THE EFFECTS OF EXOGENOUS TESTOSTERONE ON SEXUAL RISK-TAKING IN MEN

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Abstract

Research aimed at predicting sexually risky behaviour (SRB) has primarily focused on socio-demographic, psychological, and behavioural factors. Hence, biological predictors of SRB, such as androgen hormones, are not well understood. Evidence demonstrates that testosterone (T) can modulate traits associated with risk-taking, yet questions remain about its impact on SRB. The objective of the present study was to address this research gap by examining the causal role of a single dose of T on social, cognitive, and affective processes involved in men's intention to engage in unprotected casual sex. In this experiment, healthy young men (n = 110, M_{age} = 23.3, SD = 5.1) were administered T or placebo and asked to imagine a scenario in which they could engage in unprotected sex. The extent to which individual differences in sociosexual orientation moderated the relationship between T and SRB-related constructs was also analyzed. Results indicated no difference in SRB-related constructs as a function of drug condition. Sociosexual orientation did not moderate the effect of T on SRB. Post-hoc exploratory analyses revealed that single men had more positive cognitive attitudes towards the risky sexual encounter than paired men when on placebo, but not on T. Paired men displayed more perceived control than single men when on placebo, but not on T, and paired men showed less sexual arousal on placebo than on T. This experiment is the first of its kind and the findings build upon a growing body of evidence demonstrating exogenous T can modulate human processes implicated in risk-taking propensity.

General Summary

Sexual risk-taking is of great concern among young Canadian adults because it can cause STIs and unplanned pregnancies. The current study explored the effect of testosterone on sexual risk-taking in young men. I ran an experiment where about half of the sample of men were given a dose of testosterone and the other half were given a placebo. Then, the men read a story that asked them to imagine they were single and met a woman they knew at a bar. The woman then invited him to her place and wanted to have sex, but there is no condom available. The men then answered questions about how they perceived the situation and whether they intended to have unprotected sex with the woman. I expected to find that testosterone would increase men's intention to have unprotected sex, although my results did not support that prediction. There was an effect, however, of testosterone in men who were in committed relationships such that testosterone increased their sexual arousal, led them to have more positive attitudes towards the sexual encounter, and they reported less of a sense of control over their behaviour compared to single men. Given that this study is the first of its kind, validation research is needed.

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Chapter 1: Introduction and Literature Review

Engaging in sexual risky behaviour (SRB), such as having unprotected sex, presents a serious public health concern because it contributes to the growing number of sexually transmitted infections (STIs) occurring at disproportionally higher rates in Canadian youth (Public Health Agency of Canada [PHAC], 2019b). Over the past four decades, SRB has been the subject of much systematic investigation with a particular focus of identifying the prevalence and predictors of sexual risk-taking in order to increase safer sex practices and improve health outcomes by reducing incidences of STIs and unplanned pregnancies (Hall & Witherspoon, 2011). What is known about SRB is largely based on investigations of the various behavioural, socioeconomic, and demographic factors, with less attention directed towards the study of biological or neuroendocrine predictors of sexual risk-taking.

Many hormones are pivotal in human development, however, the steroid hormone testosterone (T) has been studied extensively because of its crucial role in the support and maintenance of a number of biological processes involved in maturation, reproduction, and mating across the lifespan (Archer, 2006; Kaufman et al., 2019; Pollet et al., 2011). Testosterone has been shown to have important consequences for traits associated with risk-taking propensity such as aggression, impulsivity, and sensation seeking in humans (Aluja et al., 2016; Archer, 2006; Carré et al., 2016; Nave et al., 2017). These studies report developments primarily related to T and financial and economic risk-taking outcomes, and findings generally indicate an association between higher T and increased economic risk-taking (r = .12; Kurath & Mata, 2018), although results are mixed (Apicella et al., 2015; Stanton, 2017). A smaller body of mostly correlational research has explored T and indirect measures of SRB, revealing associations between T and mate-seeking, relationship commitment, frequency of sexual activity,

and number of sex partners (Archer, 2006; Cooper, 2002; Peters et al., 2008; Pollet et al., 2011; Puts et al., 2015; Salmimies et al., 1982).

With respect to how T levels may influence direct measures of sexual risk-taking, such as engaging in unprotected sex with a casual sex partner, research is scarce. To this end, the goal of the present experiment is to add to that body of knowledge by, for first time, experimentally manipulating T levels to better understand the potential causal role of T on increasing men's intention to engage in SRB with a new partner.

1.1 Sexually Risky Behaviours

Sexually risky behaviours (SRB) can broadly be considered as acting in such a manner that may result in negative outcomes due to a sexual interaction (Cooper, 2002). Negative outcomes may include, but are not limited to, an unwanted pregnancy or contracting a sexually transmitted infection (STI). Generally, SRB fit into two categories. The first is indiscriminate behaviours, such as having a lot of sexual partners, engaging in casual sex or sex with unknown partners, and not discussing potential risks prior to intercourse. The second category, which is more pertinent to this experiment, surrounds failure to take protective actions, which includes the use of prophylactics such as condoms or birth control (Cooper, 2002)**.**

Engaging in SRB contributes to the alarming number of cases of STIs in Canada and internationally (Public Health Agency of Canada [PHAC], 2019b; World Health Organization [WHO], 2018). According to the Report on Global Sexually Transmitted Infection Surveillance by the WHO (2018), there were an estimated 376 million new cases of the four most common and treatable STIs (chlamydia, gonorrhoea, syphilis, and trichomoniasis) in 2016 alone. The PHAC (2019b) indicated that rates of STIs in Canada increased between 2008 and 2017: with chlamydia increasing by 39%, gonorrhoea by 109% and infectious syphilis by 167% (PHAC,

2019b). Despite increasing STI prevention and intervention measures in Canada, young adults are disproportionately at risk of contracting sexually transmitted viruses and infections in this country (Caruthers et al., 2014; Milhausen et al., 2013; PHAC 2019b, 2019a). In order to decrease instances of unsafe sex, and improve youth morbidity, it is important to advance our understanding of predictors of SRB in this population (Catalano et al., 2012).

Recent research suggests the predictors of STIs in young Canadians include a broad range of demographic variables (i.e., income, age, sex, gender identity, sexual orientation, education, relationship status; Bajaj et al., 2017; Fetner et al., 2020; Haghir et al., 2018). For example, there are gender differences in STI risk such that women are more at risk of contracting an STI than men, due to bacterial STIs such as general herpes and gonorrhoea being more efficiently transmitted from men to women (Wong et al., 2004). On the subject of age as a predictor, PHAC (2019b) noted that rates of STIs are highest among people aged 15 to 29. They also reported rates of gonorrhoea were twice as high in men than women, and most prevalent in the 20-to-29-year age bracket. Furthermore, PHAC (2019b) found that men were approximately eight times more likely than women to have infectious syphilis, and this disease was most common among those aged 25 to 39. Observed trends in chlamydia, however, were slightly different with rates being higher in women than men, and these rates were more prevalent in a slightly younger population, ranging from age 15 to 29 (PHAC, 2019b).

Beyond demographic predictors, behavioural patterns (i.e., substance use and abuse, STI testing, sexual activity, sexual aggression, and sexual practices) may also predict SRB and incident STIs in young adults (Bajaj et al., 2017; Davis et al., 2016; Fetner et al., 2020; Haghir et al., 2018). For example, alcohol use can impact SRB. In a systemic review and meta-analysis, Scott-Sheldon et al. (2016) analyzed data from 30 experimental studies with a total of 3,964

participants and found that alcohol use was significantly correlated with decisions to engage in sexually risky behaviour, including unprotected sex. Further support of these findings were reported on in an earlier meta-analysis by Rehm et al. (2012) who analyzed 12 experimental studies and showed that level of alcohol consumption significantly predicted intention to use condoms, with higher levels of blood alcohol correlated with lower intention to use condoms.

While the evidence on these demographic and behavioural predictors of SRB and STIs is plentiful, few studies examine the underlying physiological predictors of SRB such as whether hormones, such as T, are linked to the socio-cognitive processes involved in sexual risk-taking. To that end, this experiment explores the impact of T on social, cognitive, and affective factors that are associated with SRB in young men.

1.2 Testosterone

1.2.1 Testosterone and Biology

Testosterone is an androgenic steroid hormone that is implicated in processes associated with physical development, maturation, reproductive functioning, and cognition (Kurath & Mata, 2018; Salonia et al., 2019; Stanton et al., 2011). The production of T takes place in the Leydig cells of the testes in men and to a lesser degree in the ovaries in women (Coates & Herbert, 2008; Dabbs, 1990; Midzak et al., 2009; Nave et al., 2017), with men displaying T levels 8 to 10 times greater than women (Apicella et al., 2015; Decaroli & Rochira, 2017). Further, smaller amounts of T are also synthesized in the adrenal cortex of both men and women. In men, T production and fertility are coordinated by the hypothalamic–pituitary–gonadal axis, which ensures normal testicular functioning (Corradi et al., 2016; Geniole & Carré, 2018).

Men's T levels are not static, but instead, fluctuate throughout the day and over the course of the lifespan contingent upon factors such as social or situational contexts, biological

processes, and life stages or circumstances. For instance, there is a small but consistent diurnal variation in T such that levels are highest in the morning, due to an increase during sleep, and lower in the evening (Axelsson et al., 2005; Diver et al., 2003; Rose et al., 1972; Shlykova et al., 2020; Winters, 1991). Age and physical development also cause T levels to vary. During puberty, there is a sharp increase in T and in later adulthood there is a gradual decline with age (Booth et al., 1999; Harman et al., 2001; Kurath & Mata, 2018; O'Connor et al., 2011; Salonia et al., 2019).

Much of the literature also highlights an association between T and relationship status (Burnham et al., 2003; Gettler et al., 2011; Gray et al., 2004; Grebe et al., 2019; Hooper et al., 2011). It has been demonstrated that T levels fluctuate during mate-seeking and pair bonding experiences with men having higher T when mate-seeking and lower T when in a long-term committed relationship (more than 6 months; Gray et al., 2004). A marked decrease in T is also observed during fatherhood (Gettler et al., 2011), and a marked increase in months surrounding a divorce (Mazur & Michalek, 1998). A recent meta-analysis of 66 studies by Grebe et al. (2019) examined the association between T levels in men and their level of relationship commitment. The authors reported that single men and non-fathers had higher T than pair-bonded men and fathers, and that pair-bonded men had higher T than fathers. These findings clearly indicate that T is implicated in the coordination of mate pursuit and pair bonding (Grebe et al., 2019).

Testosterone also exhibits adaptive characteristics as it fluctuates rapidly moment-to-moment in a context-dependent manner (Apicella et al., 2015; Losecaat Vermeer et al., 2020; Saad & Vongas, 2009). Examples of this effect include acute increases in men's T when in the presence of an attractive woman (Ronay & von Hippel, 2010) particularly in aggressive dominant men (van der Meij et al., 2008), winning a competitive interaction (Apicella et al.,

2014; Archer, 2006; Carré et al., 2013; Carré & Olmstead, 2015; Casto et al., 2020), or engaging in aggressive behaviour (Carré & McCormick, 2008). There is also evidence of a bidirectional relationship between T levels with respect to social contexts and behaviours. For example, dominance and status seeking behaviours increase T concentrations while higher baseline T concentrations also predict these types of behaviours (Coates & Herbert, 2008; Eisenegger et al., 2011).

Together these studies provide important insights into T's contribution to physiological and behavioural processes. Furthermore, the nature of the T-behaviour relationship is bi-directional; some behaviours cause changes in T and T can also influence behaviour (Apicella et al., 2015; Archer, 2006; Carré & Olmstead, 2015; Mazur & Booth, 1998; Wingfield et al., 1990) making it difficult to determine cause-and-effect relationships. The present experiment hopes to clarify whether T directly increases men's intention to engage in SRB through an experimental research design where T or placebo are administered prior to measuring variables implicated in SRB.

1.2.2 Testosterone and Traits Associated with Risk-Taking Tendency

The physiological effects of T in humans are relatively well-understood; however, there is uncertainty around its psychological and behavioural effects (Kurath & Mata, 2018). As a steroid hormone, small quantities of T can pass through the blood-brain barrier and modulate neural activity that has important consequences for behaviour and cognition (Herbert, 2018; Höfer et al., 2013). Research to date has implicated T in a number of risk-taking constructs including, but not limited to, aggression (Archer, 2006; Carré et al., 2016), impulsivity (Nave et al., 2017), and sensation-seeking (SS; Aluja et al., 2016; Aluja & Torrubia, 2004; Campbell et al., 2010; Roney & Gettler, 2015). Although these risk-taking constructs are not measured in the

current experiment, they are important to contextualize how T may be implicated in sexual risk-taking behaviours.

Aggression. To date, a considerable amount of literature has been published on the association between T and aggression, and the relationship appears to be generally inconsistent and weak (Archer et al., 2005; Geniole et al., 2020). According to Baron and Richardson (2004), aggression can be defined as follows: "any form of behavior directed toward the goal of harming or injuring another living being who is motivated to avoid such treatment" (p. 37). This construct can be viewed as a type of risk-taking due to the potential negative outcomes of engaging in aggressive behaviour such as physical harm, loss of status, imprisonment, or revenge from others (Welker et al., 2017).

There are a number of complexities within the T-aggression literature that point to the need for a more fulsome understanding of factors that influence or confound the T-aggression relationship. For instance, the form of hormone being measured (e.g., salivary, blood draws, proximal predictors of T such as finger length ratios), how T can change over time, or how T interacts with other hormones. In the past, the main focus of research in this area has been on stable and baseline T, while not highlighting T concentrations that are pharmacologically manipulated or context-dependent changes in T (Geniole et al., 2020).

To further investigate and differentiate the causal influence of the various forms of T on aggression, Geniole et al. (2020) conducted a comprehensive meta-analytic review of research on the hormone's baseline, dynamic, and pharmacologically elevated concentration on aggression. Notably, Geniole et al. (2020) found an overall weak positive correlation between baseline T and aggression ($r = 0.054$, $p < .001$), which was significant in men ($r = 0.071$, $p < .001$) but not women ($r = 0.002$, $p = .936$). They also found that dynamic fluctuations in T due to situational or

contextual factors (e.g., being provoked, when one's goals are interfered with or challenged, or when a person experiences a negative event) were positively correlated with aggression overall (r = .108, p = .02). Again, the correlation was significant in men (r = 0.162, p < .001), but not women (r = .010, p = .851). With respect to Geniole et al.'s (2020) evaluation of studies on T manipulation through pharmacological administration and aggression, they found no support for a link between exogenous T and aggression. They however posit that the lack of evidence may be due to inconsistencies across studies such as the use of different types of T administration, variations in dosages, single versus multiple doses, the sex of the sample, and the time between T administration and behavioural measures (Geniole et al., 2020).

