included happy, angry, or neutral expressions. There was no significant difference between the two groups in terms of heart rate or skin conductance for exposure to any of the three facial expressions. There was also no difference between the two groups in EMG responses for happy and angry faces. However, the AVP group exhibited a significantly higher EMG response than the saline group to the neutral face. The AVP group's EMG's response to the neutral faces was the same as their response to the angry faces. The authors interpreted these findings to indicate that AVP may facilitate aggression when men perceive neutral stimuli as aggressive, and respond in turn with aggression. Taking these three studies together, it appears AVP may have a facilitating effect on aggression. The magnitude and consistency of this effect are still unclear.

Vasopressin and Affiliation

In the rodent literature, affiliative behavior refers to bonding behavior such as olfactory investigation, grooming, and displaying partner preference. The latter refers to whether a rodent chooses to spend time with a known mate, or an unknown potential

mate. In the human literature, affiliation is the socio-emotional closeness that is expressed between individuals. In both rodents and humans, affiliation pertains largely to pair-bonding and parental behaviors. As with aggression, higher AVP or AVPR1 function is linked with affiliation in human and nonhuman animals. This seems paradoxical, and is perhaps reconciled by the context in which AVP is studied. For example, increased AVP in a male may facilitate aggression in certain male-male contexts, but facilitate affiliation in other male-female contexts. Moreover, different types and combinations of hormones and receptor activity may also account for when AVP facilitates aggression versus affiliation.

The prairie vole and the montane vole are the rodents that are probably most responsible for the conclusions drawn about AVP's role in affiliation. Young (1999) points out that one of the central differentiating features between the prairie vole and the montane vole is the distribution of AVPR1a: prairie voles appear to have more AVPR1a receptors in the diagonal band and montane voles appear to have more AVPR1a receptors in the lateral septum. This difference may account for at least part of the reason why prairie voles mate monogamously and why montane voles mate promiscuously (Hammock, Lim, Nair, & Young, 2005). In addition, Young, Nilsen, Waymire, MacGregor and Insel (1999) showed that AVP administration increases affiliative behavior in the prairie vole, but not the montane vole. AVP not only highlights between-species differences, but also within-species effects. Hammock et al. (2005) discussed how variation in AVPR1a may account for differences in AVP-related behaviors within prairie voles. Indeed, Lim, Hammock, and Young (2004) discussed how the prairie vole is a good species in which to examine the effect of AVP and AVPR1a on social behavior,

and suggested that AVP is one of the underpinnings of monogamy. Finally, not only does AVP play a role in mating style in rodents, but also in paternal investment. As noted in Chapter 1, administering AVP has also been shown to facilitate paternal care in male prairie voles (Wang et al., 1994).

Generally consistent findings on the link between AVP, or its receptors, and pair-bonding/paternal investment have been obtained in the human literature. Gray et al. (2007) investigated the relationship between various hormones and paternal status and paternal interactions in Jamaican men. The study included 28 fathers and 15 single men. Ages ranged from 18 to 38 years. The authors found a significant inverse correlation between a father's AVP and the age of his youngest child. If AVP enhances paternal investment, higher AVP may be especially important when offspring are younger and more vulnerable. Perhaps the most convincing study with humans on the AVP-pair-bonding link was conducted by Walum et al. (2008). They examined the relationship between different expressions of the AVPR1a gene and pair-bonding characteristics in 552 pairs of twins and their spouses. All participants were married or living together for a minimum of five years. RS1, RS3, and GT25 are three different repeat polymorphisms of the AVPR1a gene. Repeat polymorphisms are groups of alleles, and an allele is an alternate form of a gene. The repeat polymorphism RS3 was significantly correlated with differences in Partner Bonding Scale (PBS) which is a measure of marital quality. This suggests that AVP plays a role in pair-bonding that is at least somewhat specific to men. Among the various RS3 alleles, only the 334 allele showed a significant correlation with PBS scores in men. Lower partner-bonding scores were linked with the 334 allele. Among married and non-married men, the latter had significantly lower scores on the

PBS than the married men. Among the men with no 334 alleles, 15% experienced marital crisis, whereas 34% of men with two 334 alleles experienced marital crisis. Also, unmarried men were more likely than married men to have two 334 alleles versus no 334 alleles. In sum, variations in AVPR1a gene expression were linked with differences in marital status and quality.

Yet one study did not confirm these findings (Gray, Eisenberg, & Campbell, unpublished data). The authors examined one androgen receptor polymorphism and two AVPR1a polymorphisms in a sample of Ariaal men (pastoralists from Kenya) for correlations with marital status and fertility. Categories of marital status were: single, monogamously married, and polygynously married. Fertility was assessed in terms of the number of living offspring. There was no significant correlation between any of the three polymorphisms and marital status or fertility. In sum, despite mixed findings and a dearth of research on AVP and affiliation in humans, there seems to be some support for the hypothesis that AVP facilitates pair-bonding and paternal investment.

Vasopressin and Sexual Behavior

The role of AVP or its receptors on male sexual function has been largely unexplored in humans. Although, Segarra et al. (1998) found evidence that plasma AVP is involved in human penile erection, most predictions for the role of AVP in direct sexual function are derived from animal research. For instance, Gupta, Russell, Wayman, Hurley, and Jackson (2008) found evidence that AVPR1a mediates erection and ejaculation in rabbits and rats. Limited evidence notwithstanding, it seems that AVP and AVPR1a may be involved in sexual intercourse. Also noteworthy is that these studies investigated the

impact of AVP on sexual function rather than the impact of sexual activity on AVP responses.

Other studies have examined the effect of sexual stimuli on AVP responses. Murphy et al. (1987), noted in Chapter 2, investigated the effect of sexual arousal and orgasm on plasma AVP responses in 10 men whose ages ranged from the early 20s to the early 30s. An AVP measure was obtained in only 10 men. A venous cannula was inserted into the arm, 30 minutes passed, and then a baseline measure of AVP was obtained. Participants were then asked to achieve sexual arousal to full penile erection without manual stimulation but rather through fantasy or other available sexual material. Erections took an average of 11 minutes to achieve and blood samples were obtained at that time. Then participants were asked to masturbate to ejaculation, which took an average of 6 minutes. At this stage, another blood sample was obtained, and again 10 and 30 minutes later. AVP increased significantly with arousal, but had decreased by the time of ejaculation. As such, it appears arousal, and not ejaculation per se, may be associated with a rise in AVP. Other findings are inconsistent with those obtained by Murphy et al. For instance, Krüger et al. (2003) found no effect of sexual arousal leading to orgasm during the presentation of erotic audiovisual stimuli on AVP response. Either such stimuli do not elicit an AVP response, or the blood draw had a dampening effect on the AVP response. There are few studies on the relationship between AVP and men's sexual behavior, but it appears that AVP may be part of the sexual response cycle.

In conclusion, evidence is accumulating that AVP or its receptors have an enhancing effect on aggression, affiliation, and sexual behavior. The findings are derived in the face of many challenges associated with AVP research. For instance, making inferences about

human social behavior based on rodent research leaves much room for faulty hypotheses because the effect of AVP on social behavior varies among species (Carter, 1998; Fisher, 1998; Donaldson & Young, 2008). Moreover, there may be variation in AVP-related behavior within species. For example, even the monogamous female prairie vole, while in estrus, will sometimes mate with a male that is not the pair-bonded mate (Carter, 1995). Another challenge in AVP research concerns the measurement of AVP. This comment is made in light of the notion that plasma and CSF levels of AVP do not necessarily correlate with one another (Carter, 1998). Also, AVP and oxytocin can bind to each other's receptors (Barberis & Tribollet, 1996), making it a complex task to assess the relationship between AVP and its receptors. Yet another challenge concerns the timing and stability of hormonal changes, as shown by the autism spectrum disorders (ASD) research. That is, ASD is a developmental disorder, and higher levels of AVP during critical stages of development may lead to abnormal behavior, unlike higher levels of AVP during adulthood that may be linked with adaptive paternal investment. Alternatively, high AVP as a permanent trait may be maladaptive, as in cases leading to ASD, whereas high AVP as a temporary state may be adaptive, as in cases of facilitating men's paternal investment once they have a child.

Given the breadth of topics covered in AVP research, can a coherent theory be derived about the function of this peptide in reproduction? Recall that AVPR1a deals mostly with social behavior and AVPR1b is mostly known for its associations with stress responses. These are extremely broad domains and can potentially encompass an unlimited number of behaviors. Despite these complications, one of the broad-based conclusions that can be drawn from this literature review is that AVP is geared towards

both mating and parenting efforts in reproduction. The AVP-mating prediction is based on studies on sexual behavior (e.g., Murphy et al., 1987; Segarra et al., 1998; Gupta et al., 2008). The AVP-parenting prediction is based on the premise that AVP or AVPR1a are part of the physiological underpinning of the monogamy of prairie voles (Young et al., 1998), and of their paternal investment (Wang et al., 1994).

Although it can be questionable to predict AVP's effect in humans from conclusions drawn from rodent research, there may be some good reasons to do so. One reason to justify the application of rodent research to humans is because AVP has portrayed significant conservation, not just in mammals, but also across vertebrate species that date back hundreds of millions of years (Goodson & Bass, 2001; Donaldson & Young, 2008). There are clearly large differences between rodent reproductive behavior, which is more influenced by olfaction than vision, and men's reproductive behavior, which might rely more on vision than olfaction. However, there may have been a time when men relied much more on olfaction for reproduction than they do today. Curley and Keverne (2005) provided a discussion on how the primate brain evolved to rely less on olfactory cues and more on visual cues. If AVP co-evolved with reproductive behavior in humans at a time when olfaction was more important for reproduction, then drawing links with rodent research is likely more justified.

In summary, there is an increasing need for an integrated understanding of the relationship between hormones and men's mating and parenting practices. This is portrayed by Gray and Anderson (2010) and Ellison and Gray (2009) who have provided anthropological, biological, and evolutionary perspectives to explain men's reproductive behavior. A more specific example can be shown by Fisher (1998) who argued that there

are three general groups of emotions involved in mammalian reproduction: sexual desire, attraction, and attachment. Each of these groups has hormonal correlates that are mostly responsible for their expression: androgens and estrogens for sexual desire, catecholamines (e.g., dopamine and norepinephrine) for attraction, and the peptides AVP and oxytocin for attachment. This type of integration elucidates many of the links between hormones and reproductive behavior which span various social and natural sciences, and highlight various questions raised by the literature, to which we now turn.

CHAPTER 5

AIMS OF THE STUDY

This dissertation started with an explanation of how human mating has varied considerably across cultures and time. As Fisher (1998) stated, "Mating flexibility is the hallmark of *Homo sapiens*." Next, socioevolutionary theories of T and AVP were discussed. In short, the Challenge Hypothesis as applied to humans predicts that T is geared more towards mating than parenting efforts. One theory based on the rodent research is that AVP is the hormonal underpinning of monogamy and paternal investment. These socioevolutionary theories of T and AVP are conceptualized in Figure 1.

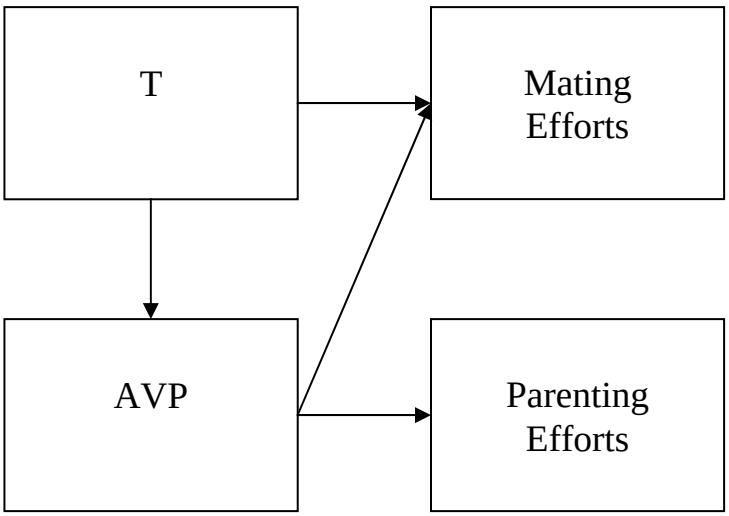


Figure 1. Model of Socioevolutionary Theories of T and AVP. Hormone and behavior literature broadly suggests that: (1) T modulates AVP, (2) T is geared towards mating efforts, and (3) AVP is geared towards both mating and parenting efforts. It should be noted, however, that there is a bidirectional relationship among the four variables, each having the capacity to influence, and be influenced by, the other three variables.

Chapters 3 and 4 provided a review of the behavioral correlates of T and AVP, respectively. When considering the findings discussed heretofore, several questions are raised by the literature. One such question is: Has the mating emphasis of men been overstated in socioevolutionary theory to the exclusion of parenting drives? Evolutionary psychology has given more attention to men's mating than parenting efforts (e.g., Buss, 2005). This is understandable given the reasonable notion that during the ancestral past men may have maximized their reproductive success by trying to mate with as many females as possible. However, it is possible that researchers may have underrated men's parenting efforts as contributors to reproductive success.