The literature on the impact of T on aggression, a construct associated with risk-taking, continues to reveal either weak, or little relationship between the hormone and aggressive behavioural measures. Weak and mixed results are pervasive throughout the literature on not only aggression and T, but also other character traits as they relate to T.

Impulsivity. Like aggression, impulsivity is considered a trait linked to risk-taking (Cross et al., 2011), and can be generally defined as "the tendency to act spontaneously and without deliberation" (Carver, 2005, p. 313). Considerable evidence has accumulated to show that impulsivity tends to predict risk-taking behaviours such as drug use (De Wit, 2009), binge eating, problem drinking, pathological gambling (Fischer & Smith, 2008), and risky sexual behaviours (Dir et al., 2014).

T has been explored in relation to impulsivity using quasi-experimental (Aluja et al., 2015; Coccaro et al., 2007; Giotakos et al., 2003; Kurath & Mata, 2018; Virkkunen et al., 1994) and experimental methods (Doi et al., 2015; Ortner et al., 2013; Peper et al., 2013; Takahashi et al., 2006; Wu et al., 2020) yielding mixed results. Giotakos et al. (2003) found that, although

convicted rapists showed significantly higher basal T levels and higher aggression-impulsivity scores than non-offenders, basal T levels were not associated with aggression or impulsivity scores. Correspondingly, Coccaro (2007) also noted a significant correlation between basal T and aggression and impulsivity in men with a history of personality disorders. More recently, literature emerged that offers rather contradictory findings. In a systematic literature review and meta-analysis, Kurath and Mata (2018) analyzed 69 studies and 108 effect sizes related to T and impulsivity and reported a weak positive correlation ($r = 0.12$).

Similarly, experimental designs assessing the relationship between T and impulsivity also reported mixed results. When evaluating the association between basal T and impulsivity in university students, Takahashi et al. (2006) found an inverted U-shaped relationship between impulsivity and salivary T, meaning that men with both high and low T displayed impulsive tendencies. Further mixed results were reported by Doi et al. (2015) who studied sex differences in impulsivity and basal T. Findings noted that T in women was positively correlated with impulsivity, while in men, there was a negative correlation meaning women with higher T were more impulsive and men with lower T were more impulsive.

Experiments using exogenous T show contradictory results. In a double-blind placebo-controlled study of 91 men with exogenous T or placebo administration, Ortner et al. (2013) found no effect of T on impulsivity, measured through a delayed discounting task. Delay discounting is the tendency to consider a delayed reward to be reduced in value or worth less compared to the perceived value of an immediate reward (Bickel & Marsch, 2001). Contradicting Ortner et al.'s (2013) findings, however, is a study by Wu et al. (2020) who administered T or placebo to young men and found a higher delay discounting rate, indicating greater impulsivity, amongst the T group compared with the controls (Wu et al., 2020).

Similarly, when investigating the effects of exogenous T on decision making and cognitive reflection, Nave et al. (2017) found that T significantly increased impulsive and intuitive decision-making compared with placebo in a sample of men (n = 243). The authors noted that their results draw attention to the importance of considering that T may inhibit deliberation at times when it may be needed, possibly increasing risk-taking. A more recent study by Knight et al. (2020) failed to replicate these results when evaluating the effects of T on cognitive reflection in a large sample of men (n = 628) across three studies. They speculated that trait impulsivity or level of task performance (high versus low) may moderate the association between T and cognitive reflection, and recommended further research to examine these potential moderators (Knight et al., 2020).

Sensation Seeking. Zuckerman (1994) defined sensation seeking (SS) as a trait characterised by the "seeking of varied, novel, complex, and intense sensations and experiences, and the willingness to take physical, social, legal, and financial risks for the sake of such experience'' (p. 27). A positive correlation exists between SS and risk-taking because sensation seekers tend to be more susceptible to boredom and engage in stimulating–ergo, possibly risky behaviours–to alleviate boredom (Zuckerman, 1994). A broadly similar point has also been made by Roberti (2004) who noted that when impulsivity is paired with higher SS, the person may possess reduced sensitivity to risk and demonstrate a lack of planning. Activities sought-after by those who are high in SS and impulsivity (e.g., drug use, dangerous driving, or sex with multiple partners) may be inherently higher risk due to their urge to increase the degree of stimulation they experience (Zuckerman, 1991, 1994).

As with the character traits of aggression and impulsivity, SS has also been linked to T concentrations. The seminal work of Daitzman et al. (1978) and Daitzman and Zuckerman

(1980) identified an association between sex hormones and SS. Both studies involved measuring sex hormones through blood draws and using the self-report Sensation Seeking Scale (SSS; Daitzman et al., 1978). Daitzman et al. (1978) found a significant positive correlation between androgen hormones and the SS disinhibition subscale, which represents one's level of drive to seek out varied and novel social and sexual experiences (Zuckerman, 1994). In their follow-up study, Daitzman and Zuckerman (1980) reported that T specifically was positively associated with disinhibition.

There is now evidence for the association between T and SS from several studies. For example, Aluja (2005) measured hormone levels in a sample of inmates and found an association between T and the SS trait of disinhibition. Aluja et al. (2016) found a weak positive correlation between T and the SS construct of novelty seeking only after controlling for age in a sample of 105 heterosexual adult men. Other authors such as Perini et al. (2012) explored the potential association between SS and T in men before and after fatherhood by comparing men with children to a control group of men in committed relationships without children. They found that 8 weeks after the birth of their child, fathers had lower T and SS than controls, and lower T and SS than they had had 4-weeks prior to the birth. They also found a moderation effect whereby fathers with the lowest T levels also showed the lowest SS. What emerges from this research is reasonably consistent evidence of an association between T and traits associated with risk-taking.

1.2.3 Testosterone and Risk-Taking

Greater risk-taking may have evolutionary value as it can signal the ability to obtain resources or status (Apalkova et al., 2021). Successive researchers over several decades have noted the importance of investigating causes of risk-taking due to the potential for negative health outcomes (Freeman et al., 2011). For example, Byrnes et al. (1999) conducted a meta-

analysis of 150 studies on sex differences in risk-taking from 1967 to 1994 and found that men engaged in significantly more risk-taking than women. More recently, a growing body of published work provides evidence of possible biological predictors of risk-taking, including steroid hormones such as T (see Apicella et al., 2015; Kurath & Mata, 2018; Stanton et al., 2021). As expanded upon below, several sources have identified an association between higher T and increased financial or economic risk-taking and physical risk-taking, while others show no effect or mixed results.

A literature review undertaken by Apicella et al. (2015) provides a good overall summary of studies on T and economic risk-taking published between 2008 and 2015. The studies reviewed were primarily based on T measured though blood draws or saliva samples, or proximal indicators of T such as second and fourth finger length ratio (2D:4D), an indirect proxy for prenatal T exposure (Manning & Taylor, 2001). Outcome variables were often assessed using economic risk-taking measures that typically involved tasks whereby participants engaged in financial decision-making with notable incentives such as higher payoffs for risky gambling or betting behaviour, although risk-taking could also lead to potential losses. Less risky behaviour often resulted in more certain but lower payoffs. Regarding studies on endogenous T and economic risk-taking, Apicella et al. (2015) indicated that higher T concentrations were associated with increased economic risk-taking, and noted the findings were often mixed and fairly inconsistent. As for research on indirect measures of T, Apicella et al. (2015) concluded that right-hand measures of 2D:4D show less of an association with risk-taking than left-hand measures, and that lower left 2D:4D (proxy for elevated prenatal T exposure) was associated with more risk-taking in men. Two T administration studies with pharmacologically elevated

concentration of T were also reviewed, and both were conducted in women and found no evidence that T increased proclivity to economic risk-taking (Apicella et al., 2015).

The findings of more recent studies on T administration and economic risk-taking in women showed that women on T exhibited predictable and less risky decision-making on gambling tasks compared with women on placebo (van Honk et al., 2016; Wu et al., 2016). Wu et al. (2016) examined the effect of a single dose of T on loss chasing in a sample of 26 women. Loss chasing is defined as the increased risky betting behaviour gamblers exhibit following a loss. Their results showed no difference in risky choices between the T and placebo groups and Wu et al. (2016) noted that T administration had no direct effect on risk-taking behaviour in women. There was, however, a significant interaction effect whereby women on placebo behaved riskier based on their prior win or loss gambling outcome, and those on T showed no risk preference based on their prior win or loss outcome. Wu et al. (2016) concluded that exogenous T blunted the tendency towards loss chasing in women.

Similarly, van Honk et al. (2016) administered T or placebo to a sample of 20 women and evaluated economic decision-making in a computer-based gambling task that was analogous to poker. Their results showed that the women bluffed less randomly and more so in line with the strength of their hand when on T compared with placebo. This tendency towards predictability is a deviation from the game's profit-maximizing strategy of bluffing more randomly and less predictably. Van Honk et al. (2016) concluded that T led to more predictable and less risky gambling behaviour in women and argued that this finding contradicts typical beliefs that T would lead to increased risk-taking.

A somewhat similar observation was made by Stanton et al. (2021) who were also not able to determine a consistent link between T and economic decision-making or risk-taking in a

multi-study investigation. Their research evaluated the effects of endogenous and exogenous T in men, and endogenous T in men and women on a variety of economic decision making, loss aversion, and risk-taking measures across three studies. Stanton et al. (2021) observed no effect of exogenous T on risk-taking in men and conflicting findings where exogenous T both significantly decreased and increased loss-aversion compared with placebo in men. They also found no correlation between T and economic decision making or risk-taking in men or women. In their conclusion, Stanton et al. (2021) highlighted the lack of published studies with null findings due to the tendency of academic journals to mainly publish studies with positive results, which ultimately provides researchers with a less comprehensive understanding of the relationship between T and economic decision-making.

While the majority of T and risk-taking studies focus on economic and financial risk-taking, Ronay and von Hippel (2010) explored the impact of T on physical risk-taking by assessing the impact of the presence of a young attractive female on physical risk-taking and T levels in a sample of 96 young male skateboarders. The skateboarders completed tricks while being recorded by either a male or a female experimenter. A noteworthy finding of this study was that T levels were significantly higher in the skateboarders when the female experimenter was recording than when they were recorded by the male experimenter. The authors concluded that the presence of the attractive female experimenter caused the skateboarders to take more risks, which resulted in a greater number of crash landings. Ronay and von Hippel (2010) suggested that increased circulating T, as a result of the presence of an attractive female, amplified physical risk-taking in the male skateboarders. The authors noted, however, a limitation of their study was that T levels were measured only after the experimental manipulation. Thus, they indicated that the male experimenters may have caused a decrease in

circulating T in the skateboarders, rather than T increasing when the skateboarders interacted with the female experimenter. These findings reflect the general pattern identified earlier, whereby dynamic fluctuations in T levels due to situational or contextual factors may be associated with risk-taking related constructs (Geniole et al., 2020).

Outside of experimental and quasi-experimental studies on T and risk-taking, researchers have explored T and the more general propensity for risk-taking. Kurath and Mata (2018) conducted a meta-analysis, evaluating 41 effect sizes from a number of studies evaluating the association between endogenous T and risk-taking propensity, and reported a small positive correlation (r = .12). Overall, they concluded that there is support for theories suggesting an association between T and risk-taking related measures or behaviours. While evidence of the link between T and risk-taking is increasing, a consistent empirical picture is missing to show the extent to which risk-taking may be attributed to T.

1.2.4 Testosterone and Sexual Risk-Taking

Research on sexual risk-taking behaviours has a long history due to potentially negative consequences of such behaviour including unplanned pregnancies and STIs (Cooper, 2002). To this end, researchers have explored a variety of demographic, social, psychological, and behavioural predictors of SRB (Bajaj et al., 2017; Cooper, 2002; Davis et al., 2016; Fetner et al., 2020; Haghir et al., 2018; Poppen, 1995; Rehm et al., 2012; Scott-Sheldon et al., 2016; Sheeran & Taylor, 1999; Wong et al., 2004) yet the contribution of hormones such as T on sexual risk-taking has received much less attention.

It has been suggested that men with higher T tend to invest more energy in mating effort, which can result in greater mating success (Archer, 2006; Peters et al., 2008). Animal research comparing the effect of pharmacologically elevated T versus placebo on reproductive success in

typically monogamous male dark-eyed junco birds found that those given T had higher rates of copulations with females other than their mate (Raouf et al., 1997). In humans, men with higher T are more likely to never marry, and those who do marry tend to engage in more extramarital sex than men with lower T (Mazur & Booth, 1998). Related findings have been observed showing endogenous T levels are higher in polygamous than monogamous men (Alvergne et al., 2009; Gray, 2003; van Anders et al., 2007).

Early research on hormone administration in hypogonadal men identified empirical support for exogenous T's effect on increasing sexual thoughts, sexual arousal, and sexual activity (O'Carroll et al., 1985; Salmimies et al., 1982). With regards to endogenous T, Halpern et al. (1994) identified a positive association between T measured through blood draws and sexual behaviour and permissive sexual attitudes in a sample of adolescent males. In a subsequent longitudinal study on salivary T and sexual activity in adolescent boys, Halpern et al. (1998) found that boys with higher T reported significantly more sexual activity and were much more likely to initiate sex than those with average or low-level T.

This area of study has been further explored, albeit in a limited number of studies. Research has mainly focussed on questions concerning T's effect on indiscriminate SRB such as having casual sex or sexual activity with a high number sexual partners (Cooper, 2002). One of the first studies in this area was conducted by Bogaert and Fisher (1995) who investigated predictors of university men's number of sexual partners. They analyzed salivary T levels and found a positive correlation with both lifetime number of sex partners and number of sex partners over the last 30 days. Subsequent studies produced similar findings showing salivary T predicts lifetime number of sex partners in men, but not woman (Peters et al., 2008; Pollet et al., 2011; Puts et al., 2015).

This general line of research continued with similar results when using correlates of endogenous T and prenatal T such as rapid weight gain in male babies and finger length ratios (2D:4D) in men (Hönekopp et al., 2006; Kuzawa et al., 2010). Men who grew more rapidly from birth to 6 months were found to reach sexual maturity at an earlier age, reported a younger age of first intercourse, and a greater lifetime number of sex partners (Kuzawa et al., 2010). These findings are supported by those of Hönekopp et al. (2006) who carried out two studies on the association between 2D:4D ratios, T levels measured through blood draws, and number of sexual partners in a sample of German and Austrian men. They found a significant positive association between endogenous T and number of sex partners and this association was also significant but weaker when analyzing the association between 2D:4D and number of sexual partners. Their findings indicated that men with more masculinized 2D:4D reported more sexual partners than those with more feminized 2D:4D (Hönekopp et al., 2006).