Another question is: What kind of mating strategy do male endocrine responses reflect: monogamous, slightly polygynous, or opportunistic? Opportunistic refers to being flexible and able to adapt to a variety of mating strategies. Researchers have long debated men's mating strategy. One distinction that needs to be made is the difference between the mating strategy that a man would ideally prefer, and the one that he actually pursues based on his constraints in terms of religion, culture, resources, etc.

A third question is: What are the hormonal correlates of human sexual arousal? The sexual response cycle as described by Masters and Johnson (1966) is comprised of excitement, plateau, orgasm, and resolution. The first three stages involve an increase in sexual arousal, leading to a peak with orgasm. To some extent the typical endocrine response that accompanies physiological and subjective sexual arousal in men are still somewhat unknown.

A fourth question is: What are the hormonal correlates of human paternal responses? Paternal responses, as opposed to sexual arousal responses, are perhaps much broader and

more challenging to operationalize. Engaging in paternal responses can encompass numerous behaviors, some of which may elicit no hormonal responses, and some of which may trigger a cascade of endocrine responses. Determining which parenting contexts trigger a hormonal or behavioral reaction will increase researchers' understanding about the relationship between particular hormones and paternal behavior.

A fifth question is: Does marriage/fatherhood reduce a man's hormonal response to sexual stimuli, and increase his hormonal response to paternal stimuli? This question arises out of the notion that married fathers have lower T than single, childless men. There may be important differences between men's baseline levels of hormones and responses in those hormones to various mating and parenting stimuli. In addition, if increased parenting efforts that cost time and energy necessitate a decrease in other endeavors such as mating efforts, this change may be reflected in hormonal responses to various reproductive stimuli.

A sixth question is: Do sociosexuality, sexual function, and paternal investment moderate hormonal responses to stimuli that are relevant to reproduction? Given the great diversity in men's physiology, motivations, values, personalities etc., investigators may expect hormone variation within populations of single, childless men and married fathers. As such, differences in T and AVP between these two groups may not be detectable until other biopsychosocial variables are taken into account. Once such variables are taken into account, variations in endocrine and paternal responses within single, childless men and married fathers can be examined.

In an attempt to chip away at the questions raised in this literature review, we started translating some of them into testable predictions that we could then investigate

empirically. As such, the following questions and literature-supported hypotheses constitute the purpose of the proposed study:

1. Do single, childless men have higher baseline T than married fathers? Hypothesis #1 - Single, childless men will have higher baseline T than married fathers.
2. Do married fathers have higher baseline AVP than single, childless men? Hypothesis #2 - Married fathers will have higher baseline AVP than single, childless men.
3. Do sexual stimuli increase men's T, and does it increase more for single, childless men than married fathers? Hypothesis #3 – Sexual stimuli will increase men's T, especially for single, childless men.
4. Do sexual stimuli increase men's AVP, and does it increase more so for single, childless men than married fathers? Hypothesis #4 – Sexual stimuli will increase men's AVP, especially for single, childless men.
5. Do crying baby stimuli decrease men's T, and if so, would there be a difference between single, childless men and married, fathers? Hypothesis #5 - Crying baby stimuli will decrease men's T, especially for married fathers.
6. Do crying baby stimuli increase men's AVP, and if so, would there be a difference between single, childless men and married, fathers? Hypothesis #6 - Crying baby stimuli will increase men's AVP, especially for married fathers.

CHAPTER 6

METHODOLOGY

Participants

Participants were recruited via the Department of Psychology's Subject Pool, word-of-mouth, and advertisements posted around campus. Inclusion criteria were: (1) male sex, (2) between the ages of 18 and 45 years, to avoid the potential confound of declines in T from early adulthood onwards (Dabbs, 1990a), and (3) either single (not in an exclusive, romantic relationship) and childless, or married and the biological father of at least one child under the age of six (when there is typically more proximate paternal care). Participants received either course credit or $20 reimbursement for their time or travel expenses.

Sixty men, ages 21-44 years, M = 29.20, SD = 5.51, completed the study. Thirty were single, childless men and 30 were fathers, 29 of whom were married. Ethnic breakdown was as follows: 40 European American, 9 African American, 5 Multiracial, 4 Hispanic, 1 Asian, and 1 other. In relation to the fathers, the youngest biological child's age ranged from 1-72 months, M = 22.78, SD = 19.47. Participants' highest level of education was as follows: 29 finished high school, 19 had a Bachelor's degree, 7 had a Master's degree, and 5 had a doctoral degree.

Stimuli

Participants were randomly assigned to view one of two videos, each of which was approximately 15 minutes in length. One of the videos involved heterosexual couples engaged in various stages of consensual sexual activity: caressing, kissing, oral sex, and

sexual intercourse. This video was free of profanity, coercion, deviant sexual themes, and harmful behavior, and was similar to those used in research on sexuality conducted in the United States (e.g., Rowland et al., 1987), Australia (e.g., Julien & Over, 1988), and Europe (e.g., Stoléru et al., 1999; Krüger, et al., 2003). The sexual video was made from segments of the movie *Island Fever 2* (Joone, 2003). The other video was designed specifically for the purpose of this study and involved 13 clips of babies and toddlers crying as a result of receiving a vaccination shot. The clips ranged in length from approximately 30 seconds to 2 minutes. Typically, a parent was seated with or near the child and a healthcare provider administered the needle. The child cried in response to the needle and the parent or healthcare provider attempted to soothe the child with kind words and gentle touches. The clips were obtained from http://www.youtube.com.

Measures

Hormones

Saliva samples were assayed for T with Salivary Testosterone Enzyme Immunoassay Kit 1-1402 from Salimetrics, LLC. Collection and handling procedures were based on recommendations by Salimetrics and Ellison (1988). James and Baxendale (1984) and Wang, Plymate, Nieschlag, and Paulsen (1981) portrayed how salivary T correlates highly with free T. Saliva samples are also easier and less intrusive to collect than blood samples. Salivary samples were stored in a -20 C freezer within two hours after participants completed the experiment. Samples were assayed in batches, and the interassay coefficients of variation for salivary testosterone assays were 20.54% and 5.95% for low and high controls, respectively. Also, each individual sample was assayed

in duplicate, and the intrassay coefficient of variation for testosterone samples was 6.33%. These coefficients of variation are measures of reliability and are similar to those obtained in other studies from UNLV's Human Behavior Endocrinology Lab (e.g., Steiner et al., 2010).

Urine samples were assayed for AVP with Kit 901-017 from the Wisconsin National Primate Research Center (WNPRC) at The University of Wisconsin-Madison. Collection and handling procedures were based on recommendations by the NPRC's Assay Services Unit. Pooled human urine was parallel to the vasopressin standards, $t = 1.36$, $p < 0.05$, and accuracy was 84.32 ± 4.86. Sensitivity of the assay was 0.40 pg. Recovery of added vasopressin to the assay procedure was 95%. The interassay coefficient of variation was 12.7%, and the intrassay coefficient of variation was 7.8%, $N = 3$. Again, these are measures of reliability and consistent with those obtained from other studies at WNPRC.

Digit Ratio

Weak but significant inverse links have been observed between digit ratio and variables such as sperm count and reproductive success (Manning, 2002), and was therefore measured in the current study for its potential link with adult reproductive behaviors and characteristics. Measurement was similar to the procedure described by Stoyanov, Marinov, and Pashalieva (2009) in which a fine-tipped pen was used to mark the proximate finger crease of 2D and 4D, followed by photocopying the ventral surface of the hand and measurement of 2D and 4D using Vernier calipers. The right hand was used because digit ratio effects tend to be stronger in the right hand (Manning, 2002). Measurement of digit lengths from the photocopies were taken to the nearest one-thousandths of an inch by the principal investigator and also independently by a research

assistant. Interrater reliability was high, $r(118) = .997$, $p < .001$. The average of the measurements taken by the principal investigator and the research assistant were used in analyses.

Self-Report Instrument

Participants completed one of four versions of a self-report instrument, depending if they were single, childless men or married fathers, and if they viewed the sexual video or the baby video. The versions were the same except for five items inquiring about reactions to the videos, and 29 items regarding marital and parental variables which only the married fathers completed. The complete instrument can be found in Appendix 1, and details in brackets explain who saw which version. The self-report instrument was organized in the following manner: Items 1-14 inquired about background information; Items 15-34 consisted of the Sociosexual Orientation Inventory (SOI; Simpson & Gangestad, 1991), the Extrapair Sexual Interest Inventory (EPSI; McIntrye et al., 2006) and the Brief Sexual Function Inventory (BSFI; O'Leary et al., 1995). Items 35-42 addressed responses that pertained directly to the video watched, and were primarily a manipulation check. Items 43-71 consisted of the Dyadic Adjustment Scale – 7 (DAS-7, Hunsley, Best, Lefebvre, & Vito, 2001), relationship length and child characteristics, and a non-standardized measure of paternal investment. Items and measures included in this survey instrument were chosen primarily for their theoretically hypothesized links with hormone results, in addition to their descriptive purposes. Details of the survey items and standardized measures are provided below.

Background Variables

Item 1 asked for relationship status in order to confirm that a participant was indeed a single, childless man or a married father. Items 2 and 3 asked for age and ethnicity, respectively, in order to report demographics. These two items were also recorded because T declines with age from early adulthood onwards (Dabbs, 1990a), and different ethnicities have been linked with different levels of T (e.g., Mazur, 2009). Items 4 and 5 asked for height and weight, respectively, and were used to calculate body mass index (BMI) which has been linked with T (e.g., Osuna, Gomez-Perez, Arata-Bellabarba, & Villaroel, 2006). Item 6 addressed education, in order to report demographics. Items 7-14 addressed drugs consumed before the study, sexual orientation, if the participant ever engaged in sexual intercourse, food/drink consumed before the study, sexual activity on the day of the study, the level of discomfort with receiving a needle, and days since orgasm.

Sociosexual Orientation Inventory (SOI; Simpson & Gangestad, 1991)

Items 15-21 are the SOI. Sociosexual orientation is a measure of one's preference for commitment and intimacy with a sexual partner. Those with restricted sociosexuality tend to prefer sex with commitment and intimacy, and those with unrestricted sociosexuality can enjoy sex without commitment and intimacy. In terms of internal consistency, Simpson and Gangestad (1991) reported a Cronbach's alpha of .73 for the SOI. The authors (1991) also noted test-retest reliability of $r = .94$ from unpublished data in 1989. In a study that involved 48 nations and over 14,000 participants, Schmitt (2005) reported a Cronbach's alpha of .77 for the 7 unweighted SOI items. In the current study,

Cronbach's alpha was .65 once an extreme outlier (seven standard deviations from the mean) was removed from the analysis.

Extrapair Sexual Interest Inventory (EPSI; McIntyre et al, 2006)

Items 15-23 are the EPSI. In other words, the addition of Items 22 and 23 to the SOI make up the EPSI, which is considered another assessment of sociosexuality. In the current study, Cronbach's alpha was .61, a modest level of internal consistency.

Brief Sexual Function Inventory (BSFI; O'Leary et al., 1995)

Items 24 through 34 are the BSFI which assesses sexual function in terms of sexual desire, erection, ejaculation, and overall sexual satisfaction. The authors obtained test-rest reliability coefficients of .79 to .90. In a study that involved 1185 men, Mykletun, Dahl, O'Leary, and Fossa (2005) reported Cronbach's alphas of .90 to .94 for the first ten items of the BSFI. (The 11th item of the BSFI is the measure of overall sexual satisfaction.) In the current study, internal consistency was moderate with a Cronbach's alpha of .77.

Manipulation Check

Prior to checking for the perceived effect of the manipulation, Item 35 asked the men who viewed the sexual video about their attitudes toward pornography. For those who viewed the baby video, Item 35 addressed the level of discomfort with seeing someone else receive a needle. In either case, the purpose of Item 35 was to investigate if prior attitudes about central aspects of the manipulations could be potential confounds and thus necessitate statistical control.

Questions checking for the effect of the manipulation then followed. For those who viewed the sexual video, Items 36-39 asked how much the video sexually aroused them. For those who viewed the baby video, Items 36-39 asked how much they wanted to

soothe the crying babies in the video. In both cases, Items 36-39 each were accompanied by a nine-point Likert-type response scale. These items served as a manipulation check to determine if the videos had the intended effect: sexual arousal for the sexual video and urge to soothe the crying babies for the baby video. A score above the midpoint for the sum of these four items (i.e., a score above 18) was considered, a priori, to reflect sexual arousal for the sexual video, and urge to soothe the crying babies for the baby video. Scores suggest that both videos were moderately effective in these regards: $M = 23.43$, $SD = 7.02$ for the sexual video, and $M = 26.27$, $SD = 9.52$ for the baby video.

Items 40, 41, and 42 were the same for all participants in the study and asked how intense, emotional, and pleasant the video was, respectively. The rationale for these items was to determine if the videos differed in these qualities and, if so, to control for differential responses. In other words, the intent was to portray that any difference in T or AVP response between the two videos was due to the marital/parental status of the participants or the content of the videos, and not due to differences in the intensity, emotion, or pleasantness of the videos. There was no significant difference between the two videos in terms of intensity scores, $t(57) = 1.35$, $p = .183$, or emotion scores, $t(57) = 1.12$, $p = .268$. However, as would have been expected, viewers of the sexual video reported higher pleasantness scores than viewers of the baby video, $t(57) = 8.21$, $p < .001$. Descriptive statistics for responses that pertain to the videos (Items 35-42) are presented in Table 1.