Although there are a number of studies evaluating the effects of T on indiscriminate SRBs, the effects of T on sexual risk-taking that involve a failure to take protective action when engaging in sexual behaviour, such as having unprotected sex (Cooper, 2002) remains largely unexamined. A search of the literature revealed only one study on this topic with findings that offer conflicting evidence on the relationship between T and SRB. van Anders et al. (2012) investigated whether salivary T levels were associated with behaviourally relevant attitudes regarding sexual risk-taking and safer sex in a sample of young men. They described their results as the first to show that higher T levels predicted safer sex attitudes and intentions in men and less sexual risk-taking. van Anders (2012) reported that "T was the strongest and only significant predictor of safer sex resilience" (p. 731) such that men with higher T were more likely to report using condoms even in the face of obstacles (e.g., using a condom when in the heat of the

moment). These contradictory findings suggest the need for further evaluation of T's effect on SRB.

1.3 The Theory of Planned Behaviour

Scholarship demonstrates the longstanding influence of the Theory of Planned Behaviour (TPB) in the domain of the prediction of human social and health behaviours. Ajzen (1991) proposed this conceptual framework to predict and explain specific human behaviours through the evaluation of social, cognitive, and affective factors. In essence, the TPB proposes that the way people consider and judge certain aspects of a behaviour influences their intention to engage or not engage in that particular behaviour (Carmack & Lewis-Moss, 2009).

The TPB extended the earlier Theory of Reasoned Action (TRA; Ajzen, 1985; Ajzen & Fishbein, 1980), which drew scrutiny for neglecting to account for behaviours that are not entirely within a person's volitional control (Godin & Kok, 1996). Ajzen (1985) noted that the difference between the two theories is that the TPB "takes into account perceived as well as actual control over the behavior under consideration" (p. 12), while actual control is not explained by the TRA.

The TPB emphasizes that an individual's intentions are the most proximal predictor of their actions (see Figure 1; Ajzen, 1985, 1991; Ajzen & Fishbein, 2005). Intentions represent an individual's level of motivation and their readiness to exert effort to engage in a certain behaviour. Thus, the greater a person's behavioural intentions, the greater the likelihood they will enact a target behaviour. Intentions are said to be directly predicted by three distinct social cognitive (SC) factors: *attitudes, subjective norms, and perceived behavioural control* (PBC; Ajzen, 1985, 1991; Ajzen & Fishbein, 2005).

Attitudes indicate an individual's positive or negative evaluations of a behaviour and their perception of the probable consequences of engaging in that behaviour (Ajzen, 1985, 1991). The two sub-types of attitudes are *cognitive*, such as whether the perceived behavioural consequences are desirable or undesirable, and *affective*, such as whether the behaviour will be pleasant or unpleasant (Ajzen & Fishbein, 2005). In the context of SRBs, if an individual has positive cognitive and affective attitudes towards a condomless sexual encounter, and they anticipate the outcome of having intercourse will be favourable and enjoyable, they will be more willing to have unprotected sex.

Subjective norms represent a person's perception of how referent others view their behaviour and what social pressures are associated with the mode of conduct when enacting a behaviour (Ajzen, 1985, 1991). There is evidence to support the delineation of subjective norms into *injunctive*, referring to whether one believes important others would approve of their behaviour, and *descriptive*, referring to what one believes others are doing (Ajzen & Fishbein, 2005; Ajzen & Schmidt, 2020; Durán et al., 2017; McEachan et al., 2016). Both aspects increase one's perception of the amount of social pressure associated with engaging in a behaviour (Ajzen & Schmidt, 2020). Costenbader and colleagues (2017) reviewed the literature on the influence of social norms on contraceptive use, primarily condom use, and found that the term 'subjective norms' was predominantly used when evaluating the influences of social approval on contraceptive behaviours, without distinguishing between injunctive and descriptive. When applying subjective norms to SRBs, an individual's intention to engage in unprotected sex is believed to be predicted by the social pressures they perceive from referent others such as their current sexual partner, their peer group, or their family. If the person believes those important

others would disapprove of them having unprotected sex, they will be less likely to engage in that behaviour.

The most notable predictor of behavioural intentions is PBC, which is an individual's appraisal of the extent to which engaging in the behaviour is within their volitional control (Ajzen, 1985, 1991). PBC is determined by the individual's perception of the relative difficulty or ease of performing the behaviour based on past experience and the current availability of the means (e.g., skills, resources, and opportunities) necessary to overcome obstacles that may arise in performing the behaviour (Ajzen, 1985, 1991). As with attitudes and social norms, there is evidence to show that PBC consists of two distinguishable factors; *self-efficacy*, an individual's sense of the relative ease or difficulty of performing the behaviour (Bandura, 1977, 1999) and *controllability*, appraisal of one's volitional control over the behaviour (Trafimow et al., 2002).

PBC is said to account for a considerable proportion of the variance in the prediction of behavioural intentions and—if the person has a sufficient degree of actual control over performing the behaviour—subsequent behaviour (Ajzen, 1985, 1991, 2012). In general, since one's ability to perform a target behaviour is limited by obstacles that affect volitional control, PBC is posited to directly influence both behavioural intentions and behavioural execution (Ajzen, 1985, 1991). When a measure of actual control is unobtainable, PBC is said to reflect a reasonably accurate approximation of actual control (Ajzen & Fishbein, 2005; Ajzen & Sheikh, 2013). In the case of SRBs, an optimistic sense of behavioural control would suggest the individual is confident they have access to the means and opportunity to engage in intercourse such as a consenting partner, suitable setting, and the physical ability and stamina to have intercourse. Hypothetically, this would increase their sense of self-efficacy and controllability

and consequently augment their intention to engage in unprotected sex in the event a condom was not available.

1.3.1 The Theory of Planned Behaviour and Sexually Risky Behaviours

The Theory of Planned Behaviour (TPB) has been applied to predict and explain many aspects of SRB including casual sex, condom use, contraceptive use, and STI prevention across a broad range of populations (Conner & Sparks, 2005; Durán et al., 2017; Tyson et al., 2014). It is also used to inform the design and evaluation of interventions used to promote safer sex behaviours (Ajzen & Schmidt, 2020; Morales et al., 2018; Tyson et al., 2014). The extant research in these areas is vast. The following meta-analyses provide evidence for the application of the TPB as it relates to condom use, which is the focus of the current experiment.

Sheeran and Taylor (1999) performed a meta-analysis to evaluate the sample-weighted average correlations between 23 psychosocial factors and condom use intentions across 56 studies. Their analysis established empirical support for the use of the TPB as a reliable predictor of condom use intention. Specifically, their findings indicated that intentions, attitudes, and subjective norms demonstrated medium to strong effect sizes, and PBC explained an additional 5% of the variance in condom use. Correspondingly, Albarracín et al.'s (2001) meta-analysis analyzed 96 datasets to determine the strength of the associations between TPB variables and condom use. Their results showed that attitudes, subjective norms, and PBC explained 40-50% of the variance in intentions to use condoms, with attitudes (r = 0.58) and PBC (r = 0.45) being stronger predictors than social norms (r = 0.39; Albarracín et al., 2001). More recently, Tyson et al. (2014) performed a meta-analysis using data from 32 studies with a primary outcome of evaluating the effectiveness of TPB and TRA sexual health interventions on condom use and protected sex behaviours. They noted the efficacy of TPB interventions on condom use/protected

sex behaviours was highly significant and concluded that the TPB is a valuable model to employ in the development of interventions to curb SRBs (Tyson et al., 2014).

To summarize, the TPB proposes that attitudes (cognitive and affective), subjective norms, and PBC (self-efficacy and controllability) are antecedents to intention, and the latter is an important predictor of behaviour. Also, PCB and intentions are the most reliable predictors of actual behaviour (Ajzen, 1985, 1991). There is considerable evidence showing the TPB is a proximal predictor of SRB. The current experiment sought to explore the effects of T on TPB constructs implicated in sexual risk-taking. To this end, participants were given a single dose of T or placebo and were then asked to read a vignette that described a relatable scenario of an encounter with an attractive sexual partner when a condom is not easily accessible. The vignette is followed by a TPB questionnaire to measure constructs associated with the likelihood that the participant would engage in condomless casual sex.

1.4 Socio Sexual Orientation

Sociosexual orientation (SOI) refers to one's behaviours, attitudes, and desire with regard to sexual relations. Penke and Asendorpf (2008) succinctly summarized the three components of sociosexual orientation as: 1) *sociosexual behaviour,* which is the behaviour surrounding an individual's time spent in short-term and long-term relationships; 2) *sociosexual attitudes,* which are an individual's perceptions and beliefs about engaging in non-committal sexual relationships; and 3) *sociosexual desire*, which is an individual's level of motivation and the intensity of the mating effort they direct towards securing long-term versus short-term sexual relationships (Penke & Asendorpf, 2008). The Sociosexual Orientation Inventory – Revised (SOI-R; Penke, 2013) is used to compute a total SOI score, with separate scores for each of the three subscales. The total score, referred to as *global sociosexual orientation*, indicates whether a person's level

of orientation towards sexual relations is more or less restricted along a continuum. A higher total score reflects an *unrestricted* orientation, which signifies a propensity for engaging in sex with partners with whom the person has little to no relationship commitment or closeness (i.e., psychological or emotional). A low total score indicates a more *restricted* orientation such that individuals would engage in sexual activities only when they are in a committed and close relationship with their sexual partner (Penke, 2013; Simpson & Gangestad, 1991).

Research has consistently found gender differences in SOI, whereby men have higher, more unrestricted SOI on average than women (Hall & Witherspoon, 2011; Rodrigues & Lopes, 2017; Simpson & Gangestad, 1991), and this effect has been demonstrated across cultures (Schmitt, 2005). Varying levels of SOI have a demonstrable impact in and outside relationships such that people with a more restricted SOI express greater love in relationships, and demonstrate higher commitment, dependency, and relationship investment (Simpson & Gangestad, 1991). However, those who have a more unrestricted SOI more often report having other sexual partners while in a committed relationship and typically have sex earlier in a relationship (Simpson & Gangestad, 1991). With respect to relationship status differences in SOI levels, single individuals show a more unrestricted orientation than those in committed relationships (Rodrigues & Lopes, 2017).

The relationship between SOI and relationship has been further explored by including the impact of T levels. In a key study by Edelstein et al. (2011), it was shown that T levels were lower in paired compared to single men and women, but only among those with a more restricted SOI. They also found that men and women who reported a more unrestricted SOI showed no differences in T levels based on relationship status. These findings corroborated earlier research by McIntyre et al. (2006) who found that paired men with a more unrestricted SOI maintained

high T levels despite being in a committed relationship. McIntyre et al. (2006) also noted this effect persisted when controlling for relationship length and nature of the relationship commitment (i.e., dating, married, engaged, or living together).

1.4.1 Socio Sexual Orientation and Sexually Risky Behaviours

It is well known from several decades of research that SOI maps on to a range of sexual behaviours including sexually risky behaviours (Hall & Witherspoon, 2011; Ostovich & Sabini, 2004; Seal & Agostinelli, 1994; Simpson & Gangestad, 1991; Snyder et al., 1986). Ostovich and Sabini (2004) studied predictors of lifetime number of sex partners and found that SOI independently predicted this outcome, regardless of sex drive. They went on to state that sex drive does not predict lifetime number of sex partners when controlling for the effect of SOI because the relationship is only significant in those with a more unrestricted sociosexual orientation (Ostovich & Sabini, 2004). Moreover, Seal and Agostinelli (1994) found a negative correlation between SOI and condom use such that those with a more unrestricted orientation reported less likelihood of condom use, regardless of their knowledge about safe sex practices. Timmers and Olivers (2012) argued that sexually risky behaviours in those with unrestricted orientations may result from less sensitivity to risk cues, and possibly arousal by those same risk cues, thus increasing their motivation to engage in casual sex.

The evidence presented in this review reveals that SOI can predict T levels and risky sexual behaviours and proclivities, thus it is important to examine its potential moderating effect on the T-sexual risk-taking relationship.

1.5 The Present Study

Although the association between T and risk-taking has been explored, no known empirical research has focused on the effect of exogenous T on SRB in humans. Importantly,

most studies in this field have largely focused on baseline and dynamic fluctuations in T and on outcome variables related to financial or more general risk-taking, with little effort directed towards investigating sexual health-related risks (van Anders et al., 2012). Moreover, T has never been pharmacologically manipulated to measure its causal effects on social and cognitive predictors of sexual risk-taking.

Thus, this experiment examines the effects of a single dose of T on sexual attitudes, perceptions, and intentions to have unprotected sex in healthy young men. The experiment involved a between-subjects, double-blind, placebo-controlled design. In the T condition, participants were given a single intra-nasal dose of 11mg of testosterone gel (Natesto®) or placebo to temporarily elevate T concentrations. Testosterone administration at this dose has been shown to cause a significant increase in serum levels of T at 15-minutes post-administration and to be elevated up until at least 180-minutes post-drug administration compared to placebo (Geniole et al., 2019). The placebo condition received the same dose of an inert gel. This experimental design enables causal inferences to be made by observing whether T influences social, cognitive, and affective factors associated with intentions to engage in sexual risk-taking, compared with placebo.

It was hypothesized that:

H1: Testosterone will have an effect on SRB-related predictors (cognitive attitudes, affective attitudes, subjective norms, intention to have sex, sexual arousal, trust in the woman, controllability, self-efficacy, realism of the scenario, and past unprotected sex) compared with placebo.

H2: The effect of attitudes, subjective norms, and PBC on men's intention to engage in sexual risk-taking will vary as a function of T.

H3: The association between T and SRT-related predictors will be strongest in men with an unrestricted sociosexual orientation.

Chapter 2: Methods and Materials

2.1 Overview

This section outlines the methodology used to evaluate the effects of T on men's intention to engage in SRB. The opening section outlines the participants and recruitment methods followed by a summary of the experimental procedure including the timeline and tasks completed by participants. Next is a description of the T and placebo administration and saliva sampling methods. The final section describes the demographic, cognitive, and behavioral data collected, and the descriptive and inferential statistics performed using the free-available Jamovi software.

2.2 Participants and Participant Recruitment

Participants were selected through a convenience sample of men between the ages of 18 and 45, recruited from a Northern Ontario post-secondary campus and community to take part in a larger T administration study (see Table 1 for demographic details). Only men were included because the T nasal gel (Natesto ®) is only approved for use in men (Natesto, 2017). The age range was determined in light of substantial evidence that T levels drop as men age (Kaufman et al., 2019). Therefore, a restricted age range of 18-45 reduced the potential confound of low T levels in older men.

Recruiting methods involved posters, ads on social media and the university's online research participant pool; public recruitment booths; and contacting previous participants of other research studies via email who had consented to offers to participate in future studies. Undergraduate and graduate research assistants (RAs) and the lab manager led recruiting efforts. Participants were compensated with course credit or $40 for two hours of their time along with a

monetary reward of up to an additional $15 for their performance on a decision-making task (Resource Allocation Task; Forsythe et al., 1994) that was unrelated to the current analyses.