Dyadic Adjustment Scale – 7 (DAS-7, Hunsley et al., 2001)

Married fathers also completed the DAS-7 found in Items 43-49 on the self-report instrument. The DAS-7 is a short form of Spanier's (1976) measure of dyadic adjustment.

Hunsley et al. (2001) report Cronbach's alphas for the DAS-7 that range from .75 to .80 in independent samples that have a total of approximately 1300 participants. Cronbach's alpha was .84 in the current study for the 30 partnered participants.

Relationship Length and Child Characteristics

Items 50-53 asked how long the participant had been married, how long he had been in a committed relationship before marriage, how many children he had, and the age and gender of his children.

Paternal Investment

Married fathers also completed an exploratory measure of paternal investment as found in Items 54-71. This measure is based on items used by Gray et al. (2002) and Durette, Marrs, and Gray (in press), and has not yet been psychometrically validated.

Procedure

When men scheduled an appointment to participate in the study, they were asked to refrain from sexual activity on the day of the experiment to control for potentially confounding effects on hormones. Participants were also asked to refrain from eating or drinking anything except water within one hour of the experiment, as food residue may contaminate salivary samples. Furthermore, they were asked to drink about eight ounces of water approximately one hour before the appointment, an amount that should be in addition to their regular consumption. The participants were informed that the purpose of this request was to ensure that they could urinate when they arrived for the study.

The date that participants were run was noted, given that T tends to peak in the winter and reach its nadir in the summer (Svartberg, Jorde, Sundsfjord, Bonaa, & Barrett-

Connor, 2003), and may have required statistical control. The experiments were held on the UNLV campus in room CBC-B139A. Experiments were scheduled to begin between 2:00pm and 5:00pm to control for effects caused by natural diurnal patterns of T. Dabbs (1990b) found that T drops by approximately 50% from early morning to late evening; the largest drop occurring in the morning. When participants arrived for the study, informed consent was obtained and participants were given 500mL of bottled water to drink in order to stimulate urination for the second urinary sample. Participants were then given a plastic, sealable cup inside an envelope, for privacy, to take to a nearby bathroom and provide the first urinary sample of approximately 25ml. When they returned, their right 2D and 4D finger creases were measured with a fine-tipped pen and their right hand was photocopied so 2D:4D digit ratios could be measured. Participants were then taken to a small, entirely enclosed office within CBC-B139A (a video room) where they privately viewed a 15-minute introductory psychology distance education video clip regarding research methods. The clip was chosen for its non-arousing content. The purpose of the video was to standardize the pre-experimental experience and give T time to stabilize or return to baseline. Ideally, urine (AVP) would not have been collected until after this video too, but there needed to be a reasonable amount of time in between samples in order to for the participants to be able to urinate a second time.

When the introductory psychology video was over, participants came out of the video room, at which time they were given a short straw to dispense about 1mL of saliva into a 1.8mL cryovial container. Participants were then taken into the video room in which one of the two randomly assigned experimental videos was played. Participants were instructed to exit the video room at their leisure after the video was over. The investigator

then left the video room and closed the door behind him. All participants exited only a few seconds after the video ended. When they exited, they provided a second saliva and urine sample. Elapsed time between the end of the video and the collection of biological samples was assessed in 48 of the 60 participants. To the nearest half minute, it ranged from 4.5 to 10.5 minutes, $M = 6.5$, $SD = 1.54$. Participants were then taken to the video room one last time to complete the self-report instrument. They were instructed not to put their name on the survey, as each survey had an ID number. They were further instructed that when the survey was completed, they were to seal it in an unmarked envelope and place it anywhere among other sealed envelopes in a box. Participants were encouraged to answer honestly, as their responses would not be linked to their identity. The investigator left the video room to give them privacy. When the participants exited the video room into the main office, they were given course credit or $20 reimbursement. All saliva and urine samples were stored in a freezer at -20 Celsius within two hours after the experiment ended.

One question that has not yet been decisively answered is how long to wait to collect a saliva sample after an experimental manipulation. Collecting a sample too soon results in failure to detect a hormonal response because a change in serum has not had sufficient time to manifest itself in saliva. Conversely, collecting a sample too late can result in missing a hormonal response because the hormone has returned to a baseline level. Riad-Fahmy, Read, Walker, Walker, and Griffiths (1987) found a significant rise in salivary cortisol one minute that after an intravenous injection of cortisol. Although T is different from cortisol, both are steroids and thus both are lipid soluble hormones that easily pass through cell membranes. In addition, Steiner et al. (2010) suggest that salivary changes in

hormones are detected very quickly after an experimental manipulation. As such, the investigator predicted a maximum change in steroid hormones to be detected in saliva about three minutes after the experimental manipulation. In terms of the length of a video to be used, Julien and Over (1988) found that men's physiological and subjective arousal were highest in response to erotic film clips approximately 12 minutes after the onset of the video. Thus for the current study, videos that were approximately 15 minutes in length were used, with saliva samples being collected immediately afterwards. As far as AVP is concerned, there is no human data to our knowledge regarding the ideal time to sample urine in order to detect a change in AVP after an experimental manipulation intended to impact AVP.

Statistical Analyses

Hormone value outliers beyond 3 *SD*s of the mean were excluded from data analyses. Kolmogorov-Smirnov tests of normality were performed on the data after outliers were removed. Baseline T (T1) was not normally distributed, *K-S*(55), = .25, $p < .001$, given that normality tests typically use alpha levels of .01 or .001 (Tabachnik & Fidell, 2007, p. 80). A base-10 log transformation was performed which produced a borderline normal distribution for T1, *K-S*(55), = .15, $p = .003$. The post-video T level (T2) was not normally distributed, *K-S*(53), = .18, $p < .001$. A base-10 log transformation was performed which produced a borderline normal distribution for T2, *K-S*(53), = .17, $p = .001$. Log transformed values did not change the significance of the results, and therefore non-log transformed values were used for all analyses. Baseline AVP (AVP1)

had a normal distribution, *K-S*(59), = .13, *p* = .018, and the post-video AVP level (AVP2) had a borderline normal distribution, *K-S*(59), = .15, *p* = .003.

F tests and *t* tests were used in data analyses; both are moderately robust to a violation of the assumption of normality (Howell, 2010). All *t* tests were independent samples *t* tests, two-tailed, unless otherwise specified. To examine group differences in hormone responses, 2 (Relationship status: single/childless, married/fathers) X 2 (Video condition: sex video/baby video) ANCOVAs were used. The DV was the post-video hormone sample, and the covariate was the pre-video hormone sample. Other ANCOVAs/ANOVAs used are described in the Results. Unless otherwise specified, Levene's test of equality of error variances for *F* tests was not statistically significant, *p*s >.05, and thus the assumption of homogeneous variances was met in each ANOVA/ANCOVA conducted.

The remaining analyses included correlations using Spearman's rho rather than Pearson's *r* because some of the data were not normally distributed. The general experimental design is presented in Figure 2.

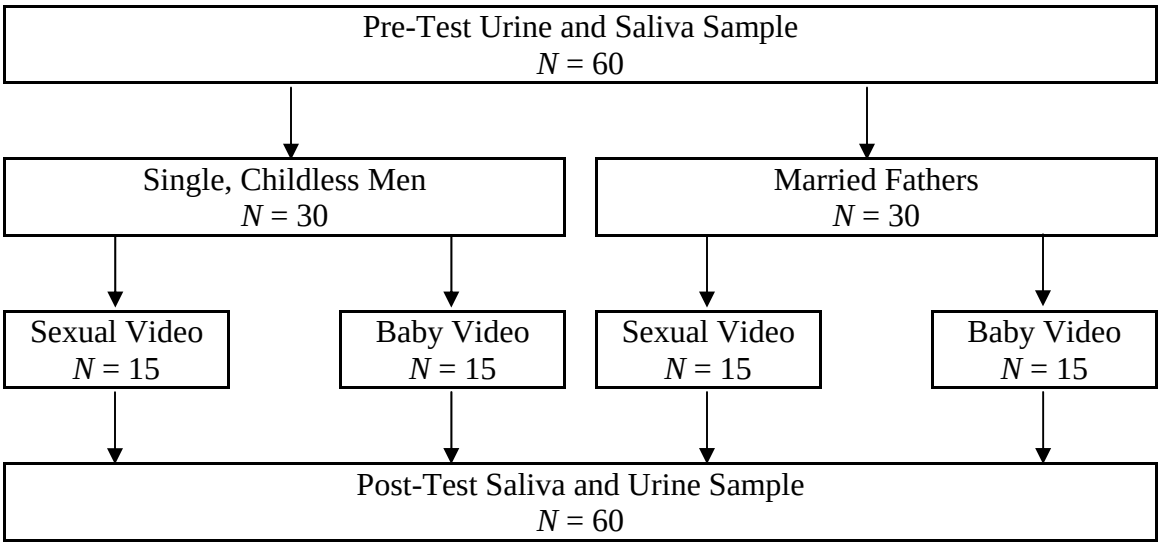


Figure 2. General Experimental Design

CHAPTER 7

RESULTS

Overview

The results are divided into the following sections: Covariation; Baseline Hormone Levels; Hormone Responses as a Function of Relationship/Parental Status and Video Condition; Relationship of Psycho-Social Variables to Baseline Hormones, Hormone Responses, and Relationship/Parental Status; Digit Ratio. In the Covariation section, background variables are examined in terms of their relationship to hormonal DVs (baseline hormone levels and post-experimental paradigm hormone responses), as well as in terms of their relationship to the IVs (relationship/parental status and video condition). Subjective responses to the videos are also investigated in terms of their potential relation to hormone responses. In the Baseline Hormone Levels section, the two relationship/parental status groups of men are compared in terms of their baseline T and AVP. In the Hormone Responses as a Function of Relationship/Parental Status and Video Condition section, tests of significance varying in the operationalization of the DV and covariates are presented. The Relationship of Psycho-Social Variables to Baseline Hormone Levels, Hormone Responses, and Relationship/Parental Status section does just what the title describes. Finally, the Digit Ratio section presents statistics addressing the potential relation of prenatal exposure to androgens and estrogens (operationalized through digit ratio variation) to this study's relevant DVs and IVs.

Covariation

Background Variables in Relation to Baseline Hormones

Background variables (age, ethnicity, BMI, education, drugs consumed before the study, sexual orientation, whether the participant had ever engaged in sexual intercourse, food/drink consumed before the study, sexual activity on the day of the study, the level of discomfort with receiving a needle, and days since orgasm) were investigated for potential associations with baseline T and AVP. Season was also investigated. Descriptive statistics for age, BMI, the level of discomfort with receiving a needle, and days since orgasm are presented in Table 2. Frequencies of ethnicity, education, drugs consumed before the study, sexual orientation, whether the participant had ever engaged in sexual intercourse, food/drink consumed before the study, sexual activity on the day of the study, and season are presented in Tables 3-6, respectively.

Correlation analyses were conducted between baseline hormones and all background variables, excluding ethnicity and season because these latter two are categorical variables with more than two levels. Drugs consumed before the study, if the participant ever engaged in sexual intercourse, food/drink consumed before the study, and sexual activity on the day of the study were coded dichotomously so that correlation analyses could be performed. Among all background variables (excluding ethnicity and season), there was only one significant correlation. Specifically, there was a significant negative correlation between education and baseline T, $r(53) = -.30$, $p = .029$. Correlations for baseline hormones, hormone responses, and background variables (excluding ethnicity and season) are presented in Table 7.

Drugs consumed before the study is addressed in more detail here to clarify how responses were coded and analyzed. The types of drugs consumed varied considerably and thus were categorized into drug classes for ease of comparisons, as shown in Table 4. The drug classes included narcotics, stimulants, hallucinogens, antidepressants, and anti-anxiety medications. Both marijuana and alcohol were the substances consumed most frequently 24 hours prior to the experiment, whereas marijuana alone was the most frequently consumed drug 30 days prior to the experiment. No one listed alcohol consumption for the 30 days prior to the experiment, clearly because they failed to identify it as a drug, which is how the item was written. Drugs consumed by a small minority but not reported in Table 4 include prescription medications such as Metformin for diabetes, Uroxatral for enlarged prostate, Sumatriptan for migraine, etc.

Only marijuana was examined for a relationship with baseline T and AVP because it was the most frequently used drug. Responses for marijuana use were coded as a dichotomy: ‘yes’ or ‘no’, and this was done for usage 24 hours prior to the study in addition to 30 days prior. Then these responses were examined for significant correlations with baseline T and AVP. There was, however, no significant correlation between baseline T or AVP and marijuana consumed in the last 24 hours, or between baseline T or AVP and marijuana consumed in the last 30 days, ps > .05.

The relationship between the two remaining background variables, ethnicity and season, and baseline hormones were investigated as follows. A one-way ANOVA revealed that there was a significant difference in baseline T among the ethnic groups, $F(5, 49) = 10.84$, $p < .001$. Post-hoc, alpha-adjusted, Bonferroni pairwise comparisons revealed that African Americans, who had the highest baseline T levels differed

significantly from the multiracial group who had the lowest baseline T levels ($p < .001$), but also from Caucasians, the group with the second highest baseline T, $p < .001$.

A one-way ANOVA revealed no significant difference among the six ethnic groups in terms of baseline AVP, $F(5, 53) = .54$, $p = .749$. Descriptive statistics for baseline T and AVP by ethnicity are presented in Table 8.

In terms of season, one-way ANOVAs revealed no significant difference in baseline T or AVP as a function of season, *p*s >.05.

Background Variables and Video Responses in Relation to Hormone Responses

Background variables, as well as season, were investigated for potential associations with percent change in T and AVP regardless of relationship/parental condition or video condition. None of the background variables were significantly correlated with percent change in T or AVP, *p*s >.05. Correlations for hormone responses and background variables are presented in Table 7. One-way ANOVAs revealed no significant differences in percent increase in T or AVP as a function of season or ethnicity, *p*s >.05.

Two responses that pertained to each video were examined for their potential link with hormone responses, which entailed first splitting participants according to the video they viewed. In terms of the sexual video, attitude towards pornography, and how much the video sexually aroused the participant were examined. There was a significant positive correlation between percent increase in T and how much participants like pornography, $r(25) = .40$, $p = .037$. There was a significant negative correlation between percent increase in AVP and how much participants like pornography, $r(27) = -.50$, $p = .005$. Correlations for hormone responses and the two item responses that pertain to the sexual video are presented in Table 9.

In terms of the baby video, the level of discomfort with seeing someone else receive a needle, and how much participants experienced an urge to soothe the crying babies in the video were examined. There were no significant correlations between either of these responses and percent increase in either hormone, *p*s > .05. Correlations for hormone responses and the two item responses that pertain to the baby video are presented in Table 10.

Differences in Background Variables between Relationship/Parental Statuses and between Video Conditions

Married fathers were compared to single, childless men to investigate whether there were any group differences on the background variables, as well as season. There was a significant difference between the two groups of men for age, BMI, and education. Specifically, the married fathers were significantly older, $t(58) = 5.55$, $p < .001$, had significantly higher BMI, $t(58) = 2.25$, $p = .028$, and had marginally significantly more education than the single, childless men, $t(58) = 1.94$, $p = .057$. There was no significant difference between the two groups of men in terms of sexual orientation, and days since orgasm, *p*s > .05. Substantially more single, childless men than married fathers consumed marijuana before the study, whereas other drugs consumed were relatively evenly distributed between the two groups of men. Substantially more single, childless men than married fathers participated in the winter, and substantially more married fathers than single, childless men participated in the spring. The distribution of ethnicities, food/drink consumed before the study, and whether participants engaged in sexual activity on the day of the study were relatively even between the two groups of men. The only remaining

background variable is virginity, and in that regard there were four virgins, all of whom were obviously among the single, childless men.

In addition, men in the sexual video condition were compared to men in the baby video condition to check for differences in background variables and season that might have occurred despite the attempt to randomize into video condition. One-way ANOVAs revealed no significant differences between the men in the video conditions in terms of age, BMI, education, sexual orientation, needle discomfort, and days since orgasm, *p*s > .05. An examination of frequency data revealed relatively few differences between the videos' viewers in terms of ethnicity, drugs consumed 24 hours and 30 days prior to the study, virginity, food/drink consumed before the study, whether participants engaged in sexual activity on the day of the study, and season.

Covariation Summary

In sum, in terms of baseline hormones, baseline T had a significant negative correlation with education. In terms of hormone responses, there was a significant positive correlation between percent increase in T and attitude towards pornography, and a significant negative correlation between percent increase in AVP and attitude towards pornography. In terms of differences in background variables between relationship/parental conditions and between video conditions, married fathers were significantly older, had a significantly higher BMI, and had marginally significantly more education than the single, childless men. More single, childless men than married fathers consumed marijuana before the study, and more single, childless men participated in the winter, whereas more married fathers participated in the spring. Although the ANCOVA results have not yet been presented, it is noted upfront that none of these variables, when

separately entered as covariates, revealed significant main effects or interactions, *p*s > .05. As such, these variables are excluded from the final set of analyses presented in the following sections.

Finally, as mentioned in the methods, the sexual video was reported to be significantly more pleasant than the baby video, but there was no difference between the videos in terms of intensity or emotion scores. When pleasantness scores were entered as a covariate, they did not reveal significant main effects or interactions, *p*s > .05, and are therefore also excluded from the final set of analyses.

Baseline Hormone Levels

There was no significant difference between the single, childless men and the married fathers in terms of baseline T, $t(53) = .78$, $p = .436$, or baseline AVP, $t(57) = .18$, $p = .857$. As a side note, but still of interest given the relationship between T and AVP in reproductive behaviors, there was no significant correlation between baseline T and AVP, $r(53) = .19$, $p = .157$. Descriptive statistics for baseline T and AVP are presented in Table 11.

Hormone Responses as a Function of Relationship/Parental Status and Video Condition

Four different types of ANOVAs/ANCOVAs were run varying in dependent variable operationalization (post-video hormone levels or percentage change in hormone levels from pre- to post-video) and covariates as follows:

T2 and AVP2 as DVs with T1 and AVP1 as Covariates, Respectively

Descriptive statistics for pre- and post-video hormone values for the sexual video are presented in Table 12, and the same statistics for the baby video are presented in Table 13. The covariate, T1, was significantly related to the DV, T2, $F(1, 47) = 48.39$, $p < .001$. An ANCOVA for T yielded no main effects for status, $F(1, 47) = .36$, $p = .550$, or video, $F(1, 47) = .00$, $p = .954$, and no status by video interaction, $F(1, 47) = .78$, $p = .383$. The covariate, AVP1, was significantly related to the DV, AVP2, $F(1, 53) = 37.04$, $p < .001$. An ANCOVA for AVP yielded no main effects for status, $F(1, 53) = .58$, $p = .451$, or video, $F(1, 53) = 3.09$, $p = .085$, and no status by video interaction, $F(1, 53) = .02$, $p = .884$.

Percent Increase in T and AVP as DVs

ANOVA's were conducted using percent increase in T and AVP as the DVs. There were no main effects for status or video, and no status by video interaction, *p*s > .05. Error bars with 95% confidence intervals for the percent increase in T and AVP are presented in Figures 3 and Figure 4, respectively.

T2 as the DV with T1 and AVP1 as Covariates; also AVP2 as the DV with AVP1 and T1 as Covariates

ANCOVAs were conducted, with the baseline value for the hormone not being directly examined added as a covariate. That is, baseline AVP was added as a covariate in examining T responses, and baseline T was added as a covariate in examining AVP responses. The rationale was that group differences in one hormone response may only be apparent for those who have a low or high level of the other hormone. However, these

added covariates were not significantly related to the DVs, and there were no significant main effects or interactions, *p*s > .05.

T2 as the DV with T1 and Percent Increase in AVP as Covariates; also AVP2 as the DV with AVP1 and Percent Increase in T as Covariates

ANCOVAs were conducted with the percent increase of the hormone not being directly examined added as a covariate in addition to the baseline level of the hormone being directly examined. To clarify, when differences in T2 were examined using T1 as a covariate, the percent increase in AVP was also added as a covariate. Similarly, when differences in AVP2 were examined using AVP1 as a covariate, the percent increase in T was also added as a covariate. However, these added covariates were not significantly related to the DVs, and there remained no significant main effects or interactions, all *p*s > .05.

ANOVAs for Those who Experienced the Largest Endocrine Change

A procedure was employed that was similar to what Josephs, Sellers, and Newman (2006) used when they divided participants' baseline levels of T into thirds for examining high and low T individuals paired with high and low status positions. Specifically, participants in the current study were split according the video they viewed, and then for each of these two groups the percent increase in T was divided into thirds: the greatest percent increase, the greatest percent decrease, and the least change in either direction. The same procedure was repeated for percent increase in AVP. Then, 2x2 ANOVAs were conducted for percent increase in T and AVP, but there were no significant main effects for status or video, and no significant status by video interactions, *p*s > .05.

Hormone Responses for Combined Status Groups, and then Combined Videos

To test for within subject effects, a series of dependent samples *t* tests were carried out to examine possible changes in T and AVP when the two status groups were combined, and then when the two video groups were combined. When the single, childless men and the married fathers were combined, there was a significant decrease in AVP from AVP1 to AVP2 for the sexual video, $t(27) = 4.33$, $p < .001$, and for the baby video, $t(29) = 5.52$, $p < .001$. When the video conditions were combined, there was a significant decrease in AVP from AVP1 to AVP2 for the single, childless men, $t(28) = 4.43$, $p < .001$, and the married fathers, $t(28) = 5.85$, $p < .001$. In other words, AVP decreased from Time 1 to Time 2 regardless of status or condition. When these four *t* tests were performed for T, none were statistically significant, *p*s > .05.

Relationship of Psycho-Social Variables to Baseline Hormone Levels, Hormone Responses, and Relationship/Parental Status

Descriptive statistics for the SOI, EPSI, and BSFI are presented in Table 14, and descriptive statistics for the DAS-7, relationship length, child characteristics, and paternal investment are presented in Table 15.

Relationship between Baseline Hormone Levels and Psycho-Social Variables

There was no significant correlation between the baseline values of either hormone and any of the psycho-social variables, *p*s > .05. Correlations for baseline hormones and psycho-social variables are presented in Table 16.

Relationship between Hormone Responses and Psycho-Social Variables

Sexual Video Condition

For the following analyses, only data from those who viewed the sexual video were used. There was a significant negative correlation between percent increase in AVP and age of youngest child, $r(11) = -.66$, $p = .013$, such that the older the youngest child was the lower the AVP increases. There were no other significant correlations between hormone responses for the sexual video and the SOI, EPSI, BSFI, DAS-7, relationship length, child characteristics, or paternal investment, ps > .05. Correlations for hormone responses and psycho-social variables for those who viewed the sexual video are presented in Table 9. When age of youngest child was entered as a covariate in one-way ANCOVAs, it did not reveal a significant difference between the single, childless men and the married fathers in terms of T or AVP response, ps > .05.

Baby Video Condition

For the following analyses, only data from those who viewed the baby video were used. There was a significant negative correlation between percent increase in T and age of youngest child, $r(9) = -.69$, $p = .020$, such that the older the youngest child the smaller the T increases. There were no other significant correlations between hormone responses for the baby video and the SOI, EPSI, BSFI, DAS-7, relationship length, child characteristics, or paternal investment, ps > .05. Correlations for hormone responses and psycho-social variables for those who viewed the baby video are presented in Table 10. When age of youngest child was entered as a covariate in one-way ANCOVAs, it did not reveal a significant difference between the single, childless men and the married fathers in terms of T or AVP response, ps > .05.

Differences between the Single, Childless Men and the Married Fathers in Psycho-Social Variables

One-way ANOVAs revealed no significant differences between the single, childless men and the married fathers with respect to the SOI, EPSI, and BSFI, *p*s > .05. Note that differences in the DAS-7, relationship length, child characteristics, and paternal investment could obviously not be examined between these two groups of men.

Digit Ratio

The focus of the current study was on the relationship between adult hormone levels and reproductive behaviors. The following section on digit ratio is a separate and brief examination of the relationship between prenatal hormone levels and adult hormone levels, and between prenatal hormone levels and reproductive efforts. The single, childless men and the married fathers had the same mean and standard deviation in digit ratio: $M = .95$, $SD = .03$. There was no significant correlation between digit ratio and baseline T or AVP, *p*s > .05. In terms of hormone responses in the sexual video condition, there was a significant negative correlation between digit ratio and percent increase in T to the sexual video, $r(24) = -.39$, $p = .047$, such that higher T increases were linked with lower digit ratio. In terms of hormone responses in the baby video condition, there were no significant correlations between digit ratio and percent increase in T or AVP, *p*s > .05. Correlations for digit ratio and hormone responses with the sexual video and the baby video are presented in Table 9 and Table 10, respectively. Finally, there were no significant correlations between digit ratio and any of the psycho-social variables, *p*s > .05.

CHAPTER 8

DISCUSSION

Baseline Hormone Levels

There was no significant difference in baseline T between the single, childless men and the married fathers. Therefore, the hypothesis that baseline T would be higher in single, childless men than in married fathers was not supported. This result is inconsistent with other studies that have found higher T in unmarried men versus married men (e.g., Booth & Dabbs, 1993; Gray et al., 2002), and higher T in paired versus unpaired men (e.g., Gray et al., 2004; Maestripieri, Barani, Sapienza, & Zingales, 2010). Booth and Dabbs (1993) had a sample size that numbered in the thousands, and if the difference in T is small between married versus unmarried men, then it may take larger samples than those in the current study to reliably detect such a difference. The studies by Gray et al. (2002) and Gray et al. (2004) reported significantly lower T in paired/married men, but only in evening T samples. Similarly, Berg and Wynne-Edwards (2001) found lower T in fathers versus non-fathers, but only in evening samples. If the difference in T between paired men/fathers and unpaired men/single men is more likely to be detected in the evening, then perhaps the saliva samples in the current study were not obtained late enough in the day. Single, childless men and married fathers may engage in different evening activities, but both groups of men probably engage in the same early morning activity, i.e. sleep. Differences in evening activities and environments may be related to differences in baseline T. For example, single, childless men may be more likely to spend evenings in competitive leagues such as softball or engaging in mating efforts, such as dating. Married fathers of young children may be more likely to be at home interacting

with their young children. Furthermore, ours is not the only study that failed to detect a significant difference in T between paired and unpaired men (e.g., Sakaguchi et al, 2006). It should be noted that in even in the latter study, T was marginally lower for the paired men, but only for the evening sample. Judging from all available studies, including the current one, it appears that the difference in baseline T between single, childless men and married fathers may be significant, albeit small, and more likely to be detected in the evening.