Prospective participants were screened by RAs and the lab manager using either a phone interview or in-person interview to determine their eligibility for the study. Inclusion criteria comprised the following: identifying as male; aged between 18 and 45; able to understand the experimental procedures; willing to sign informed consent; willing to provide saliva samples for hormone analyses; and willing to have their T concentrations temporarily manipulated using testosterone nasal gel. Exclusion criteria comprised the following: identifying as female; currently taking prescription medication for medical conditions affecting hormone concentrations (e.g., hypogonadism, prostate cancer, thyroid disease, Cushing's disease, Addison's disease); currently using hormonal medications and/or supplements; current diagnosis of a psychiatric disorder (e.g., anxiety, depression, schizophrenia, bipolar); current diagnosis of a heart condition or prostate cancer; alcohol and/or drug dependency; and current member of teams or organizations (e.g., student athletes) for whom T is a banned substance.

The study was approved by the Nipissing University Research Ethics Board under protocol #102026 and the Memorial University of Newfoundland Interdisciplinary Committee on Ethics in Human Research under protocol # 20200443-ED (Appendix C). All individual participants provided informed consent prior to taking part in the experiment. Of the 120 participants who completed the experiment, two failed to respond to the questionnaire for the vignette task and were excluded. Those who identified as exclusively homosexual (n = 8) were also excluded due to the heterosexual nature of the hypothetical sexual risk-taking vignette (i.e., a second-person account of a heterosexual male protagonist who meets an attractive female at a bar). Consequently, our final sample size for analyses was n = 110.

2.3 Experimental Procedure

Testing took place at Dr. Justin Carré's Social Neuroendocrinology Lab at Nipissing University in North Bay, Ontario, Canada. The procedural timeline is shown in Figure 2. Participants arrived at the lab between Monday and Friday at one of three scheduled testing times: 8:30am, 12:00pm, or 2:30pm. Those who had not been screened prior to arriving at the lab were screened upon arrival by an RA using the inclusion and exclusion criteria described above. Participants were greeted in the reception area by an RA then directed to a private testing room where they remained during the duration of their testing session (≈ two hours total). They were then given a detailed description of the experimental procedures and their written informed consent was obtained prior to commencement of testing (see Appendix A; ≈ five minutes). All measures relating to the current research questions were computer-based and the RA was not present in the room when the participant completed the measures.

Participants were randomly assigned to one of two experimental conditions: 11 mg of testosterone gel or 11mg of a placebo gel. To ensure the RAs and the participants were blind to the drug condition (double-blind), participant IDs were randomized to either condition before any data were collected. This information was stored in a password protected Microsoft Excel file that was not accessible to RAs. Due to this random assignment, when participants received their participant ID, by extension they were randomly assigned to an experimental condition.

After providing their informed consent, participants were asked to complete a brief demographic questionnaire to collect data on age, ethnicity, relationship status, education level, employment status, and sexual orientation. Next, they completed personality questionnaires, including the Sociosexual Orientation Inventory-Revised (SOI-R; see below; ≈ twenty minutes).

Following the questionnaires, participants provided their first saliva sample (≈ two minutes), which was collected to determine baseline levels of T. They then provided a mouthwash sample for a research question unrelated to the present experiment (≈ two minutes). Next, participants received an application of 11 mg of either testosterone gel or placebo gel from an RA who was blind to the experimental condition. The gel was self-administered as two separate intra-nasal doses of 5.5 mg per nostril (≈ three minutes). During the 30-minute waiting period between the drug or placebo application and subsequent behavioural measures, participants performed two tasks to test predictions unrelated to the current investigation (a photograph of their face and scans of their right and left hands). Participants were then free to rest or read articles made available on the testing room computer for the remainder of the waiting period.

Of the seven behavioural measures that followed, only the risky sexual behaviour task was associated with the present study while the other six measures were part of a larger study protocol to answer additional questions unrelated to the current hypotheses. The behavioural measures were administered in the following order: 1) Victoria Stroop task (Strauss & Spreen, 1998; ≈ four minutes); 2) Digit Span task (Croschere et al., 2012; ≈ five minutes); 3) Tower of London (Fimbel et al., 2009; ≈ six minutes); 4) Go/No Go task (Verbruggen & Logan, 2008; ≈ ten minutes); 5) IOWA Gambling task (Bechara et al., 1994; ≈ ten minutes); 6) Risky Sexual Behaviour task (Conner et al., 2008; ≈ ten minutes); and 7) Resource Allocation Task (Forsythe et al., 1994; ≈ twelve minutes). The risky sexual behaviour task involved participants reading a vignette in which they were asked to imagine themselves engaging in a potentially risky sexual encounter followed by a self-report questionnaire measuring perceived attitudes, cognitions, and

behaviours. Following the completion of these measures, participants provided their second and final saliva sample (≈ two minutes).

At the end of the study, each participant was paid or assigned course credit. Their email address was requested to contact them at a later date to notify them about the additional monetary rewards they would receive for their performance on the decision-making tasks. Participants received a debriefing (see Appendix B) via email at the conclusion of data collection for the study. The debriefing included a description of the deception methods used in the study, the rationale for the use of deception, and an apology for deceiving the participants. Contact information for the lab director was also provided and participants were informed that they could request their data be removed from the database with no penalty. The debriefing also thanked participants for taking part in the study.

2.3.1 Hormone dosage and administration

Natesto is a T replacement therapy gel that is approved by Health Canada and the US Food and Drug Administration to treat men for clinically low endogenous T (Rogol et al., 2016). The recommended dose of Natesto gel (4.5% T) is 11mg applied intra-nasally three times per day (Natesto nasal gel: Prescribing information, 2014). Geniole et al. (2019) demonstrated that a single dose of 11mg of Natesto significantly increased serum T concentrations in their sample of healthy young men (n = 13) to the high-normal physiological range within 15 minutes of application. Concentrations peaked within 30 minutes and began to decline, but remaining elevated related to placebo, after three hours of drug application (Geniole et al., 2019). For hypogonadal men, T levels rise within 30 minutes of drug application, and return to baseline within three hours of application (Rogol et al., 2016). Other protocols commonly used to pharmacologically manipulate T concentrations in humans often lead to a slow rise to peak T

levels compared to Natesto. Thus, the use of testosterone nasal gel produces a rise in T that more closely mirrors acute fluctuations in T that occur naturally (Carré & Robinson, 2020).

The T application included two blunted-tip syringes that each contained 5.5 mg of clear gel for a total of 11 mg of either testosterone or placebo. The placebo gel matched the vehicle of the T gel but lacked the T. An RA (blind to the drug condition) first demonstrated the intra-nasal application technique, then participants were supervised by the RA during self-administration. The RA instructed participants to carefully insert the tip of one syringe at a time into each nostril and depress the applicator to dispense the gel. They were directed to angle the tip of the syringe outwards, towards their ear, and deliberately scrape the tip of the applicator on the lateral sides of their nostrils to ensure all of the gel remained in their nostril. Once the gel had been applied to each nostril, participants were asked to pinch their nostrils closed to ensure the gel was evenly distributed inside and around the nostril wall for maximum absorption. Participants were instructed to refrain from sniffing or blowing their nose for the remainder of the testing period. Once the self-administration was complete, participants were instructed to thoroughly sanitize their hands with ethanol in order to prevent contamination of the testing area.

Saliva Collection. The first 1-2ml saliva sample was collected prior to receiving T or placebo in order to determine baseline T levels. Participants were given a polystyrene tube that contained a cotton swab and were asked to chew on the swab for 30 seconds and place it back into the tube. Approximately 30 minutes after the administration of the intra-nasal T or placebo gel, participants were asked to provide a second and final 1-2ml saliva sample using the same method as the first sample. The samples were stored at −20 °C until they could be thawed, centrifuged, and analyzed using commercial enzyme immunoassay kits.

Methodological Limitations. Due to public health measures related to the COVID-19 pandemic, Nipissing University research labs were closed in March 2020, and saliva samples could not be assayed to determine participants' baseline T levels or any increase in T due to the drug administration. Despite these missing data, conclusions related to the impact of the drug administration can still be drawn by referring to findings from recent pharmacokinetic studies carried out by Dr. Carré's lab (see Geniole et al., 2019; Luberti et al., 2021). The drug's time-course effects showed a sharp increase in blood serum T 15 minutes post-administration. Concentrations remained at significantly higher levels for 180 minutes. Therefore, despite not having salivary T measurements in the current work, we are confident that this dosage would lead to a rapid and sustained increase in T concentrations.

2.4 Measures

2.4.1 Sociosexual Orientation

The nine-item self-report Sociosexual Orientation Inventory-Revised (SOI-R; Penke, 2013) was used to assess sociosexual orientation. This scale is a global measure of sociosexual orientation, and also has three subscales: *behaviour, attitude*, and *desire*. Participants responded to each item along nine-point Likert scales. Items 1 to 3 were averaged to create a continuous sociosexual *behaviour* score (Cronbach's α = .85) that represents past sexual behaviour with reference to: 1) the number of sexual partners within the past 12 months; 2) the total number of different casual sexual partners ("one-night stand"); and 3) number of sexual partners where there was a lack of interest in a long-term relationship. Responses for items 1 to 3 ranged from "*1 = 0*" to "*9 = 20 or more*". After reverse-scoring item 6, items 4 to 6 were averaged to create a continuous sociosexual attitude score (Cronbach's α = .84), which reflects explicit attitudes about having uncommitted sex such as: 4) asserting it is acceptable to engage in sex without

love; 5) enjoying casual sex and having a sense of ease about engaging in casual sex; and 6) not wanting to engage in sex unless the partner is interested in a long-term relationship. Response options for items 4 to 6 ranged from "*1 = strongly disagree*" to "*9 = strongly agree*". The continuous sociosexual *desire* variable was calculated by averaging items 7 to 9 (Cronbach's α = .87) that relate to a person's interest in engaging in uncommitted sex such as: 7) how frequently they fantasize about having uncommitted sex; 8) how frequently they experience sexual arousal when interacting with someone they do not have a committed relationship with; and 9) how frequently they experience fantasies about casual sex with a new acquaintance. Response options for items 7 to 9 ranged from "*1 = never*" to "*9 = at least once a day*".

A continuous global sociosexual orientation score (SOI-Total, Cronbach's α = .83) was obtained by computing the mean of all nine items. Higher SOI-Total scores indicated a more unrestricted sociosexual orientation (i.e., greater tendency towards engaging in sexual behaviours, more sexual partners, and greater desire for uncommitted sex), and lower scores represented more restricted sociosexual orientation.

2.4.2 Sexual Risk-Taking Propensity

Outcome variables associated with sexual risk-taking were assessed using standard procedures described by Conner et al. (2008). First, participants were asked to read a vignette that was at the seventh-grade reading level while trying to project themselves into the hypothetical situation. The vignette was as follows:

> *Imagine that you are single and that you run into a very attractive acquaintance while ordering a drink at the bar. The two of you begin to talk, and both of you find the conversation very enjoyable. She has a good sense of humour, and seems genuinely interested in what you are saying. It is clear that there is definite 'chemistry' between you and that you are attracted to this person. You continue to spend time together throughout the night, drinking more alcohol, and you even dance together later on in the evening. When the bar closes you discover you are going in the same direction and decide to share a taxi. When you get to your place, you kiss her and ask her if she wants to come in for a*

drink. She agrees, and you go inside and sit on the sofa. After talking for a while, you begin to kiss passionately. You are feeling very sexually aroused. You know she's on the pill, and you don't think she sleeps around. However, neither of you has access to a condom.

Given that details about the hypothetical female's health status or sexual history were not expressly stated, engaging in casual sex without a condom should be perceived as a risky decision (Comer & Nemeroff, 2000). A 17-item self-report questionnaire (adapted from Conner et al., 2008) was used to evaluate constructs associated with the TPB in relation to SRB. All responses were along seven-point Likert scales with endpoints labelled. The questionnaire stated to answer honestly and defined the behaviour in question as "having penetrative sex in the situation described."

Cognitive attitudes were assessed by computing the mean of responses to three items (Cronbach's α = .85), "My having sex in this situation would be…" with end points labeled "1 = bad, 7 = good;" "1 = risky, 7 = safe;" and "1 = foolish, 7 = wise." *Affective attitudes* were assessed by computing the mean of three items (Cronbach's α = .90), "My having sex in this situation would be…" with end points labeled "1 = dull, 7 = exciting;" "1 = unpleasant, 7 = pleasant;" and "1 = unenjoyable, 7 = enjoyable." Higher mean scores on the continuous attitude measures indicated more positive attitudes towards having unprotected sex in the imagined hypothetical scenario.

The mean of the following 4 items (Cronbach's α = .60) was computed as a continuous measure of *subjective norms*, "How would the following people react to your having sex in this situation: your best friend would... your family would... the media would... your female sexual partner in this situation would..." (1 = strongly disapprove, 7 = strongly approve; Conner et al., 2008).

Each of the following 7 constructs were assessed with one ordinal-level item per construct. *Intention* to have sexual intercourse was assessed with the question, "I would intend to have sex in this situation" (1 = strongly disagree, 7 = strongly agree). *Sexual arousal* was assessed with the question, "How sexually aroused do you think you would feel in this situation?" (1 = not at all, 7 = very aroused). *Trust* in the sexual partner was assessed with the question, "How much would you trust the woman described in this situation?" (1 = not at all, 7 = very much so). *Controllability* was assessed with the question, "How much control do you think you would have over having sex in this situation?" (1 = no control, 7 = complete control). *Self-efficacy* was assessed with the question, "For me to have sex in this situation would be..." (1 = difficult, 7 = easy) with higher scores indicating greater self-efficacy. *Realism of scenario* was assessed with the question, "How realistic do you find this scenario?" (1 = not at all realistic, 7 = very realistic). *Past unprotected sex* was assessed with the question "How often in the past have you had unprotected sex?" (1 = never, 7 = very often).

2.5 Statistical Analyses

Analyses were conducted with Jamovi and SPSS. Descriptive statistics were calculated. Pearson correlations were computed to investigate bivariate correlations between all 14 variables including the 10 SRB-related constructs as well as the total SOI score and the three SOI subscales: behaviour, attitude, and desire. A multiple linear regression was calculated using Jamovi to determine which of the five TPB *determinants of intention* (see Figure 1) including aspects of attitudes (cognitive and affective), subjective norms, and PBC (self-efficacy and controllability) were the strongest predictors of intention to have sex. Each determinant was entered as a covariate and intention to have sex was entered as the dependent variable.

Moderation analyses were also performed using SPSS (PROCESS Model 1; Hayes, 2022) to determine whether drug condition moderated associations between the five determinants of intention on intention to have sex. For these analyses, the determinants of intention were entered separately as predictor variables (X), intention was entered as the dependent variable (Y), and drug condition was dummy coded (0 = placebo, 1 = testosterone) and entered as the moderator (W).

To evaluate Hypothesis 1, independent samples *t*-tests were performed using Jamovi to investigate the effect of the binary-level independent variable, drug condition (T versus placebo), on the 10 continuous dependent variables associated with SRBs including: cognitive attitudes, affective attitudes, subjective norms, intention to have sex, sexual arousal, trust in the woman, controllability, self-efficacy, realism of the scenario, and past unprotected sex.