There was no significant difference in baseline AVP between the single, childless men and the married fathers. Therefore, the hypothesis that baseline AVP would be higher in married fathers than in single, childless men was not supported. The null result is consistent with Gray et al. (2007) who also failed to observe a difference in baseline AVP between single men and fathers. No published study to date has found a difference in baseline AVP between such groups of men. A failure to link AVP with mating/parenting efforts might be explained by methods. For example, Young et al. (1998) predicted that AVP (and oxytocin) are the endocrine bases of monogamy in different mole species, but the current study attempted to link AVP with mating/parenting efforts within a single species (humans). Furthermore, Young et al. (1998) predicted AVPR1a receptor distribution to be part of what differentiates male mating/parenting efforts among vole species. Possibly, variation in human reproductive efforts may be linked more with AVPR1a receptor distribution than levels of AVP. Indeed, the most convincing link between an AVP characteristic and reproductive effort (mating effort) in humans was found by Walum et al. (2008) who reported that marital status and quality were related to variations in AVPR1a phenotype. Research on the relationship between

human AVP and reproductive status and efforts is in its infancy and further studies are required to elucidate AVP's role in human reproduction.

Hormone Responses

For those who viewed the sexual video, there was no significant difference in T response between the single, childless men and the married fathers, and no significant change in T when all men were combined into one group. Therefore, the hypothesis that sexual stimuli would increase men's T, especially for single, childless men, was not supported. This null finding is inconsistent with studies that have linked exposure to audiovisual sexual stimuli with an increase in T (e.g., Pirke et al., 1974; Hellhammer et al., 1985; Stoléru et al., 1999), but consistent with studies that failed to make such a link, (e.g., Rowland et al., 1987; Carani et al., 1990). One consideration is that the context in which sexual stimuli are presented may have differential effects on men's hormone responses. More men may experience an increase in T to sexual stimuli in the comfort of their own home versus in a novel and arguably less relaxing environment, such as a lab. Indeed, context may have particular relevance when it comes to humans and sex since humans are one of the few (if not the only) species that go out of their way to have sex in private. This interpretation may help contextualize the null results of the current study, and the mixed results of previous studies on the effect of sexual stimuli on T responses.

Furthermore, with respect to those who viewed the sexual video, there was no significant difference in AVP response between the single, childless men and the married fathers. However, there was a significant decrease in AVP for the two groups of men combined. Therefore, the hypothesis that sexual stimuli would increase men's AVP,

especially for the single, childless men, was not supported. The lack of an observed difference in AVP response between the two groups of men may be attributable to the post-video urine sample having been collected too soon after exposure to the stimulus. Unlike lipid-soluble T, which quickly passes though cell membranes, AVP responses may take longer until detection is possible in urine. In terms of the overall decrease in AVP, this may have been due to AVP's antidiuretic properties. Specifically, participants were asked in advance to consume water before they arrived for the experiment, and then were given an additional 500mL of water to drink once they did arrive. The increase in participants' bodily water volume may have caused the decrease in AVP. The result is inconsistent with Murphy et al. (1987) who found men's AVP to increase significantly with sexual arousal but decrease before orgasm was reached. On the other hand, our results are consistent with Krüger et al. (2003) who did not observe a significant change in men's AVP to sexual arousal or orgasm. Noteworthy is that both of these studies measured AVP concentrations in blood rather than in urine. Overall, it is possible that sexual stimuli have a limited effect on men's AVP response, but there has been insufficient research to draw any such conclusion.

For those who viewed the baby video, there was no significant difference in T response between the single, childless men and the married fathers, and no significant change in T when all men were combined into one group. Therefore, the hypothesis that crying baby stimuli would decrease men's T, especially for married fathers, was not supported. No published studies have examined T responses to audiovisual clips of crying babies. The null finding in the current study is inconsistent with Berg and Wynne-Edwards (2001) who linked parenting stimuli with a decrease in T, and with Storey et al.

(2000) who linked parenting stimuli with an increase in T. However, the current finding is consistent with Gray et al. (2007) who observed no significant change in fathers' T consequent to interacting with their children. The null results in the current study and the mixed results of previous studies that investigated the link between T and paternal efforts in men suggest that this relationship may not be as strong as the one between T and men's mating efforts. Whereas the latter link has drawn much support (e.g., Archer, 2006), the link between T and paternal investment has not been as reliably observed across vertebrates (Hirschenhauser & Oliveira, 2006).

Furthermore, with respect to those who viewed the baby video, there was no significant difference in AVP response between the single, childless men and the married fathers. However, there was a significant decrease in AVP for the two groups of men combined. Therefore, the hypothesis that crying baby stimuli would increase men's AVP, especially for married fathers, was not supported. Again, the lack of an observed difference in AVP response between the two groups of men may have been due to the post-video urine sample having been collected too soon, and the overall decrease in AVP may have been due to AVP's antidiuretic properties. To date, no published studies have examined AVP responses to parenting stimuli, probably because AVP is still relatively new to behavioral endocrinology. Overall, it is possible that parenting stimuli have a limited effect on men's AVP response, but more research would be required to draw such a conclusion with any degree of certainty.

Psycho-Social Variables

There was no significant link between baseline T or AVP and any of the psycho-social variables. However, there were two significant links between hormone responses and psycho-social variables. Furthermore, both of these links pertained to the same psycho-social variable: age of the participant's youngest child. Each of these two relationships is discussed as follows.

For those who viewed the sexual video, there was a significant negative correlation between percent increase in AVP and age of youngest child. This relationship was in the opposite direction of what someone might hypothesize (if the assumption is that AVP facilitates parenting efforts more than mating efforts in fathers). That is, if AVP is linked with paternal care, then it might be adaptive for fathers of younger children, who are in need of intense proximate care, to exhibit a lower increase in AVP to sexual stimuli. Conversely, if AVP does indeed facilitate mating effort, then fathers of younger children may experience a larger increase in AVP to sexual stimuli, given that couples engage in less sexual activity during the months after birth compared to before pregnancy (Gray & Anderson, 2010). Thus, fathers of younger children may not be engaging in as much sexual activity as they would like, and sexual stimuli may trigger AVP release to facilitate mating effort.

For those who viewed the baby video, there was a significant negative correlation between percent increase in T and age of youngest child. Again, the relationship was in the opposite direction of what someone might hypothesize. That is, if T is predicted to work in the opposite direction of paternal investment, it might be hypothesized that T decreases more when intense proximate care is needed; when offspring are younger.

Conversely, T may also be linked with the type of aggression that is needed to protect offspring from, for example, a predator or someone who intends to harm the child. In that case, a crying baby may stimulate a rise in T. The result of the current study is somewhat consistent with Storey et al. (2000) in which the early postnatal group experienced a significant increase in T to baby stimuli, whereas the late postnatal group did not. Taken together, the inverse correlations between hormone responses and age of youngest child may reflect spurious effects. However, this psycho-social variable is gaining importance for its relationship with hormones in reproductive contexts (e.g., Gray et al., 2007).

Links among psycho-social variables were not the focus of the current study, but three of them are briefly discussed here to help elucidate the relationship between the mating and parenting domains of human reproduction. There was a significant positive correlation between paternal investment and both marital adjustment, $r(28) = .51$, $p = .004$, and sexual function, $r(28) = .38$, $p = .037$. There was also a significant positive correlation between marital adjustment and sexual function, $r(28) = .50$, $p = .005$. These links may suggest that efforts in one domain of reproduction do not necessarily occur at the cost of efforts in the other domain. Indeed, efforts in one domain may actually facilitate efforts in the other. However, marital adjustment may reflect a particular type of mating effort, because committing sexual infidelity may also be classified as mating effort but one with a negative impact on paternal investment. Of notable interest is that sexual function was linked with both mating and parenting efforts. Conceivably, positive marital adjustment is part of a direct consequence to positive sexual function, and paternal investment is part of an indirect consequence of positive sexual function.

Digit Ratio

Among baseline hormones, hormone responses, and psycho-social variables, there was only one significant correlation with digit ratio. That is, for those who viewed the sexual video, there was a significant negative correlation between digit ratio and percent increase in T, such that larger T increases were linked with lower estradiol:testosterone ratios. Possibly, a lower prenatal estradiol-testosterone ratio is linked with larger adult T increases to sexual stimuli. In other words, more male-typical prenatal hormone ratios may be linked with more male-typical adult hormone responses. In terms of the organizational/activational hypothesis (discussed in Chapter 1), the current finding may suggest continuity in the developmental trajectory from early organizational effects to later activational effects of steroid hormones.

Implications

The current study has several implications. These include the sensitive nature of the testis in responding to social stimuli, the current state of hormone-behavior literature, and methodological issues involved in the measurement of hormone responses to reproductive stimuli. Each is discussed as follows.

One implication is that despite reasonable experimental control in the current study, the large variation in hormone responses within groups points to the potential sensitivity of the male testis to biological, social, and environmental stimuli. T influences, and is influenced by, a number of internal and external factors; these multifactorial links may explain the range of T responses in the current study. One married father experienced a 176% increase in T to the sexual video, while one single, childless man experienced a

54% decrease. There may have been other stimuli influencing T responses during those 15 minutes, or there were delayed effects of influences that occurred prior to the study, or there was significant variation in participants' reactions to the same sexual stimuli. Such variation may help explain why results have been equivocal in other studies that have examined hormone responses to various stimuli. Although the current study does not directly address this, a host of physiological, behavioral, and environmental factors seem to simultaneously interact to create such variation.

Another implication concerns the current state of the hormone-behavior literature. First, only significant results tend to get published. As a result, hormone-behavior relationships may get overstated because for every one study that finds a hormone-behavior effect, there may be numerous studies that do not. Second, effect sizes tend to be small for human hormone-behavior links. As an example that speaks to both of these latter two points, the meta-analysis on the link between T and aggression conducted by Book et al. (2001) reported small effect sizes (Rosenthal *r* values of approximately .1 or less) for many of the dozens of studies they reviewed. The authors went on to caution that the overall statistically significant, but weak positive correlation between T and aggression was possibly overstated because non-statistically significant studies were not included. Hence, results from hormone-behavior studies are often challenging to replicate, and although hormones are predictive of behavior, the predictive power appears to be quite limited. Third, published results in behavioral endocrinology often reflect inconsistent and contradictory notions. For example, Taylor (2006) linked both increases and decreases in social stress with high oxytocin.

Another implication concerns methodological issues. Real-world validity of experimental designs such as the one used in the current study is a perennial issue of concern. The videos in this study did not elicit significant group differences in hormone responses, but that does not necessarily mean that significant group differences do not occur in real-life social interactions. Eliciting mating/parenting responses by way of audiovisual stimuli may be an unstable affair with questionable validity, and the current study may have failed in this regard. The null results were possibly the result of not having used real-life, face-to-face interactions as stimuli. Although some studies have obtained significant endocrine responses with the use of audiovisual stimuli (e.g., Stoléru et al., 1999), real social contact may be more reliable. Face-to-face interactions are more direct, may be interpreted by the participant as being more important, and may require more of the participant's attention because the other individual's behavior is influenced by the participant. A variety of studies have shown human endocrine effects to real social interactions such as male-male competition (e.g., Steiner et al., 2010), and male-female conversation with eye contact (e.g., Roney et al., 2007). Skin-to-skin contact between individuals can also be considered a more proximate form of real social interaction, and there is evidence that this too can elicit endocrine responses. For example, prolactin and oxytocin change in response to breastfeeding (Svennersten-Sjaunja & Olsson, 2005), T can be released during sexual intercourse, (e.g., Dabbs & Mohammed, 1992), and oxytocin can even rise from petting a dog (e.g., Odeendaal & Meintjes, 2003).

Limitations

The current study had limitations, four of which are discussed as follows. One limitation was that a narrow range of content was used in each video to tap broad domains of reproductive behavior. Male mating efforts include a wide range of behaviors beyond sexual intercourse, such as seducing a woman with words, attracting a woman with wealth, gaining a woman's commitment to a relationship by making family plans for the future, etc. Likewise, parenting efforts include a wide range of behaviors beyond tending to a crying infant/toddler, such as playing with a child, teaching middle school algebra, protecting a child from a vicious dog, making a down payment on a son's/daughter's home, etc. The content of the videos was chosen for its proximate relationship with mating and parenting efforts, but the videos were obviously not fully representative of the reproductive stimuli that could potentially elicit a T or AVP response. As an added note with respect to the baby video, one possible limitation was that, although the babies were distressed and crying, the situation was clearly a beneficent one in which the children were receiving vaccinations for their protection. Videos in which the source of the child's distress is either more threatening may have been more competent stimuli to elicit parental responses from viewers.

Another limitation was that there was no control condition. An introductory psychology video, similar to the one used in the study, could have been used as a control video. There was a significant decrease in AVP for all groups involved, but as it stands, it is unclear if the sexual video and baby video both caused AVP to decrease, or if another variable such as the antidiuretic properties of AVP was responsible. Had group differences been observed, the study would have been extended to include a control

condition. Given the lack of results, however, the addition of a control condition was deemed unnecessary.

Another limitation is that there was no standardized pre-experimental experience for AVP, as there was for T. The first urine sample (for AVP assay) was collected soon after participants arrived for the experiment, whereas the first saliva sample (for T assay) was not collected until after they viewed the introductory psychology video (i.e. the standardized pre-experimental experience). Hence, this lack of control added another source of variance to the AVP results. However, this procedure was used to allow sufficient time for participants to urinate twice, but without committing them to well over an hour of time for the study.

A final limitation concerns general sampling issues. Multiple saliva and urine samples taken before and after the videos, at different intervals, would have increased the reliability of the hormone results. Also, as is always the case, a larger and more representative sample of participants would have increased statistical power and the ability to generalize results to the population, respectively. The current sample of participants was likely more educated than the general population since most of them were recruited on a university campus; a substantial number being professors. Furthermore, there were no single men with children, or married men without children. As such, the sample of participants only included men from two ends of a mating/parenting effort continuum. Surprisingly, though, differences between these two groups of men were not found.

Future Directions

Future studies might be enhanced by taking the limitations of the current study into consideration. Also, a within-subjects design in which each participant watches both the sexual video and the baby video would increase the statistical power to detect differences in hormone responses, though there would have to be provisions made for potential carry-over effects. Another consideration is that even though serum samples are more invasive to collect than saliva and urine samples, serum has the advantage of greater precision regarding the timing of post-test sample collection. As well, serum T and AVP samples would reflect measurements that were taken at the exact same time. More importantly, blood draws would also avoid the need for participants to urinate twice during an experiment, a need that adds the challenge of determining how much water participants should consume beforehand. Finally, blood draws would avoid the need to guess how long to wait until a change in AVP is optimally detected in urine.

A different direction for the endocrinology of human reproductive behavior would be to conduct more research on the relationship between reproductive efforts and the hormones oxytocin and prolactin, in both men and women. Oxytocin is involved in milk letdown during lactation and in uterine contractions during childbirth (Keverne & Kendrick, 1992). Oxytocin has also been shown to increase during orgasm (Carmichael et al., 1987). However, oxytocin might be best known for its role in bonding and attachment between individuals (Campbell, 2010). Given these relationships with oxytocin, it appears that this hormone has particular relevance to reproductive behaviors.

Prolactin is commonly known as the hormone that promotes lactation in nursing mothers (Svennersten-Sjaunja & Olsson, 2005). However, prolactin has also been linked

with paternal investment, and has been termed the "hormone of paternity" (Schradin & Anzenberger, 1999). Links between prolactin and paternal behavior have been observed in vertebrates (e.g., Buntin, Hnasko, Zuzick, Valentine, & Scammell, 1996), mammals (e.g., Gubernick & Nelson, 1989), and primates (e.g., Dixson & George, 1982), thus showing conservation across taxa. Yet examining the prolactin-paternal behavior link in men is still a relatively new area of inquiry (e.g., Gordon, Zagoory-Sharon, Leckman, & Feldman, 2010), and may prove to be fruitful.

Another future direction is to synthesize studies on particular aspects of reproductive effort by using a Tinbergen (1963) framework. For example, synthesizing the reasons that men commit sexual infidelity (a type of mating effort) may be achieved with a Tinbergen-like approach that includes four levels of analysis: (1) What are the proximate causes of men's sexual infidelity? That is, what genes, hormones, neurotransmitters, and immediate environmental stimuli trigger such behavior? (2) What are the developmental causes of men's sexual infidelity? In other words, what effects in organization/activation of neural substrates, epigenetic processes, life history, socialization, and learning explain men's sexual infidelity? (3) What are the phylogenetic causes of men's sexual infidelity? That is, what can fossil records and comparative research on extrapair copulations in other species reveal about the origins and causes of men's sexual behavior? (4) What are the distal causes of men's sexual infidelity? In other words, how were men's sexual infidelities (or extrapair copulations) evolutionarily adaptive during the ancestral past?

In closing, the concept of thresholds in hormone-reproductive behavior links seems important to highlight. Hormones do not cause behavior per se, but they may lower the threshold for when a given stimulus elicits a particular behavior (Nelson, 2005).

Assuming adequate levels of hormones are present, stimuli still need to be sufficiently strong to trigger endocrine-mediated behavioral responses. In a similar vein, there are instances when a minimum level of a hormone is required to influence a particular behavior, regardless of the strength of the stimulus, and variations in that hormone's level beyond the minimum threshold do not necessarily further affect behavior. For example, some minimum level of T is required for typical sexual function, but variations of T in the eugonadal range do not necessarily alter sexual function (Isidori et al, 2005). Conceivably, this principle might apply to the more general link between hormones and mating/parenting efforts. Hormones are continuous variables, but their effect on human reproductive behavior may not be linear.

TABLE 1

Responses that Pertain to the Videos

	Single, Childless *N* = 30		Married Fathers *N* = 30		All Men *N* = 60	
	M	*SD*	*M*	*SD*	*M*	*SD*
Sexual Video						
How much Ss likes pornography	7.53	1.46	6.60	2.29	7.07	1.95
How arousing was the video?	22.80	6.86	24.07	7.35	23.43	7.02
How intense was the video?	3.87	2.70	3.87	2.23	3.87	2.43
How emotional was the video?	4.60	2.85	4.60	2.35	4.60	2.57
How pleasant was the video?	7.13[a]	1.51	5.73[a]	1.39	6.43	1.59
Baby Video						
Discomfort seeing a needle given	3.00[b]	1.85	4.97[b]	2.57	3.98	2.42
Extent of urge to soothe babies	22.40[c]	10.08	30.13[c]	7.34	26.27	9.52
How intense was the video?	4.29	3.00	5.23	2.50	4.78	2.74
How emotional was the video?	4.86	2.82	5.83	2.52	5.36	2.67
How pleasant was the video?	3.43[d]	2.17	2.23[d]	1.15	2.81	1.79

Note: One single, childless man did not report scores for intensity, emotionality, and pleasantness for the baby video; thus $N = 14$ for those items. [a b c d] Represent significant differences between the single, childless men and the married fathers, $ps < .05$.

TABLE 2

Descriptive Statistics for Age, BMI, Needle Discomfort, and Days since Orgasm

	Single, Childless *N* = 30		Married Fathers *N* = 30		All Men *N* = 60	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	25.87	4.64	32.53	4.67	29.20	5.71
BMI	25.56	3.78	28.04	4.68	26.80	4.40
Needle Discomfort	3.05	2.27	2.53	1.83	2.79	2.06
Days since Orgasm	3.30	6.29	2.30	1.91	2.80	4.64

TABLE 3

Frequencies of Ethnicities and Education Levels

	Single, Childless *N* = 30	Married Fathers *N* = 30	All Men *N* = 60
Ethnicity			
White	17	23	40
Black	5	4	9
Hispanic	3	1	4
Asian	1	0	1
Other	0	1	1
Multiracial	4	1	5
Total	30	30	60
Education			
High School	17	12	29
Bachelor's	10	9	19
Master's	2	5	7
Doctoral	1	4	5
Total	30	30	60

TABLE 4

Frequencies of Drugs Consumed Before the Study

	Single, Childless *N* = 30	Married Fathers *N* = 30	All Men *N* = 60
Drugs in Last 24 Hours			
Marijuana	5	2	7
Alcohol	2	4	6
Narcotic	1	1	2
Stimulant	2	0	2
Hallucinogen	0	0	0
Antidepressant	1	0	1
Antianxiety	0	1	1
Drugs in Last 30 Days			
Marijuana	10	3	13
Alcohol	0	0	0
Narcotic	3	4	7
Stimulant	3	1	4
Hallucinogen	1	0	1
Antidepressant	3	0	3
Antianxiety	2	2	4

TABLE 5

Frequencies of Sexual Orientations and Virginity

	Single, Childless *N* = 30	Married Fathers *N* = 30	All Men *N* = 60
Sexual Orientation			
Exclusively heterosexual	26	27	53
Heterosexual, incidentally homosexual	2	3	5
Heterosexual, more than incidentally homosexual	1	0	1
Bisexual	1	0	1
Homosexual, more than incidentally heterosexual	0	0	0
Homosexual, incidentally heterosexual	0	0	0
Exclusively homosexual	0	0	0
Total	30	30	60
Ever had sexual intercourse?			
Yes	26	30	56
No	4	0	4
Total	30	30	60

TABLE 6

Frequencies of Food/Drink and Sexual Activity before the Study, and Season of Participation

	Single, Childless *N* = 30	Married Fathers *N* = 30	All Men *N* = 60
Food/drink within the hour before the study?			
Yes	3	2	5
No	27	28	55
Total	30	30	60
Sexual activity on the day of the study?			
Yes	2	3	5
No	28	27	55
Total	30	30	60
Season of Participation			
Fall	7	7	14
Winter	22	9	31
Spring	1	14	15
Total	30	30	60

TABLE 7

Spearman Correlations for Baseline Hormones, Hormone Responses, and Background Information

	T1	% Increase T	AVP1	% Increase AVP	Age	BMI	Education	Marij. 24 Hrs Prior	Marij. 30 Days Prior	Sex. Orientn.	Virginity	Food/Drink Prior	Sex. Prior	Needle Discomfort	Days Since Orgasm
T1	--	-.31*	.19	-.12	-.17	.02	-.30*	.00	-.13	-.12	.11	.05	.09	-.17	.04
% Increase T		--	.16	.07	.02	-.15	.18	-.05	-.08	.21	.09	-.19	-.13	.18	-.18
AVP1			--	-.02	-.02	.05	-.07	-.09	.01	.21	.12	-.08	-.00	.12	-.09
% Increase AVP				--	.11	.07	.19	.11	-.04	-.08	.02	-.22	.02	.00	-.02
Age					--	.14	.46***	.18	.29*	.28*	-.39**	-.10	.00	-.04	.01
BMI						--	-.11	-.09	-.01	.11	-.26*	-.18	-.23	-.15	-.09
Education							--	.12	.11	.10	-.16	.00	.04	.24	-.06
Marij. 24 Hrs Prior								--	.57***	-.20	.10	.14	.08	-.09	.24
Marij. 30 Days Prior									--	-.07	-.02	.01	-.01	-.16	.20
Sex. Orientn.										--	-.10	-.14	-.25	.05	-.31*
Virginity											--	-.08	.08	.10	.07
Food/Drink Prior												--	.21	-.17	.21
Sex. Prior													--	-.07	.38**
Needle Discomfort														--	-.42**
Days Since Orgasm															--

Note: Correlations for Percent Increase in T and AVP reflect all men regardless of relationship/parental condition and video condition.
*$p > .05$, **$p > .01$, ***$p < .001$

TABLE 8

Baseline T and AVP by Ethnicity

	T (pg/mL saliva)			AVP (pg/mg creatinine)		
	N	*M*	*SD*	*N*	*M*	*SD*
Ethnicity						
White	36	144.76	79.83	40	18.39	15.13
Black	8	386.10	148.65	8	16.94	12.59
Hispanic	4	121.61	35.42	4	19.42	15.14
Asian	1	118.13	.	1	27.70	.
Other	1	126.23	.	1	36.95	.
Multiracial	5	115.16	23.46	5	24.78	18.49
Total	55	174.67	122.32	59	20.81	18.87

TABLE 9

Spearman Correlations for Hormones, Psycho-Social Variables, and Responses that Pertain to the Sexual Video

	T1	% Increase T	AVP1	% Increase AVP	2D:4D	SOI	EPSI	BSFI	DAS-7	Yrs in Relnp.	Yrs Married	# of Children	Age of Youngest	Paternal Invest.	Like Porn.	Sex. Arousal
T1	--	-.39*	.15	-.28	.41*	-.04	.08	.06	-.55*	.09	.28	.43	.59*	-.17	.11	-.42*
% Increase T		--	.16	-.09	-.39*	-.19	.05	-.20	-.13	-.29	-.05	.07	-.10	-.36	.41*	.08
AVP1			--	.02	.04	-.01	.10	.22	-.14	-.16	.10	.20	-.08	-.04	.20	-.04
% Increase AVP				--	-.15	.12	-.28	-.05	.50	-.27	-.29	-.15	-.66*	.11	-.50**	.24
2D:4D					--	-.09	-.19	.24	-.09	.22	.19	.46	.02	.31	-.06	-.36
SOI						--	.53**	.27	.29	-.20	-.04	-.58*	.25	-.27	-.14	-.05
EPSI							--	.10	-.08	.01	.34	.02	.44	-.22	.29	-26
BSFI								--	.56*	-.18	-.03	-.05	-.10	.36	.10	-.19
DAS-7									--	-.28	-.43	-.54*	-.22	.45	-.21	.17
Yrs in Relnp.										--	.75**	.31	.03	.18	.20	.04
Yrs Married											--	.44	.25	-.22	.48	-.11
# of Children												--	-.04	.03	.06	-.12
Age of Youngest													--	-.32	.36	-.18
Paternal Invest.														--	-.02	-.25
Like Porn.															--	-.12
Sex. Arousal																--

Note: 'Age of Youngest' refers to age of youngest child. *$p > .05$, **$p > .01$, ***$p < .001$