To evaluate Hypothesis 2, mediation analyses were performed using Jamovi's medmod module to analyze whether drug condition modulates intention to have sex through its effect on the five determinants of intention including attitudes (cognitive and affective), subjective norms, and PBC (self-efficacy and controllability). For these analyses, the five determinants were entered separately as mediators, drug condition was entered as the predictor, and intention was entered as the dependent variable.

To evaluate Hypothesis 3, a simple linear regression was calculated to confirm whether the continuous-level variable Total SOI predicted intent to have sex prior to including total SOI as a moderator. Then, a separate analysis was performed using the Jamovi's medmod module to examine whether there was a direct effect of total SOI on each of the 10 SRB-related dependent variables, and to analyze if there were interaction effects of drug and total SOI on SRB constructs. For these analyses, drug condition was treated as a fixed factor and total SOI was

entered as a moderator, and each of the 10 SRB-related constructs were input separately as dependent variables.

Finally, for the purposes of exploratory analysis, an analysis of variance (ANOVA) was performed to examine the main and interaction effects of relationship status (paired versus single) by drug condition (T versus placebo) on each of the 10 SRB-related constructs. For these ANOVAs, relationship status and drug condition were entered as fixed factors and each of the 10 SRB-related variables were treated as dependent variables. All analyses were performed using alpha = .05 (two-tailed).

Chapter 3: Results

3.1 Descriptive Statistics

For a summary of sample demographic and descriptive statistics by drug condition, see Table 1. One hundred and ten participants (M_{age} = 23.3, *SD* = 5.1) were included in the analyses. There were no differences between T (*n* = 49) and placebo (*n* = 61) groups in age [*t*(107) = 0.344, *p* = .732, Cohen's D = .07] or weight [*t*(108) = 0.483, *p* = .630, Cohen's *D* = .09]. With regards to relationship status, 45.5% indicated they were single and 55.5% reported being in a committed relationship, and there was no difference in participant age between paired and single [*t*(107) = 0.415, *p* = .415, Cohen's *D* = .15]. The sample was primarily university students at 59%, followed by 32% college students, and the remaining 9% reported working, being unemployed, or other. The sample was 91% heterosexual, 4.5% bisexual, and 4.5% responded 'other' or 'prefer not to say'.

3.2 Preliminary Analyses

Participants perceived the hypothetical scenario described in the vignette as relatively risky (*M* = 2.64, *SD* = 1.52; Likert scale "1 = risky, 7 = safe;") and fairly realistic (*M* = 4.59, *SD* = 1.78; Likert scale 1 = not at all realistic, 7 = very realistic), which supports the use of this measure to evaluate constructs associated with sexual risk-taking.

Pearson correlations, means, and standard deviations of study variables are presented in Table 2. When analyzing the sample as a whole, a significant positive correlation was observed between intention to have sex and total SOI [*r*(109) = .272, *p* < .001], indicating that men who are more unrestricted are more likely to intend to have sex in the risky sexual encounter. Intention to have sex was also significantly positively correlated with a number of other study variables including cognitive attitudes [*r*(109) = .648, *p* < .001], affective attitudes [*r*(109) =

.641, $p < .001$], subjective norms [$r(109) = .427$, $p < .001$], self-efficacy [$r(108) = .579$, $p < .001$], sexual arousal [$r(109) = .255$, $p = .007$], trust in the woman [$r(109) = .427$, $p < .001$], realism of the scenario[$r(107) = .342$, $p < .001$], and past unprotected sex [$r(109) = .297$, $p = .002$]. Notably, intent to have sex was negatively correlated with controllability, and marginally significant [$r(109) = -.181$, $p = .06$]. Total SOI did not correlate with cognitive attitudes [($r(110) = .06$, $p = .531$] or affective attitudes [$r(110) = .134$, $p = .162$], however total SOI was positively correlated with subjective norms [$r(110) = .204$, $p = .032$]. As expected, total SOI was strongly positively correlated with all three SOI subscales; behaviour [$r(110) = .676$, $p < .001$], attitude [$r(110) = .840$, $p < .001$], and desire [$r(110) = .732$, $p < .001$].

Results of the multiple linear regression indicated there was a collective significant effect between cognitive attitudes, affective attitudes, subjective norms, self-efficacy, controllability, and intention ($F(5, 102) = 29.7$, $R^2 = .593$, $p < .001$,) suggesting that 59.3% of intention to have unprotected sex can be predicted by these five factors. The individual predictors of intention to have unprotected sex were examined further and results indicated that cognitive attitudes ($t = 3.863$, $p < .001$) and affective attitudes ($t = 5.07$, $p < .001$) were the strongest predictors of intention, followed by self-efficacy ($t = 2.63$, $p = .01$), which was also a significant predictor in the model.

Further correlational analyses were performed on SRB-related outcome variables within each experimental group (T and placebo), and these findings are summarized in Table 3. Several differences were observed between experimental groups in these data. Both groups showed significant positive correlations between intention to have sex and cognitive attitudes, affective attitudes, subjective norms, trust in the woman, self-efficacy, and past unprotected sex (all p's $< .05$). These figures show that intention to have sex was significantly negatively correlated with

controllability in the T group [$r(48) = -.397$, $p = .005$], but not the placebo group [$r(61) = -.024$, $p = .856$], indicating that men who received T who reported less controllability also reported greater intention to have unprotected sex, but this effect was not shown in the placebo group. In contrast, intention to have sex was significantly positively correlated with sexual arousal in the placebo group [$r(49) = .304$, $p = .032$] but not the T group [$r(61) = .159$, $p = .281$], implying that men who received placebo who reported greater sexual arousal also reported increased intention to have unprotected sex, and there was no association between these variables in the T group. Lastly, there was also a significant negative correlation between controllability and trust in the T group [$r(48) = -.494$, $p < .001$] but not the placebo group [$r(61) = -.149$, $p = .253$] indicating that men who were given T experienced less controllability the more they trusted the female sexual partner, and there was no evidence of this effect in the placebo group.

The correlational analyses suggested differences in associations between TPB constructs between the T and placebo groups. To further explore these differences, moderation analyses were conducted to determine whether drug condition moderated associations between the five determinants of intention on intention to have sex. The results revealed no significant interaction effect of drug condition on the associations between cognitive attitudes, affective attitudes, subjective norms, or controllability on intention to have sex (all *p*s > .05). There was, however, a significant self-efficacy by drug condition interaction effect (β = -0.35, *SE* = 0.164, *t* = -2.131, *p* = 0.035, 95 % CIs=−.676, -.024). Simple slopes analyses indicated self-efficacy was significantly positively associated with intention to have sex in men on placebo (β = 0.768, *SE* = 0.109, *t* = 7.04, *p* <.001, % CIs = 0.552, 0.984) and in men on T (β = 0.418, *SE* = 0.123, *t* = 3.399, *p* = 0.001, 95 % CIs = 0.174, 0.661).The interaction effect indicates that these two slopes significantly differ from one another because the association between self-efficacy and intention

to have sex was stronger in the placebo group than in the T group, although both associations were significant at $p < .001$.

3.3 H1: Testosterone will have an effect on SRB-related predictors

T-tests revealed no significant main effect of T on SRB-related outcome variables (all *p*s > .05)., and these results are displayed in Table 4. There was no mean difference between T and placebo groups on any of the 10 SRB-related outcomes. See the supplementary analyses for the results when the participants' relationship status was accounted for in examining the effect of drug condition on outcome variables.

3.4 H2: Effect of T on intention will be mediated by determinants of intention

The TPB model (see Figure 1) depicts attitude, subjective norm, and PBC as determinants of intention, and the latter predict an individual's behaviour. Based on this model, the potential mediating effect of attitudes, subjective norms, and perceived behavioural control on the drug condition by intention association was analyzed. Findings indicated no evidence that these determinants of intention mediated the drug condition by intention association.

3.5 H3: Effects of T on sexual risk-taking will be moderated by sociosexuality

Results of the simple linear regression confirmed that total SOI predicted intent to have sex ($\beta = 0.272$, $p = .004$), which lends support for including this variable as a moderator of the relationship between drug (T versus placebo) and SRB constructs. The regression model was adequately fit [$F(1, 107) = 8.56$, $p = .004$).

Results of the moderation analyses revealed there was no moderating effect of total SOI on the relationship between drug and the 10 SRB-related dependent variables. As for direct effects, total SOI positively predicted participant's intention to have sex [$F(1, 107) = 8.557$, $\beta = .345$, $SE = .118$, $p = 0.004$], perception of realism of the scenario [$F(1, 106) = 7.087$, $\beta = .289$,

SE = .109, *p* = 0.009], subjective norms [*F*(1, 108) = 4.712, β = .155, *SE* = .072, *p* = 0.034], self-efficacy [*F*(1, 107) = 4.001, β = .228, *SE* = .114, *p* = 0.048], controllability [*F*(1, 108) = 7.336, β = .275, *SE* = .102, *p* = 0.008], and past unprotected sex [*F*(1, 108) = 13.810, β = .441, *SE* = .119, *p* < 0.001].

3.6 Supplementary analyses

Previous research indicated that variations in baseline T levels are associated with relationship status (Burnham et al., 2003; Gettler et al., 2011; Gray et al., 2004; Grebe et al., 2019; Hooper et al., 2011), thus additional exploratory analyses were performed to investigate this relationship within the current study. Independent ANOVAs were performed to evaluate the main and interaction effects of 2 between-participant factors (drug: T versus placebo; relationship status: paired versus single) on each of the 10 SRB-related outcome variables. Results revealed significance or marginal significance for 4 of the 10 ANOVAs.

Regarding *cognitive attitudes* towards the sexual encounter, there were no main effects of drug [*F*(1,1) = 0.02, *p* = .892, η^2 < 0.000] or relationship status [*F*(1,1) = 4.41, *p* = .522, η^2 = 0.004]. The interaction of drug by relationship status on cognitive attitudes was significant [*F*(1,1) = 4.41, *p* = .038, η^2 = 0.040]. Post-hoc analyses indicated that after placebo, single men reported significantly more positive cognitive attitudes towards the risky sexual encounter (*M* = 3.47, *SE* = .25) relative to paired men [*M* = 2.72, *SE* = .28; *t*(60) = 2.037, *p* = .044, Cohen's *D* = .53] (see Figure 3). In contrast, after T, there was no difference in cognitive attitudes between single (*M* = 2.93, *SE* = .25) and paired men [(*M* = 3.33, *SE* = .30; *t*(48) = 0.987, *p* = .326, Cohen's *D* = .28]. Therefore, T appeared to eliminate the difference between paired vs. single men in terms of positive attitudes towards the risky sexual encounter.

In relation to *controllability* over having sex in this situation, there was no main effect of drug [$F(1,1) = 0.246$, $p = .621$, $\eta^2 = 0.002$] and a significant main effect of relationship status [$F(1,1) = 4.713$, $p = .032$, $\eta^2 = 0.043$]. Overall, paired men reported greater controllability ($M = 4.88$, $SE = 0.238$) than single men ($M = 4.15$, $SE = 0.208$). There was a marginally significant interaction effect of drug by relationship status on controllability [$F(1,1) = 3.436$, $p = .067$, $\eta^2 = 0.030$]. Exploratory post-hoc analyses indicated that after placebo, single men showed significantly less controllability over having sex ($M = 3.97$, $SE = .27$) than did paired men [$M = 5.24$, $SE = .33$; $t(59) = 2.988$, $p = .003$, Cohen's $D = .78$] (see Figure 4). After T, there was no significant difference in controllability between single ($M = 4.40$, $SE = .33$) and paired men [($M = 4.50$, $SE = .33$; $t(48) = 0.215$, $p = .830$, Cohen's $D = .06$]. While not statistically significant, this result suggests that T eliminates the difference between paired vs. single men in terms of controllability.

There were no main effects of drug [$F(1,1) = 2.02$, $p = .258$, $\eta^2 = 0.019$] or relationship status [$F(1,1) = 1.10$, $p = .297$, $\eta^2 = 0.010$] on *sexual arousal* associated with having unprotected sex in the imagined hypothetical scenario. As with controllability, there was a marginally significant interaction effect of drug by relationship status on sexual arousal [$F(1,1) = 3.436$, $p = .067$, $\eta^2 = 0.031$]. Post-hoc analyses indicated that the sexual arousal of paired men was significantly lower after placebo ($M = 5.80$, $SE = .22$) than after T [$M = 6.50$, $SE = .23$; $t(48) = 2.22$, $p = .029$, Cohen's $D = .63$] (see Figure 5). Conversely, there was no difference in sexual arousal for single men after receiving placebo ($M = 5.97$, $SE = .18$) relative to T [($M = 5.88$, $SE = .22$; $t(60) = 0.32$, $p = .749$, Cohen's $D = .08$].

The past *unprotected sex* outcome showed a significant main effect of relationship status [$F(1,1) = 5.891$, $p = 0.017$, $\eta^2 = 0.053$] such that paired men ($M = 3.61$, $SE = .27$) reported more

frequent past unprotected sex than single men (M = 2.67, SE = .27) (see Figure 6). There was no main effect of drug [$F(1,1) = 0.727$, $p = 0.396$, $\eta^2 = 0.007$] and no interaction effect of drug by relationship status [$F(1,1) = 0.081$, $p = 0.777$, $\eta^2 = 0.001$] on participants' reporting of past unprotected sex.

Chapter 4: Discussion

4.1 Discussion

The present research provides a timely and necessary investigation into the effects of exogenous T on men's tendency to engage in SRB. Little research has addressed the question of whether T has an effect on men's propensity to engage in unprotected sex. This study was the first of its kind to compare a single dose of T versus placebo on social, cognitive, and affective factors that are associated with sexual risk-taking behaviours in men.

Contrary to expectations, this experiment did not detect evidence to support our first hypothesis that T would increase men's willingness to engage in sexual risk-taking. Results indicated the absence of a direct effect of T on TPB-related outcome variables associated with the intention to engage in sexual risk-taking. There was also no support found for the second hypothesis that suggested a moderating effect, whereby T would change the association between intention to have sex and its predictors.

Regarding the assumption that the effect of T on men's willingness to engage in SRB would be moderated by SOI, our experiment found no evidence to support this third hypothesis. Although these null findings related to T and sexual risk-taking were not very encouraging, they are not surprising because much of the literature in this area has shown mixed results and null findings are not uncommon. In T administration studies within the broader domain of risk-taking for example, studies have found either weak support, or no support for the relationship between T and risk-taking (Apicella et al., 2015; Kurath & Mata, 2018; Stanton et al., 2021). The pages that follow elaborate on the results of the correlational analyses and exploratory analyses that, to some degree, support and contradict the predicted direction of our results.