TABLE 10

Spearman Correlations for Hormones, Psycho-Social Variables, and Responses that Pertain to the Baby Video

	T1	% Increase T	AVP1	% Increase AVP	2D:4D	SOI	EPSI	BSFI	DAS-7	Yrs in Relnp.	Yrs Married	# of Children	Age of Youngest	Paternal Invest.	Seeing Needle	Urge to Soothe
T1	--	-.23	.17	.11	.02	-.12	-.15	.07	.05	-.40	-.58*	-.37	-.08	.04	-.14	.31
% Increase T		--	.13	.26	.04	-.01	-.07	.11	.37	.05	-.32	.06	-.69*	.13	.10	.22
AVP1			--	.01	.33	-.14	-.08	-.18	.17	.27	.06	-.17	-.10	.10	.32	-.17
% Increase AVP				--	.08	-.08	-.33	.30	.13	-.15	-.07	-.01	-.01	.02	.49*	.31
2D:4D					--	-.02	.05	-.15	-.25	-.04	.01	-.17	-.41	-.13	.17	-.03
SOI						--	.75***	-.10	.17	.09	-.16	-.18	.33	.24	-.35	-.24
EPSI							--	-.17	.20	.14	-.10	-.04	.18	.26	-.23	-.15
BSFI								--	.54*	-.27	-.40	.03	-.33	.29	-.22	-.03
DAS-7									--	-.02	-.21	.18	-.33	.51	-.19	.15
Yrs in Relnp.										--	.81***	.68**	.36	-.10	-.01	.16
Yrs Married											--	.48	.53	-.13	.19	-.02
# of Children												--	-.10	-.16	-.09	.11
Age of Youngest													--	-.18	.21	.03
Paternal Invest.														--	-.01	.06
Seeing Needle															--	.39*
Urge to Soothe																--

Note: 'Age of Youngest' refers to age of youngest child. 'Seeing Needle' refers to discomfort with seeing another individual receive a needle. *p > .05, **p > .01, ***p < .001

TABLE 11

Baseline T (pg/mL saliva) and AVP (pg/mg creatinine)

	N	Min.	Max.	*M*	*SD*
Single Men					
T1	28	58.13	527.93	187.42	131.80
AVP1	30	0.00	63.70	19.63	16.60
Married Men					
T1	27	55.23	577.62	161.45	112.61
AVP1	29	0.00	50.43	18.92	12.97
All Men					
T1	55	55.23	577.62	174.67	122.32
AVP1	59	0.00	63.70	19.28	14.80

Note: Although 30 single, childless men and 30 married fathers were tested, not all assays provided a result.

TABLE 12

T (pg/mL saliva) and AVP (pg/mg creatinine) Values for the Sexual Video

	N	Min.	Max.	*M*	*SD*
Single Men					
T1	14	58.13	472.66	173.48	130.05
T2	14	76.21	353.39	161.66	74.99
AVP1	15	4.99	39.87	16.69	10.10
AVP2	14	0.00	21.95	8.77	6.99
Married Men					
T1	14	55.23	577.62	179.46	146.94
T2	12	57.59	443.92	164.63	118.54
AVP1	14	0.00	42.78	18.89	11.86
AVP2	15	0.00	40.51	11.93	10.92

TABLE 13

T (pg/mL saliva) and AVP (pg/mg creatinine) Values for the Baby Video

	N	Min.	Max.	*M*	*SD*
Single Men					
T1	14	68.59	527.93	201.36	136.92
T2	14	80.81	544.10	202.19	147.71
AVP1	15	0.00	63.70	22.56	21.21
AVP2	15	0.00	23.89	7.57	7.48
Married Men					
T1	13	86.10	263.71	142.06	57.46
T2	13	95.39	449.17	170.96	112.11
AVP1	15	0.00	50.43	18.95	14.34
AVP2	15	0.00	33.52	7.83	8.72

FIGURE 3

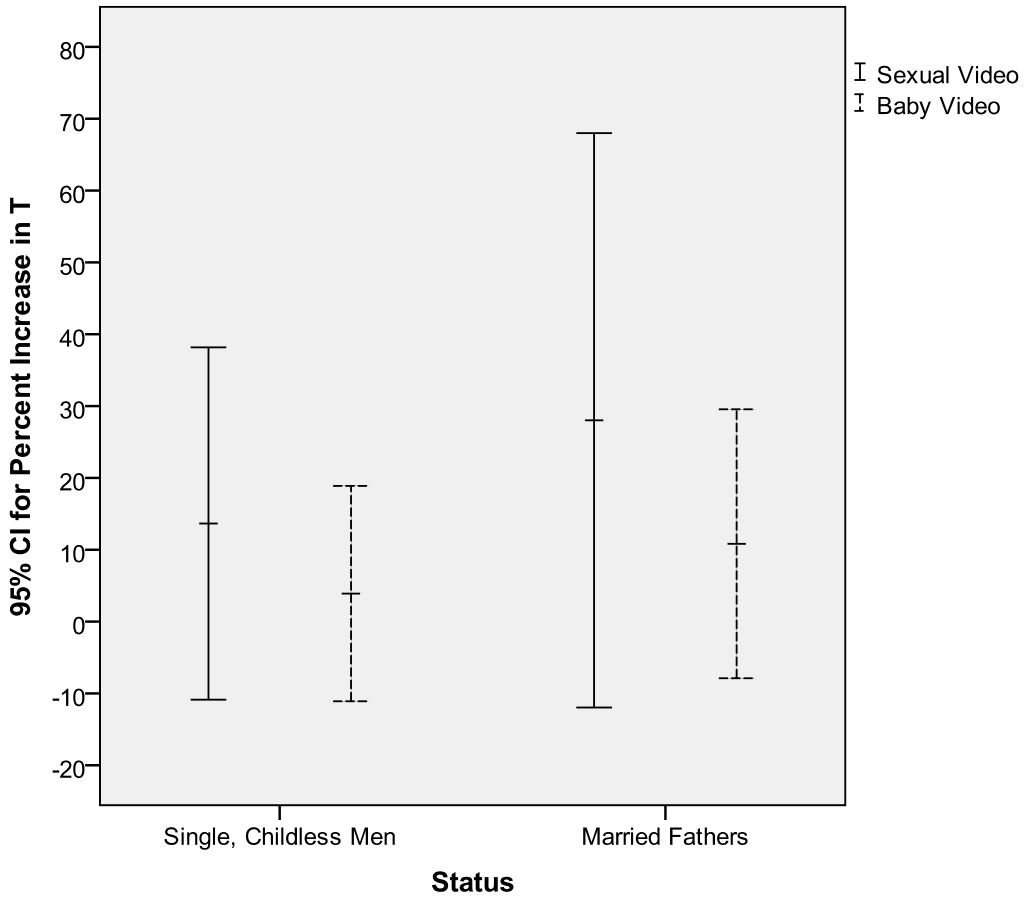


Figure 3. Mean Increase in T by Status and Video

FIGURE 4

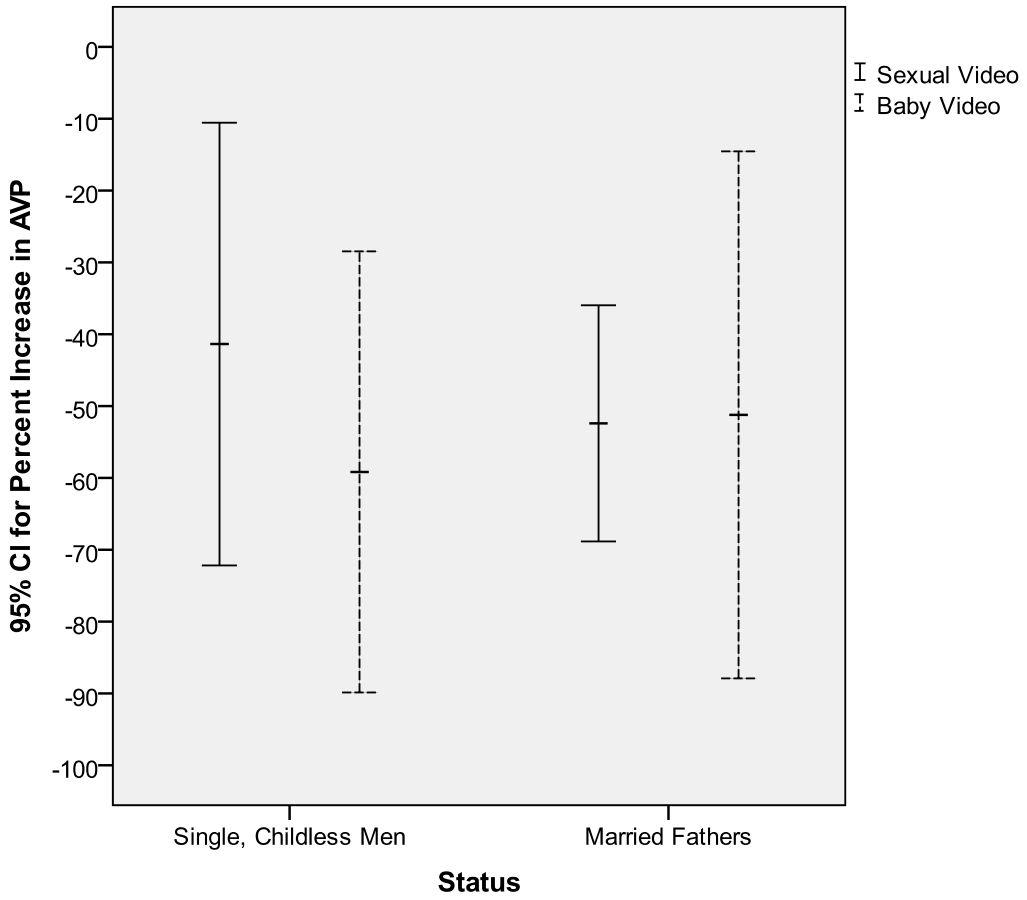


Figure 4. Mean Increase in AVP by Status and Video

TABLE 14

Descriptive Statistics for Sociosexuality and Sexual Function

	Single, Childless *N* = 30		Married Fathers *N* = 30		All Men *N* = 60	
	M	*SD*	*M*	*SD*	*M*	*SD*
SOI	104.92	63.12	112.72	262.11	108.82	189.06
EPSI	.04	.63	-.06	.83	-.01	.73
BSFI	37.93	4.50	37.37	5.44	37.65	4.96

TABLE 15

Descriptive Statistics for Marital Adjustment, Relationship Length, Child Characteristics, and Paternal Investment for the Married Fathers

	Min.	Max.	*M*	*SD*
DAS-7	8	34	24.43	5.42
Number of Years Married	6	11.25	59.90	32.22
Years in Exclusive Relationship	2	16.50	81.98	31.16
Number of Children	1	5	1.90	1.03
Age in Years of Youngest Child	1	6.00	22.78	19.47
Paternal Investment	26	41	35.49	3.26

Note: In terms of offspring gender, ten of the married fathers only had a son or sons, eight only had a daughter or daughters, and ten had at least one son and at least one daughter.

TABLE 16

Spearman Correlations for Baseline Hormones and Psycho-Social Variables

	T1	AVP1	2D:4D	SOI	EPSI	BSFI	DAS-7	Yrs in Relnp.	Yrs Married	# of Children	Age of Youngest	Paternal Invest.
T1	--	.19	.25	-.07	-.04	.09	-.32	-.11	-.03	.08	.26	-.10
AVP1		--	.21	-.07	-.00	.02	.02	.10	.09	.00	-.12	.05
2D:4D			--	-.10	-.11	.12	-.09	.07	.08	.07	-.18	.10
SOI				--	.65***	.06	.24	.00	-.15	-.17	.15	.00
EPSI					--	-.08	.12	.10	.02	.06	.16	-.01
BSFI						--	.50**	-.21	-.20	-.14	-.09	.38*
DAS-7							--	-.12	-.32	-.23	-.21	.51**
Yrs in Relnp.								--	.82***	.58*	.21	.04
Yrs Married									--	.52**	.40*	-.20
# of Children										--	-.09	-.14
Age of Youngest											--	.30
Paternal Invest.												--

Note: 'Age of Youngest' refers to age of youngest child. *$p > .05$, **$p > .01$, ***$p < .001$

APPENDIX 1

SELF-REPORT INSTRUMENT

[The title was one of the following: Single Men and Sexual Video Survey, Single Men and Baby Video Survey, Married Men and Sexual Video Survey, Married Men and Baby Video Survey]

Fill in the blank or circle the response that best describes you. Your responses will remain confidential, even from the experimenter, so please answer honestly.