When analyzing associations between variables for the participant group as a whole, the current experiment found several significant correlations. Notably, there was a positive correlation between intention to have sex and total SOI. Specifically, these findings demonstrate that men who are more unrestricted reported a greater intention to have sex in the risky sexual encounter. These results align with those reported by Seal and Agostinelli (1994) who found that an unrestricted SOI predicts reduced condom use. Additionally, earlier observations noted in the literature demonstrate that SOI predicts a number of behaviours associated with SRB such as frequency of casual sex, STI history, and condom use (Hall & Witherspoon, 2011; Ostovich & Sabini, 2004; Simpson & Gangestad, 1991; Snyder et al., 1986).

Another finding that emerged from the preliminary analyses was that intention to have sex was significantly correlated with the TPB's major constructs. The strongest positive associations were observed between intention to have sex and cognitive attitudes, affective attitudes, and self-efficacy. Slightly lower *r*-values were found for subjective norms, and a marginally significant negative correlation between intention and controllability. These results generally support observations made by Gomes and Nunes (2017) who demonstrated that attitudes were a stronger predictor of condom use intention than subjective norms. Also, Bennett and Bozionelos (2000) found that self-efficacy was more influential than controllability in predicting condom use intention and condom use.

As described in the literature review, a major construct of the TPB is PBC, which comprises both self-efficacy and controllability (Trafimow et al., 2002). Consistent with a growing body of literature on the TPB and condom use intention, results indicated a stronger relationship between intention to have unprotected sex and the perceived self-efficacy construct (r = .579) than the perceived controllability construct of PCB (r = -.181; Carmack & Lewis-

Moss, 2009; Giles et al., 2005; Muñoz-Silva et al., 2007). At a glance, these are seemingly conflicting correlational results between intention and the two aspects of PBC. An explanation as to why intention may be strongly positively associated with self-efficacy, and marginally negatively associated with controllability, can be found in how these variables were measured as two distinct constructs. The question used to quantify self-efficacy asked participants to rate their perceived level of ease/difficulty with regard to having sex in the hypothetical scenario; higher scores reflected greater self-efficacy. The resulting strong positive correlation between intention to have sex and self-efficacy indicates men's greater ease with having sex is associated with greater intention to have sex. As for controllability, this construct was measured by asking about the men's sense of whether having sex was under their volitional control, with low scores indicating a lesser sense of personal control over the behaviour. Therefore, the negative correlation reflects how a reduced sense of control is associated with greater intention to have unprotected sex. These findings add to the body of literature that support self-efficacy and controllability as two separate PBC constructs rather than one (Ajzen, 2002; Ajzen & Fishbein, 2005; Povey et al., 2000; Trafimow et al., 2002).

Other important findings resulted from analysing intercorrelations between study variables within the T and placebo groups separately, with differences observed between experimental groups in these data. Results indicated a significant negative correlation between intention to have sex and controllability in the T group but not the placebo group such that men on T who reported less control over having sex indicated greater intention to have sex, yet there was no evidence of this association in the placebo group. Similarly, there was a significant negative correlation between trust and controllability in the T group, but not the placebo group, suggesting that men on T experienced less controllability the more they trusted the female sexual

partner. With respect to the placebo group, one particularly notable finding emerged: sexual arousal and intention to have sex were significantly positively correlated in the placebo group, but not in the T group.

These findings suggest that T heightens men's perceived controllability over having unprotected sex in relation to how much they trust a woman and how strongly they intend to have sex. There also appears to be more consideration when it comes to decision-making involving unprotected sex as it appears that T blunts the association between sexual arousal and intention to have unprotected sex. It stands to reason that T may increase men's discernment surrounding condom use such that greater trust in the woman is an important factor for men to feel less control over their actions. Additionally, sexual arousal no longer predicts men's intention to have unprotected sex when on T, and they reported a greater sense of behavioural control the less they intended to have sex. These results provide further support for those of Rinella et al. (2019) who found that more masculinized 2D:4D finger length ratios predicted less deliberate risk-taking and greater precautionary behaviours in a sample of male and female cavers. Moreover, van Anders et al. (2012) reported findings showing T was a significant predictor of safer sex resilience whereby men with higher endogenous T were more likely to engage in safer sex behaviours, such as using a condom, even in the face of barriers in doing so. van Anders et at. (2012) reasoned that safer sex was the bolder choice as it necessitates greater confidence during condom negotiation and pointed to this tendency as being socially risky and may align with a greater sense of perceived status.

There were also notable differences found in SRB-related outcomes when comparing T versus placebo in paired versus single men, which provided some support for our first hypothesis. These analyses were performed in light of evidence in the literature that men in a

committed relationship generally have lower T than single men (Burnham et al., 2003; Gettler et al., 2011; Gray et al., 2004; Grebe et al., 2019; Hooper et al., 2011), and it is therefore possible that a single dose of T has a different effect based on men's relationship status. Findings indicated that paired men had greater controllability over having sex and more negative cognitive attitudes towards the risky sexual encounter than single men when on placebo, but not on T. Paired men also showed an increase in sexual arousal on T compared with placebo. It can thus be suggested that T has a greater effect on SRB-related constructs in partnered men. Evidence from a meta-analysis conducted by Isidori et al. (2005) established that exogenous T has a significant positive effect on sexual functioning compared to placebo, only in men with low to low-normal T levels. Comparing Isidori et al's (2005) findings with those of the current experiment confirms exogenous T may affect sexual behaviour-related outcomes differently for paired versus single men, or particularly for men with low basal T concentrations. Unfortunately, the baseline and post-drug administration T concentrations of the current experiment's participants are unknown due to reasons discussed in the study limitations.

4.2 Limitations and Future Direction

There are several limitations to the current experiment. First, propensity toward sexual risk-taking behaviour was assessed using self-report measures, which can be less reliable due to problems with response bias, or the participants' responses may not reflect their actual behaviour (Ajzen & Fishbein, 2005; Geniole & Carré, 2018). Second, the data were collected in a laboratory setting, which can also bias behaviour due to the experimenter demand effect (Henderson et al., 2018). Third, we cannot exclude the possibility that the intranasal T administration did not actually increase serum T levels since we were unable to analyze saliva samples collected during the experiment to confirm this anticipated outcome. As described

earlier in the methodological limitations section, Geniole et al.'s (2019) psychopharmacogenetic study using the same T administration protocol as the current experiment showed a rapid increase in serum T that lasted over 3 hours, and there is no reason to suspect this effect would be any different in the current experiment. However, it is still recommended to use caution when interpreting these data.

Fourth, questions aimed at measuring social norms did not measure the two separate aspects of this construct. Injunctive norms are beliefs about other people's approval of one's behaviour, and descriptive norms are one's beliefs about how other people behave. The questionnaire used in the current experiment to measure SRB-related constructs was developed based on Connor et al.'s (2008) measures. Although Connor et al. (2008) differentiated between injunctive and descriptive norms in their literature review, their questionnaire only measured injunctive norms. They justified this decision by noting that few studies use the two-factor model for social norms even though most researchers continue to distinguish between the two aspects of attitudes (cognitive and affective) and PBC (self-efficacy and controllability). However, Ajzen and Fishbein (2005) recommend questionnaires be designed to assess both types of subjective norms in order to quantify subjective norms more completely. Having based the study questionnaire on that of Connor et al. (2008), which was missing items that assess descriptive norms, an outcome variable was omitted. Future research in the area should include measures that also assess descriptive norms, and refer to Ajzen's (2019) publication for more information on how best to construct a TPB questionnaire.

Fifth, the heterosexual nature of the vignette used for the hypothetical sexual encounter in this experiment made it such that we could only include data from participants who identified as heterosexual, bisexual, or who did not report their sexual orientation. Having different vignettes

depending on the participants' sexual orientation would have been helpful in order to include participants who identified as exclusively homosexual. For example, Conner et al. (2008) included vignettes with a male sexual partner, and it would also be possible to create the same vignette with a gender neutral sexual partner for those who identified as bisexual or did not report their sexual orientation. Although these gender and sexual orientation-specific variations in the vignette are beyond the scope of this preliminary research in the area, future studies should consider using vignettes that are suitable for any and all sexual orientations.

Sixth, this experiment's sample size is also a limitation. Based on the current sample size of $N = 110$, it was determined there is sufficient power (80%) to detect medium-to-large effect sizes ($d = .54$ or greater), however, not enough power to detect small ($d = .20$) to medium ($d = .50$) effect sizes. The original study design aimed to collect data from $N = 300$ participants, in order to have $n = 150$ per experimental group, which would have provided greater statistical power. Unfortunately, public health measures associated with the Covid-19 pandemic caused a premature cessation of data collection.

4.3 Conclusion

Considering the enormous personal and health-related costs of SRB, improving our understanding of their biological basis can inform interventions used to curb maladaptive sexual risk-taking behaviours (Conrod et al., 2013). The present study was designed to examine the effect of a single dose of T on men's willingness to engage in SRB with a new partner. The second aim of this study was to determine whether SOI moderated the hypothesized T-SRB relationship. There was no evidence of a direct effect of T on SRB-related outcomes, and no indication that SOI moderated the expected T-SRB relationship. Results also showed negative intention-controllability and trust-controllability correlations in the T group, but not the placebo

group, and the sexual arousal-intention association was only significant in the placebo group. Our study is the first to demonstrate links between exogenous T and greater potential for sexual risk-taking behaviour in men. Specifically, T upregulated positive cognitive attitudes and sexual arousal, and downregulated perceived control over having sex in a casual sexual encounter in paired men. The current study provides important findings to further theorize about the role of T in modulating human decision-making processes that play a role in sexual risk-taking and can be used to increase awareness of testosterone's effect on socio-cognitive processes associated with sexual risk-taking behaviours in young men.

References

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.), *Action control: From cognition to behavior* (pp. 11–39). Springer-Verlag. https://doi.org/10.1007/978-3-642-69746-3

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179–211.

Ajzen, I. (2002). Perceived behavioural control, self-efficacy, locus of control, and the theory of planned behaviour. *Journal of Applied Social Psychology*, *34*(4), 665–683.

Ajzen, I. (2012). Martin Fishbein's legacy. *The ANNALS of the American Academy of Political and Social Science, 640*(1), 11–27. https://doi.org/10.1177/0002716211423363

Ajzen, I. (2019). *Constructing a theory of planned behavior questionnaire*. TPB Questionnaire Construction. https://people.umass.edu/aizen/pdf/tpb.measurement.pdf

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Prentice-Hall.

Ajzen, I., & Fishbein, M. (2005). The influence of attitudes on behavior. In D. Albarracin, B. T. Johnson, & M. P. Zanna (Eds.), *The handbook of attitudes* (pp. 173–222). https://doi.org/10.1007/BF02294218

Ajzen, I., & Schmidt, P. (2020). Changing behavior using the theory of planned behavior. In *The handbook of behavior change* (pp. 17–31). https://doi.org/10.1017/9781108677318.002

Ajzen, I., & Sheikh, S. (2013). Action versus inaction: Anticipated affect in the theory of planned behavior. *Journal of Applied Social Psychology*, *43*(1), 155–162. https://doi.org/10.1111/j.1559-1816.2012.00989.x

Albarracín, D., Fishbein, M., Johnson, B. T., & Muellerleile, P. A. (2001). Theories of reasoned

action and planned behavior as models of condom use: A meta-analysis. *Psychological Bulletin*, *127*(1), 142–161. https://doi.org/10.1037/0033-2909.127.1.142

Aluja, A., & García, L. F. (2005). Sensation seeking, sexual curiosity and testosterone in inmates. *Neuropsychobiology*, *51*(1), 28–33. https://doi.org/10.1159/000082852

Aluja, A., García, L. F., García, Ó., & Blanco, E. (2016). Testosterone and disinhibited personality in healthy males. *Physiology and Behavior*, *164*, 227–232. https://doi.org/10.1016/j.physbeh.2016.06.007

Aluja, A., García, L. F., Martí-Guiu, M., Blanco, E., García, O., Fibla, J., & Blanch, À. (2015). Interactions among impulsiveness, testosterone, sex hormone binding globulin and androgen receptor gene CAG repeat length. *Physiology and Behavior*, *147*, 91–96. https://doi.org/10.1016/j.physbeh.2015.04.022

Aluja, A., & Torrubia, R. (2004). Hostility-aggressiveness, sensation seeking, and sex hormones in men: Re-exploring their relationship. *Neuropsychobiology*, *50*(1), 102–107. https://doi.org/10.1159/000077947

Alvergne, A., Faurie, C., & Raymond, M. (2009). Variation in testosterone levels and male reproductive effort: Insight from a polygynous human population. *Hormones and Behavior*, *56*(5), 491–497. https://doi.org/10.1016/j.yhbeh.2009.07.013

Apalkova, Y., Butovskaya, M. L., Shackelford, T. K., & Fink, B. (2021). Personality, aggression, sensation seeking, and hormonal responses to challenge in Russian alpinists and special operation forces. *Personality and Individual Differences*, *169*, 1–9. https://doi.org/10.1016/j.paid.2020.110238

Apicella, C. L., Carré, J. M., & Dreber, A. (2015). Testosterone and economic risk taking: A review. *Adaptive Human Behavior and Physiology*, *1*(3), 358–385.

https://doi.org/10.1007/s40750-014-0020-2

Apicella, C. L., Dreber, A., & Mollerstrom, J. (2014). Salivary testosterone change following monetary wins and losses predicts future financial risk-taking. *Psychoneuroendocrinology*, *39*(1), 58–64. https://doi.org/10.1016/J.PSYNEUEN.2013.09.025

Archer, J. (2006). Testosterone and human aggression: An evaluation of the challenge hypothesis. *Neuroscience and Biobehavioral Reviews*, *30*(3), 319–345. https://doi.org/10.1016/j.neubiorev.2004.12.007

Archer, J., Graham-Kevan, N., & Davies, M. (2005). Testosterone and aggression: A reanalysis of Book, Starzyk, and Quinsey's (2001) study. *Aggression and Violent Behavior*, *10*(2), 241–261. https://doi.org/10.1016/j.avb.2004.01.001

Axelsson, J., Ingre, M., Åkerstedt, T., & Holmbäck, U. (2005). Effects of acutely displaced sleep on testosterone. *Journal of Clinical Endocrinology and Metabolism*, *90*(8), 4530–4535. https://doi.org/10.1210/jc.2005-0520

Bajaj, S., Ramayanam, S., Enebeli, S., Nsohtabien, H., Andkhoe, M., Yaghoubi, M., Gall, S., Szafron, M., & Farag, M. (2017). Risk factors for sexually transmitted diseases in Canada and provincial variations. *Social Medicine*, *11*(2), 62–69.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Advances in Behaviour Research and Therapy*, *1*(4), 139–161. https://doi.org/10.1016/0146-6402(78)90002-4

Bandura, A. (1999). A social cognitive theory of personality. In L. Pervin & J. John (Eds.), *Handbook of personality* (2nd ed., pp. 154–196). Guilford Publications/Guilford Press. https://doi.org/10.1016/0749-5978(91)90022-L

Baron, R., & Richardson, D. (2004). *Human aggression*. Plenum Press.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*, 7–15.

Bennett, P., & Bozionelos, G. (2000). The theory of planned behaviour as predictor of condom use: A narrative review. *Psychology, Health and Medicine*, *5*(3), 307–326. https://doi.org/10.1080/713690195

Bickel, W. K., & Marsch, L. A. (2001). Toward a behavioral economic understanding of drug dependence: delay discounting processes. *Addiction*, *96*, 73–86. https://doi.org/10.1080/09652140020016978

Bogaert, A. F., & Fisher, W. A. (1995). Predictors of university men's number of sexual partners. *The Journal of Sex Research*, *32*(2), 119–130. https://doi.org/10.1080/00224499509551782

Booth, A., Johnson, D. R., & Granger, D. A. (1999). Testosterone and men's health. *Journal of Behavioral Medicine, 22*(1).

Burnham, T. C., Chapman, J. F., Gray, P. B., McIntyre, M. H., Lipson, S. F., & Ellison, P. T. (2003). Men in committed, romantic relationships have lower testosterone. *Hormones and Behavior*, *44*(2), 119–122. https://doi.org/10.1016/S0018-506X(03)00125-9

Byrnes, J. P., Miller, D. C., & Schafer, W. D. (1999). Gender differences in risk taking: A meta-analysis. *Psychological Bulletin*, *125*(3), 367–383. https://doi.org/10.1037/0033-2909.125.3.367

Campbell, B. C., Dreber, A., Apicella, C. L., Eisenberg, D. T. A., Gray, P. B., Little, A. C., Garcia, J. R., Zamore, R. S., & Lum, J. K. (2010). Testosterone exposure, dopaminergic reward, and sensation-seeking in young men. *Physiology and Behavior*, *99*(4), 451–456. https://doi.org/10.1016/j.physbeh.2009.12.011

Carmack, C. C., & Lewis-Moss, R. K. (2009). Examining the theory of planned behavior applied to condom use: The effect-indicator vs. Causal-indicator models. *Journal of Primary Prevention*, *30*(6), 659–676. https://doi.org/10.1007/s10935-009-0199-3

Carré, J. M., Campbell, J. A., Lozoya, E., Goetz, S. M. M., & Welker, K. M. (2013). Changes in testosterone mediate the effect of winning on subsequent aggressive behaviour. *Psychoneuroendocrinology*, *38*(10), 2034–2041. https://doi.org/10.1016/j.psyneuen.2013.03.008

Carré, J. M., Geniole, S. N., Ortiz, T. L., Bird, B. M., Videto, A., & Bonin, P. L. (2016). Exogenous testosterone rapidly increases aggressive behavior in dominant and impulsive men. *Biological Psychiatry*, *82*(4), 249–256. https://doi.org/10.1016/j.biopsych.2016.06.009

Carré, J. M., & McCormick, C. M. (2008). Aggressive behavior and change in salivary testosterone concentrations predict willingness to engage in a competitive task. *Hormones and Behavior*, *54*(3), 403–409. https://doi.org/10.1016/j.yhbeh.2008.04.008

Carré, J. M., & Olmstead, N. A. (2015). Social neuroendocrinology of human aggression: Examining the role of competition-induced testosterone dynamics. *Neuroscience*, *286*, 171–186. https://doi.org/10.1016/j.neuroscience.2014.11.029

Carré, J. M., & Robinson, B. A. (2020). Testosterone administration in human social neuroendocrinology: Past, present, and future. *Hormones and Behavior*, *122*, Article 104754. https://doi.org/10.1016/j.yhbeh.2020.104754

Caruthers, A. S., Van Ryzin, M. J., & Dishion, T. J. (2014). Preventing high-risk sexual behavior in early adulthood with family interventions in adolescence: Outcomes and developmental processes. *Prevention Science*, *15*(S1), 59–69. https://doi.org/10.1007/s11121-013-0383-9

Carver, C. S. (2005). Impulse and constraint: Perspectives from personality psychology,

convergence with theory in other areas, and potential for integration. *Personality and Social Psychology Review*, *9*(4), 312–333. https://doi.org/10.1207/s15327957pspr0904_2

Casto, K. V, Edwards, D. A., Akinola, M., Davis, C., & Mehta, P. H. (2020). Testosterone reactivity to competition and competitive endurance in men and women. *Hormones and Behavior*, *123*, 1–18. https://doi.org/10.1016/j.yhbeh.2019.104665

Catalano, R. F., Fagan, A. A., Gavin, L. E., Greenberg, M. T., Irwin, C. E., Ross, D. A., & Shek, D. T. L. (2012). Worldwide application of prevention science in adolescent health. *The Lancet*, *379*(9826), 1653–1664. https://doi.org/10.1016/s0140-6736(12)60238-4

Coates, J. M., & Herbert, J. (2008). Endogenous steroids and financial risk taking on a London trading floor. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(16), 6167–6172. https://doi.org/10.1073/pnas.0704025105

Coccaro, E. F., Beresford, B., Minar, P., Kaskow, J., & Geracioti, T. (2007). CSF testosterone: Relationship to aggression, impulsivity, and venturesomeness in adult males with personality disorder. *Journal of Psychiatric Research*, *41*(6), 488–492. https://doi.org/10.1016/j.jpsychires.2006.04.009

Comer, L. K., & Nemeroff, C. J. (2000). Blurring emotional safety with physical safety in AIDS and STD risk estimations: The casual/regular partner distinction. *Journal of Applied Social Psychology*, *30*(12), 2467–2490. https://doi.org/10.1111/j.1559-1816.2000.tb02446.x

Conner, M., & Sparks, P. (2005). Theory of planned behaviour and health behaviour. In M. Conner & P. Norman (Eds.), *Predicting health behaviour* (2nd ed., pp. 170–222). Open University Press.

Conner, M., Sutherland, E., Kennedy, F., Grearly, C., & Berry, C. (2008). Impact of alcohol on sexual decision making: Intentions to have unprotected sex. *Psychology and Health*, *23*(8),

909–934. https://doi.org/10.1080/08870440701596551

Conrod, P. J., O'Leary-Barrett, M., Newton, N., Topper, L., Castellanos-Ryan, N., MacKie, C., & Girard, A. (2013). Effectiveness of a selective, personality-targeted prevention program for adolescent alcohol use and misuse: A cluster randomized controlled trial. *JAMA Psychiatry*, *70*(3), 334–342. https://doi.org/10.1001/jamapsychiatry.2013.651

Cooper, M. L. (2002). Alcohol use and risky sexual behavior among college students and youth: Evaluating the evidence. *Journal of Studies on Alcohol*, *63*(SUPPL. 14), 101–117. https://doi.org/10.15288/jsas.2002.s14.101

Corradi, P. F., Corradi, R. B., & Greene, L. W. (2016). Physiology of the hypothalamic pituitary gonadal axis in the male. *Urologic Clinics of North America*, *43*(2), 151–162. https://doi.org/10.1016/j.ucl.2016.01.001

Costenbader, E., Lenzi, R., Hershow, R. B., Ashburn, K., & McCarraher, D. R. (2017). Measurement of social norms affecting modern contraceptive use: A literature review. *Studies in Family Planning*, *48*(4), 377–389. https://doi.org/10.1111/sifp.12040

Croschere, J., Dupey, L., Hilliard, M., Koehn, H., & Mayra, K. (2012). The effects of time of day and practice on cognitive abilities: Forward and backward Corsi block test and digit span. *PEBL Echnical Report 2012-03*. http://sites.google.com/site/pebltechnicalreports/home/pebl-technical-report-2012-03

Cross, C. P., Copping, L. T., & Campbell, A. (2011). Sex differences in impulsivity: A meta-analysis. *Psychological Bulletin*, *137*(1), 97–130. https://doi.org/10.1037/a0021591

Dabbs, J. M. (1990). Salivary testosterone measurements: Reliability across hours, days, and weeks. *Physiology and Behavior*, *48*(1), 83–86. https://doi.org/10.1016/0031-9384(90)90265-6

Daitzman, R., & Zuckerman, M. (1980). Disinhibitory sensation seeking, personality and gonadal hormones. *Personality and Individual Differences*, *1*(2), 103–110. https://doi.org/10.1016/0191-8869(80)90027-6

Daitzman, R., Zuckerman, M., Sammelwitz, P., & Ganjam, V. (1978). Sensation seeking and gonadal hormones. *Journal of Biosocial Science*, *10*(4), 401–408. https://doi.org/10.1017/S0021932000011895

Davis, K. C., Danube, C. L., Neilson, E. C., Stappenbeck, C. A., Norris, J., George, W. H., & Kajumulo, K. F. (2016). Distal and proximal influences on men's intentions to resist condoms: Alcohol, sexual aggression history, impulsivity, and social-cognitive factors. *AIDS and Behavior*, *20*, 147–157. https://doi.org/10.1007/s10461-015-1132-9

De Wit, H. (2009). Impulsivity as a determinant and consequence of drug use: A review of underlying processes. *Addiction Biology*, *14*(1), 22–31. https://doi.org/10.1111/j.1369-1600.2008.00129.x

Decaroli, M. C., & Rochira, V. (2017). Aging and sex hormones in males. *Virulence*, *8*(5), 545–570. https://doi.org/10.1080/21505594.2016.1259053

Dir, A. L., Coskunpinar, A., & Cyders, M. A. (2014). A meta-analytic review of the relationship between adolescent risky sexual behavior and impulsivity across gender, age, and race. *Clinical Psychology Review*, *34*(7), 551–562. https://doi.org/10.1016/j.cpr.2014.08.004

Diver, M. J., Imtiaz, K. E., Ahmad, A. M., Vora, J. P., & Fraser, W. D. (2003). Diurnal rhythms of serum total, free and bioavailable testosterone and of SHBG in middle-aged men compared with those in young men. *Clinical Endocrinology*, *58*(6), 710–717. https://doi.org/10.1046/J.1365-2265.2003.01772.X

Doi, H., Nishitani, S., & Shinohara, K. (2015). Hormones and behavior sex difference in the

relationship between salivary testosterone and inter-temporal choice. *Hormones and Behavior*, *69*, 50–58. https://doi.org/10.1016/j.yhbeh.2014.12.005

Durán, M., Ferraces, M. J., Rodríguez, M., Río, A., & Sabucedo, J. M. (2017). Intention to have sexual intercourse without a condom. *Trames*, *21*(1), 15–32. https://doi.org/10.3176/tr.2017.1.02

Edelstein, R. S., Chopik, W. J., & Kean, E. L. (2011). Sociosexuality moderates the association between testosterone and relationship status in men and women. *Hormones and Behavior*, *60*(3), 248–255. https://doi.org/10.1016/j.yhbeh.2011.05.007

Eisenegger, C., Haushofer, J., & Fehr, E. (2011). The role of testosterone in social interaction. *Trends in Cognitive Sciences*, *15*(6), 263–271. https://doi.org/10.1016/j.tics.2011.04.008

Fetner, T., Dion, M., Heath, M., Andrejek, N., Newell, S. L., & Stick, M. (2020). Condom use in penile-vaginal intercourse among Canadian adults: Results from the sex in Canada survey. *PLoS ONE*, *15*(2), 1–24. https://doi.org/10.1371/journal.pone.0228981

Fimbel, E., Lauzon, S., & Rainville, C. (2009). Performance of humans vs. exploration algorithms on the Tower of London Test. *PLoS ONE*, *4*(9), 7263. https://doi.org/10.1371/journal.pone.0007263

Fischer, S., & Smith, G. T. (2008). Binge eating, problem drinking, and pathological gambling: Linking behavior to shared traits and social learning. *Personality and Individual Differences*, *44*(4), 789–800. https://doi.org/10.1016/j.paid.2007.10.008

Forsythe, R., Horowitz, J. L., Savin, N. E., & Sefton, M. (1994). Fairness in simple bargaining experiments. *Games and Economic Behavior*, *6*(3), 347–369. https://doi.org/10.1006/game.1994.1021

Freeman, J. G., King, M., Pickett, W., Craig, W., Elgar, F., Janssen, I., & Klinger, D. (2011). *The*

health of Canada's young people: A mental health focus. Public health Agency of Canada.

Geniole, S., Bird, B., McVittie, J., Purcella, R., Archer, J., & Carré, J. (2020). Is testosterone linked to human aggression? A meta-analytic examination of the relationship between baseline, dynamic, and manipulated testosterone on human aggression. *Hormones and Behavior*, *123*. https://doi.org/10.1016/j.yhbeh.2019.104644

Geniole, S., & Carré, J. (2018). Human social neuroendocrinology: Review of the rapid effects of testosterone. *Hormones and Behavior*, *104*, 192–205. https://doi.org/10.1016/j.yhbeh.2018.06.001

Geniole, S., Procyshyn, T. L., Marley, N., Ortiz, T. L., Bird, B. M., Marcellus, A. L., Welker, K. M., Bonin, P. L., Goldfarb, B., Watson, N. V., & Carré, J. M. (2019). Using a psychopharmacogenetic approach to identify the pathways through which—and the people for whom—testosterone promotes aggression. *Psychological Science*, *30*(4), 481–494. https://doi.org/10.1177/0956797619826970

Gettler, L. T., McDade, T. W., Feranil, A. B., & Kuzawa, C. W. (2011). Longitudinal evidence that fatherhood decreases testosterone in human males. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(39), 16194–16199. https://doi.org/10.1073/pnas.1105403108

Giles, M., Liddell, C., & Bydawell, M. (2005). Condom use in African adolescents: The role of individual and group factors. *AIDS Care - Psychological and Socio-Medical Aspects of AIDS/HIV*, *17*(6), 729–739. https://doi.org/10.1080/09540120500038181

Giotakos, O., Markianos, M., Vaidakis, N., & Christodoulou, G. N. (2003). Aggression, impulsivity, plasma sex hormones, and biogenic amine turnover in a forensic population of rapists. *Journal of Sex and Marital Therapy*, *29*(3), 215–225.

https://doi.org/10.1080/00926230390155113

Godin, G., & Kok, G. (1996). The theory of planned behavior: A review of its applications to health- related behaviors. *American Journal of Health Promotion*, *11*(2), 87–98. https://doi.org/10.4278/0890-1171-11.2.87

Gomes, A. I. C. da S., & Nunes, M. C. S. (2017). Predicting condom use: A comparison of the theory of reasoned action, the theory of planned behavior and an extended model of TPB. *Psicologia: Teoria e Pesquisa*, *33*, 1–8. https://doi.org/10.1590/0102.3772e33422

Gray, P. B. (2003). Marriage, Parenting, and Testosterone Variation Among Kenyan Swahili Men. *American Journal of Physical Anthropology*, *122*(3), 279–286. https://doi.org/10.1002/ajpa.10293

Gray, P. B., Chapman, J. F., Burnham, T. C., McIntyre, M. H., Lipson, S. F., & Ellison, P. T. (2004). Human male pair bonding and testosterone. *Human Nature*, *15*(2), 119–131. https://doi.org/10.1007/s12110-004-1016-6

Grebe, N. M., Sarafin, R. E., Strenth, C. R., & Zilioli, S. (2019). Pair-bonding, fatherhood, and the role of testosterone: A meta-analytic review. *Neuroscience and Biobehavioral Reviews*, *98*, 221–233. https://doi.org/10.1016/j.neubiorev.2019.01.010

Haghir, E., Madampage, C., Mahmood, R., & Moraros, J. (2018). Risk factors associated with self-reported sexually transmitted infections among postsecondary students in Canada. *International Journal of Preventive Medicine*, *9*(49), 1–8. https://doi.org/10.4103/ijpvm.IJPVM_444_17

Hall, N. M., & Witherspoon, D. D. (2011). The Influence of Sociosexuality and Perceived Susceptibility on the Sexual Behavior of African American College Students. *Journal of Best Practices in Health Professions Diversity: Education, Research & Policy*, *4*(2), 681–

694.