1. What is your relationship status?
    A. I am single (not in an exclusive romantic relationship) with no children
    B. I am a married father

2. What is your age? _____

3. What is your ethnicity? _____

4. What is your height? _____

5. What is your weight? _____

6. What is the highest level of education that you completed?
    A. High School
    B. Bachelor's degree
    C. Master's degree
    D. Doctoral degree

7. Please list all drugs (over-the-counter, prescription, and recreational) that you ingested in the last 24 hours.
    _____

8. Please list all prescription and recreational drugs that you ingested in the last 30 days.
    _____

9. What is your sexual orientation?
    0 Exclusively heterosexual
    1 Predominantly heterosexual, only incidentally homosexual
    2 Predominantly heterosexual, but more than incidentally homosexual
    3 Equally heterosexual and homosexual; bisexual.
    4 Predominantly homosexual, but more than incidentally heterosexual
    5 Predominantly homosexual, only incidentally heterosexual
    6 Exclusively homosexual

10. Have you ever engaged in sexual intercourse with penile-vaginal penetration?
    Yes / No

11. Did you eat or drink anything except water within one hour of arriving for this study?
    Yes / No If so, what did you consume? _____

12. Did you engage in sexual activity (masturbation or sexual intercourse) today?
    Yes / No

13. How uncomfortable does it make you feel to receive a needle?

1	2	3	4	5	6	7	8	9
Not at all								A lot

14. How long has it been since your last orgasm? ____ weeks and ____ day(s)

15. With how many different partners have you had sex (sexual intercourse) within the past year? _____

16. How many different partners do you foresee yourself having sex with during the next five years? (Please give a *specific, realistic* estimate.) _____

17. With how many different partners have you had sex on *one and only one* occasion? _____

18. How often do you fantasize about having sex with someone other than your current dating partner? (Circle one.)
    1/ Never
    2/ Once every two or three months
    3/ Once a month
    4/ Once every two weeks
    5/ Once a week
    6/ A few times each week
    7/ Nearly every day
    8/ At least once a day

19. Sex without love is OK.

1	2	3	4	5	6	7	8	9
I strongly disagree								I strongly agree

20. I can imagine myself being comfortable and enjoying "casual" sex with different partners.

1	2	3	4	5	6	7	8	9
I strongly disagree								I strongly agree

21. I would have to be closely attached to someone (both emotionally and psychologically) before I could feel comfortable and fully enjoy having sex with him or her.

1	2	3	4	5	6	7	8	9
I strongly disagree								I strongly agree

22. "Would you *ever* consider having an "affair" (sex with a person other than a main, current relationship partner) behind the back of your relationship partner? Here, consider not only your present partner [if you have one], but any partner you might have in the future. (Circle one.)

    1/ No, I would *never* have sex outside of a relationship under any circumstances.
    2/ I can imagine that I could possibly have sex outside of a relationship under certain circumstances.

23. Have you ever engaged in sex with a partner other than a current partner while involved in a romantic relationship? Circle one: Yes No

Let's define sexual drive as a feeling that may include wanting to have a sexual experience (masturbation or intercourse), thinking about having sex, or feeling frustrated due to lack of sex.

Sexual drive

24. During the past 30 days, on how many days have you felt sexual drive?

None	Only a few	Some	Most	Almost every day
0	1	2	3	4

25. During the past 30 days, how would you rate your level of sexual drive?

None at all	Low	Medium	Medium-high	High
0	1	2	3	4

Erections

26. Over the past 30 days, how often have you had partial or full sexual erections when you were sexually stimulated in any way?

Not at all	A few times	Fairly often	Usually	Always
0	1	2	3	4

27. Over the past 30 days, when you had erections, how often were they firm enough to have sexual intercourse?

Not at all	A few times	Fairly often	Usually	Always
0	1	2	3	4

28. How much difficulty did you have getting an erection during the past 30 days?

No erections	A lot of difficulty	Some difficulty	Little difficulty	No difficulty
0	1	2	3	4

Ejaculation

29. In the past 30 days, how much difficulty have you had ejaculating when you have been sexually stimulated?

No sexual stimulation	A lot of difficulty	Some difficulty	Little difficulty	No difficulty
0	1	2	3	4

30. In the past 30 days, how much did you consider the amount of semen you ejaculate to be a problem for you?

Did not climax	Big problem	Medium problem	Small problem	No problem
0	1	2	3	4

Problem assessment

31. In the past 30 days, to what extent have you considered a lack of sexual drive to be a problem?

Big	Medium	Small	Very small	No problem
0	1	2	3	4

32. In the past 30 days, to what extent have you considered your ability to get and keep erection to be a problem?

Big	Medium	Small	Very small	No problem
0	1	2	3	4

33. In the past 30 days, to what extent have you considered your ejaculation to be a problem?

Big	Medium	Small	Very small	No problem
0	1	2	3	4

Overall satisfaction

34. Overall, during the past 30 days, how satisfied have you been with your sex life?

Very dissatisfied	Mostly dissatisfied	Neutral or mixed	Mostly satisfied	Very satisfied
0	1	2	3	4

[The following five items were given to those who viewed the sexual video, regardless of relationship status.]

35. Circle the number below that best describes your feelings about pornography:

1	2	3	4	5	6	7	8	9
I don't like it at all								I like it a lot

The following questions refer to the video that you just watched.

36. How sexually arousing was the video?

1	2	3	4	5	6	7	8	9
Not at all								Very much

37. How much of a sexual “turn-on” was the video?

1	2	3	4	5	6	7	8	9
Not at all								Very much

38. How physically aroused did you get from the video?

1	2	3	4	5	6	7	8	9
Not at all								Very much

39. Regardless of how physically aroused you actually got from the video, how sexually arousing did you find the video mentally?

1	2	3	4	5	6	7	8	9
Not at all								Very much

[The following five items were given to those who viewed the baby video, regardless of relationship status.]

35. How uncomfortable does it make you feel to see someone else receive a needle?

1	2	3	4	5	6	7	8	9
Not at all								A lot

36. When you watched the babies cry, how much did you wish you could make them feel better?

1	2	3	4	5	6	7	8	9
Not at all								A lot

37. When you watched the babies cry, how much sympathy did you feel?

1	2	3	4	5	6	7	8	9
None at all								A lot

38. When you watched the babies cry, how strong was your urge to lessen their pain?

1	2	3	4	5	6	7	8	9
None at all								A lot

39. When you watched the babies cry, how much did you want to soothe them?

1	2	3	4	5	6	7	8	9
None at all								A lot

40. How intense was the video?

1	2	3	4	5	6	7	8	9
Not at all								Very much

41. How emotional was the video?

1	2	3	4	5	6	7	8	9
Not at all								Very much

42. How pleasant was the video?

1	2	3	4	5	6	7	8	9
Very **un**pleasant								Very pleasant

[The remaining items were given only to the married fathers.]

Most persons have disagreements in their relationships. Please indicate below the approximate extent of agreement or disagreement between you and your partner for each item on the following list.

43. Philosophy of life ___

44. Aims, goals, and things believed important ___

45. Amount of time spent together ___

5	4	3	2	1	0
Always Agree	Almost Always Agree	Occasionally Disagree	Frequently Disagree	Almost Always Disagree	Always Disagree

How often would you say the following events occur between you and your mate?

46. Have a stimulating exchange of ideas ___

47. Calmly discuss something together ___

48. Work together on a project ___

0	1	2	3	4	5
Never	Less than once a month	Once or twice a month	Once or twice a week	Once a day	More often

49. The dots on the following line represent different degrees of happiness in your relationship. The middle point, "happy," represents the degree of happiness of most relationships. Please circle the dot which best describes the degree of happiness, all things considered, of your relationship.

0	1	2	3	4	5	6
.	.	.	.	.	.	.
Extremely Unhappy	Fairly Unhappy	A little Unhappy	Happy	Very Happy	Extremely Happy	Perfect

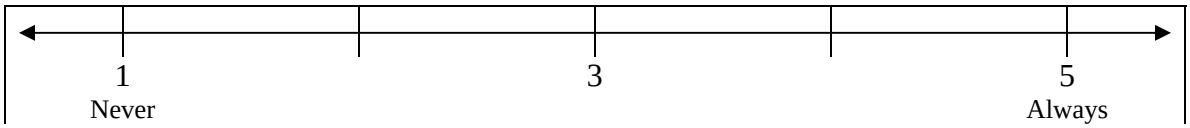
50. How many years and months have you been married? _____

51. How many years and months were you in a committed relationship with your wife before you got married? _____

52. How many children do you have? _____

53. What is the age and gender of each of your children? _____

Think of your experience as a father over the past 30 days. Please rate how good of a job you think you did as a father on each of the items on the list below.



54. Giving your children's mother encouragement and emotional support _____

55. Cooperating with your children's mother in the rearing of your children _____

56. Providing your children's basic needs (food, clothing, shelter, and healthcare) _____

57. Spending time with your children doing things they like to do _____

58. Showing physical affection to your children (touching, hugging, and kissing) _____

59. Being involved in the daily or regular routine of taking care of your children's basic needs or activities (feeding, driving them to places, etc.) _____

Place a checkmark beside each activity that you engaged in with your child during your most recent <u>normal work/school day:</u>

60. Playing (e.g. reading books, playing with toys, watching cartoons, etc.) _____

61. Feeding (e.g. spoon feeding, packing lunch, cooking, etc.) _____

62. Cleaning (e.g. changing diapers, bathing, cleaning up after eating, etc.) _____

63. Giving physical affection (touching, hugging, kissing, etc.) _____

64. Talking with your child for several consecutive minutes _____

65. Other childcare activities _____ If so, please explain briefly:
_____

Place a checkmark beside each activity that you engaged in with your child during your most recent <u>day off work/school day:</u>

66. Playing (e.g. reading books, playing with toys, watching cartoons, etc.) _____

67. Feeding (e.g. spoon feeding, packing lunch, cooking, etc.) _____

68. Cleaning (e.g. changing diapers, bathing, cleaning up after eating, etc.) _____

69. Giving physical affection (touching, hugging, kissing, etc.) _____

70. Talking with your child for several consecutive minutes _____

71. Other childcare activities _____ If so, please explain briefly:

_____

APPENDIX 2

IRB APPROVALS

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

UNLV IRB Approved SEP 0 8 2009 Expires SEP 0 7 2010

Social/Behavioral IRB – Expedited Review
Approval Notice

NOTICE TO ALL RESEARCHERS:
Please be aware that a protocol violation (e.g., failure to submit a modification for any change) of an IRB approved protocol may result in mandatory remedial education, additional audits, re-consenting subjects, researcher probation suspension of any research protocol at issue, suspension of additional existing research protocols, invalidation of all research conducted under the research protocol at issue, and further appropriate consequences as determined by the IRB and the Institutional Officer.

DATE: September 14, 2009

TO: **Dr. Marta Meana**, Psychology

FROM: Office for the Protection of Research Subjects

RE: Notification of IRB Action by Dr. Paul Jones, Chair
Protocol Title: **Hormones and Human Reproduction**
Protocol #: 0907-3145M

This memorandum is notification that the project referenced above has been reviewed by the UNLV Social/Behavioral Institutional Review Board (IRB) as indicated in Federal regulatory statutes 45 CFR 46. The protocol has been reviewed and approved.

The protocol is approved for a period of one year from the date of IRB approval. The expiration date of this protocol is September 7, 2010. Work on the project may begin as soon as you receive written notification from the Office for the Protection of Research Subjects (OPRS).

PLEASE NOTE:
Attached to this approval notice is the **official Informed Consent/Assent (IC/IA) Form** for this study. The IC/IA contains an official approval stamp. Only copies of this official IC/IA form may be used when obtaining consent. Please keep the original for your records.

Should there be *any* change to the protocol, it will be necessary to submit a **Modification Form** through OPRS. No changes may be made to the existing protocol until modifications have been approved by the IRB.

Should the use of human subjects described in this protocol continue beyond September 7, 2010, it would be necessary to submit a **Continuing Review Request Form** *60 days* before the expiration date.

If you have questions or require any assistance, please contact the Office for the Protection of Research Subjects at OPRSHumanSubjects@unlv.edu or call 895-2794.

Office for the Protection of Research Subjects
4505 Maryland Parkway • Box 451047 • Las Vegas, Nevada 89154-1047

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

UNLV IRB Approved JAN 15 2010 Expires SEP 07 2010

Social/Behavioral IRB – Expedited Review
Modification Approved

NOTICE TO ALL RESEARCHERS:

Please be aware that a protocol violation (e.g., failure to submit a modification for any change) of an IRB approved protocol may result in mandatory remedial education, additional audits, re-consenting subjects, researcher probation suspension of any research protocol at issue, suspension of additional existing research protocols, invalidation of all research conducted under the research protocol at issue, and further appropriate consequences as determined by the IRB and the Institutional Officer.

DATE: January 19, 2010

TO: **Dr. Marta Meana**, Psychology

FROM: Office for the Protection of Research Subjects

RE: Notification of IRB Action by Dr. Ramona Denby Brinson, Co-Chair RDB
Protocol Title: **Hormones and Human Reproduction**
Protocol #: 0907-3145M

The modification of the protocol named above has been reviewed and approved.

Modifications reviewed for this action include:

- Flyers will now be distributed on campus.
- The minimum age of participation is lowered from 25 to 21 years old.
- Non-subject pool participants will now be compensated in the amount of $20.

This IRB action will not reset your expiration date for this protocol. The current expiration date for this protocol is September 7, 2010.

PLEASE NOTE:
Attached to this approval notice is the **official Informed Consent/Assent (IC/IA) Form** for this study. The IC/IA contains an official approval stamp. Only copies of this official IC/IA form may be used when obtaining consent. Please keep the original for your records.

Should there be *any* change to the protocol, it will be necessary to submit a **Modification Form** through OPRS. No changes may be made to the existing protocol until modifications have been approved by the IRB.

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4505 Maryland Parkway • Box 451047 • Las Vegas, Nevada 89154-1047

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