Halpern, C. T., Udry, J. R., Campbell, B., Suchindran, C., & Masont, G. A. (1994). Testosterone and religiosity as predictors of sexual attitudes and activity among adolescent males: A biosocial model. *Journal of Biosocial Science*, *26*(2), 217–234. https://doi.org/10.1017/S0021932000021258

Halpern, C. T., Udry, J. R., & Suchindran, C. (1998). Monthly measures of salivary testosterone predict sexual activity in adolescent males. *Archives of Sexual Behavior*, *27*(5), 445–465. https://doi.org/10.1023/A:1018700529128

Harman, S. M., Metter, E. J., Tobin, J. D., Pearson, J., & Blackman, M. R. (2001). Longitudinal effects of aging on serum total and free testosterone levels in healthy men. *Journal of Clinical Endocrinology and Metabolism*, *86*(2), 724–731. https://doi.org/10.1210/jcem.86.2.7219

Hayes, A. (2022). *Introduction to mediation, moderation, and analysis, conditional process approach: A regression-based approach* (3rd ed.). Guilford Press.

Health Communication Capacity Collaborative. (2014). *Theory of planned behavior: An HC3 research prime*. https://www.healthcommcapacity.org/wp-content/uploads/2014/03/theory_of_planned_behavior.pdf

Henderson, A., Thoelen, G., Nadler, A., Barraza, J., & Nave, G. (2018). Testing the influence of testosterone administration on men's honesty in a large laboratory experiment. *Scientific Reports*, *8*(1). https://doi.org/10.1038/s41598-018-29928-z

Herbert, J. (2018). Testosterone, cortisol and financial risk-taking. *Frontiers in Behavioral Neuroscience*, *12*(May), 1–17. https://doi.org/10.3389/fnbeh.2018.00101

Höfer, P., Lanzenberger, R., & Kasper, S. (2013). Testosterone in the brain: Neuroimaging

findings and the potential role for neuropsychopharmacology. *European Neuropsychopharmacology*, *23*(2), 79–88. https://doi.org/10.1016/j.euroneuro.2012.04.013

Hönekopp, J., Voracek, M., & Manning, J. T. (2006). 2nd to 4th digit ratio (2D:4D) and number of sex partners: Evidence for effects of prenatal testosterone in men. *Psychoneuroendocrinology*, *31*(1), 30–37. https://doi.org/10.1016/j.psyneuen.2005.05.009

Hooper, A. E. C., Gangestad, S. W., Thompson, M. E., & Bryan, A. D. (2011). Testosterone and romance: The association of testosterone with relationship commitment and satisfaction in heterosexual men and women. *American Journal of Human Biology*, *23*(4), 553–555. https://doi.org/10.1002/ajhb.21188

Isidori, A. M., Giannetta, E., Gianfrilli, D., Greco, E. A., Bonifacio, V., Aversa, A., Isidori, A., Fabbri, A., & Lenzi, A. (2005). Effects of testosterone on sexual function in men: results of a meta-analysis. *Clinical Endocrinology*, *63*, 381–394. https://doi.org/10.1111/j.1365-2265.2005.02350.x

Kaufman, J.-M., Lapauw, B., Mahmoud, A., T'Sjoen, G., & Huhtaniemi, I. T. (2019). Aging and the male reproductive system. *Endocrine Reviews*, *40*(4), 906–972. https://doi.org/10.1210/er.2018-00178

Knight, E. L., McShane, B. B., Kutlikova, H. H., Morales, P. J., Christian, C. B., Harbaugh, W. T., Mayr, U., Ortiz, T. L., Gilbert, K., Ma-Kellams, C., Riečanský, I., Watson, N. V., Eisenegger, C., Lamm, C., Mehta, P. H., & Carré, J. M. (2020). Weak and variable effects of exogenous testosterone on cognitive reflection test performance in three experiments: Commentary on Nave, Nadler, Zava, and Camerer (2017). *Psychological Science*, *31*(7), 890–897. https://doi.org/10.1177/0956797619885607

Kurath, J., & Mata, R. (2018). Individual differences in risk taking and endogeneous levels of

testosterone, estradiol, and cortisol: A systematic literature search and three independent meta-analyses. *Neuroscience and Biobehavioral Reviews*, *90*(October 2017), 428–446. https://doi.org/10.1016/j.neubiorev.2018.05.003

Kuzawa, C., McDade, T., Adair, L., & Lee, N. (2010). Rapid weight gain after birth predicts life history and reproductive strategy in Filipino males. *Proceedings of the National Academy of Sciences*, *107*(39), 16800–16805. https://doi.org/10.1073/pnas

Losecaat Vermeer, A. B., Krol, I., Gausterer, C., Wagner, B., Eisenegger, C., & Lamm, C. (2020). Exogenous testosterone increases status-seeking motivation in men with unstable low social status. *Psychoneuroendocrinology*, *113*, 104552. https://doi.org/10.1016/j.psyneuen.2019.104552

Luberti, F. R., Reside, T. L., Bonin, P. L., & Carré, J. M. (2021). Development of a single-dose intranasal testosterone administration paradigm for use in men and women. *Hormones and Behavior*, *136*. https://doi.org/10.1016/j.yhbeh.2021.105046

Manning, J. T., & Taylor, R. P. (2001). Second to fourth digit ratio and male ability in sport: Implications for sexual selection in humans. *Evolution and Human Behavior*, *22*(1), 61–69. https://doi.org/10.1016/S1090-5138(00)00063-5

Mazur, A., & Booth, A. (1998). Testosterone and dominance in men. *Behavioral and Brain Sciences*, *21*(3), 353–397. https://doi.org/10.1017/S0140525X98001228

Mazur, A., & Michalek, J. (1998). Marriage, divorce, and male testosterone. *Social Forces*, *77*(1), 315–330. https://doi.org/10.1093/sf/77.1.315

McEachan, R., Taylor, N., Harrison, R., Lawton, R., Gardner, P., & Conner, M. (2016). Meta-analysis of the reasoned action approach (RAA) to understanding health behaviors. *Annals of Behavioral Medicine*, *50*(4), 592–612. https://doi.org/10.1007/s12160-016-9798-4

McIntyre, M., Gangestad, S. W., Gray, P. B., Chapman, J. F., Burnham, T. C., O'Rourke, M. T., & Thornhill, R. (2006). Romantic involvement often reduces men's testosterone levels - but not always: The moderating role of extrapair sexual interest. *Journal of Personality and Social Psychology*, *91*(4), 642–651. https://doi.org/10.1037/0022-3514.91.4.642

Midzak, A. S., Chen, H., Papadopoulos, V., & Zirkin, B. R. (2009). Leydig cell aging and the mechanisms of reduced testosterone synthesis. *Molecular and Cellular Endocrinology*, *299*(1), 23–31. https://doi.org/10.1016/j.mce.2008.07.016

Milhausen, R. R., McKay, A., Graham, C. A., Crosby, R. A., Yarber, W. L., & Sanders, S. A. (2013). Prevalence and predictors of condom use in a national sample of Canadian university students. *Canadian Journal of Human Sexuality*, *22*(3), 142–151. https://doi.org/10.3138/cjhs.2316

Morales, A., Espada, J. P., Orgilés, M., Escribano, S., Johnson, B. T., & Lightfoot, M. (2018). Interventions to reduce risk for sexually transmitted infections in adolescents: A meta-analysis of trials, 2008-2016. *PLoS ONE*, *13*(6). https://doi.org/10.1371/journal.pone.0199421

Muñoz-Silva, A., Sánchez-García, M., Nunes, C., & Martins, A. (2007). Gender differences in condom use prediction with Theory of Reasoned Action and Planned Behaviour: The role of self-efficacy and control. *AIDS Care - Psychological and Socio-Medical Aspects of AIDS/HIV*, *19*(9), 1177–1181. https://doi.org/10.1080/09540120701402772

Natesto. (2017). *Highlights of Prescribing Information*. https://www.accessdata.fda.gov/drugsatfda_docs/label/2014/205488s000lbl.pdf

Natesto. (2014). *Natesto nasal gel: Prescribing information*. https://www.accessdata.fda.gov/drugsatfda_docs/label/2014/205488s000lbl.pdf

Nave, G., Nadler, A., Zava, D., & Camerer, C. (2017). Single-dose testosterone administration impairs cognitive reflection in men. *Psychological Science*, *28*(10), 1398–1407. https://doi.org/10.1177/0956797617709592

O'Carroll, R., Shapiro, C., & Bancroft, J. (1985). Androgens, behaviour and nocturnal erection in hypogonadal men: The effects of varying the replacement dose. *Clinical Endocrinology*, *23*(5), 527–538. https://doi.org/10.1111/j.1365-2265.1985.tb01113.x

O'Connor, D. B., Lee, D. M., Corona, G., Forti, G., Tajar, A., O'Neill, T. W., Pendleton, N., Bartfai, G., Boonen, S., Casanueva, F. F., Finn, J. D., Giwercman, A., Han, T. S., Huhtaniemi, I. T., Kula, K., Labrie, F., Lean, M. E. J., Punab, M., Silman, A. J., … Jiang, M. (2011). The relationships between sex hormones and sexual function in middle-aged and older European men. *Journal of Clinical Endocrinology and Metabolism*, *96*(10), E1577–E1587. https://doi.org/10.1210/jc.2010-2216

Ortner, G. R., Wibral, M., Becker, A., Dohmen, T., Klingmüller, D., Falk, A., & Weber, B. (2013). No evidence for an effect of testosterone administration on delay discounting in male university students. *Psychoneuroendocrinology*, *38*(9), 1814–1818. https://doi.org/10.1016/j.psyneuen.2012.12.014

Ostovich, J. M., & Sabini, J. (2004). How are sociosexuality, sex drive, and lifetime number of sexual partners related? *Personality and Social Psychology Bulletin*, *30*(10), 1255–1266. https://doi.org/10.1177/0146167204264754

Penke, L. (2013). Revised sociosexual orientation inventory. In T. D. Fisher, C. M. Davis, W. L. Yarber, & S. Davis (Eds.), *Handbook of sexuality-related measures* (3rd ed., pp. 622–625). Taylor & Francis.

Penke, L., & Asendorpf, J. B. (2008). Beyond global sociosexual orientations: A more

differentiated look at sociosexuality and its effects on courtship and romantic relationships. *Journal of Personality and Social Psychology*, *95*(5), 1113–1135. https://doi.org/10.1037/0022-3514.95.5.1113

Peper, J. S., Mandl, R. C. W., Braams, B. R., De Water, E., Heijboer, A. C., Koolschijn, P. C. M. P., & Crone, E. A. (2013). Delay discounting and frontostriatal fiber tracts: A combined DTI and MTR study on impulsive choices in healthy young adults. *Cerebral Cortex*, *23*(7), 1695–1702. https://doi.org/10.1093/cercor/bhs163

Perini, T., Ditzen, B., Hengartner, M., & Ehlert, U. (2012). Sensation seeking in fathers: The impact on testosterone and paternal investment. *Hormones and Behavior*, *61*(2), 191–195. https://doi.org/10.1016/j.yhbeh.2011.12.004

Peters, M., Simmons, L. W., & Rhodes, G. (2008). Testosterone is associated with mating success but not attractiveness or masculinity in human males. *Animal Behaviour*, *76*(2), 297–303. https://doi.org/10.1016/j.anbehav.2008.02.008

Pollet, T. V., der Meij, L. van, Cobey, K. D., & Buunk, A. P. (2011). Testosterone levels and their associations with lifetime number of opposite sex partners and remarriage in a large sample of American elderly men and women. *Hormones and Behavior*, *60*(1), 72–77. https://doi.org/10.1016/j.yhbeh.2011.03.005

Poppen, P. J. (1995). Gender and patterns of sexual risk taking in college students. *Sex Roles*, *32*(7–8), 545–555. https://doi.org/10.1007/BF01544188

Povey, R., Conner, M., Sparks, P., James, R., & Shepherd, R. (2000). Application of the Theory of Planned Behaviour to two dietary behaviours: Roles of perceived control and self-efficacy. *British Journal of Health Psychology*, *5*(2), 121–139. https://doi.org/10.1348/135910700168810

Public Health Agency of Canada. (2019a). *HIV in Canada: 2018 surveillance highlights*. https://www.canada.ca/en/public-health/services/publications/diseases-conditions/hiv-2018-surveillance-highlights.html

Public Health Agency of Canada. (2019b). *Report on sexually transmitted infections in Canada, 2017*. https://doi.org/10.1128/microbiolspec.IOL5-0011-2015

Puts, D. A., Pope, L. E., Hill, A. K., Cárdenas, R. A., Welling, L. L. M., Wheatley, J. R., & Marc Breedlove, S. (2015). Fulfilling desire: Evidence for negative feedback between men's testosterone, sociosexual psychology, and sexual partner number. *Hormones and Behavior*, *70*, 14–21. https://doi.org/10.1016/j.yhbeh.2015.01.006

Raouf, S. A., Parker, P. G., Ketterson, E. D., Nolan V., J., & Ziegenfus, C. (1997). Testosterone affects reproductive success by influencing extra-pair fertilizations in male dark-eyed juncos (Aves: Junco hyemalis). *Proceedings of the Royal Society B: Biological Sciences*, *264*(1388), 1599–1603. https://doi.org/10.1098/rspb.1997.0223

Rehm, J., Shield, K. D., Joharchi, N., & Shuper, P. A. (2012). Alcohol consumption and the intention to engage in unprotected sex: Systematic review and meta-analysis of experimental studies. *Addiction*, *107*(1), 51–59. https://doi.org/10.1111/j.1360-0443.2011.03621.x

Rinella, S., Buscemi, A., Massimino, S., Perciavalle, V., Tortorici, M. M., Tomaselli, D. G., Perciavalle, V., Di Corrado, D., & Coco, M. (2019). Risk-taking behavior, the second-to-fourth digit ratio and psychological features in a sample of cavers. *PeerJ*, *2019*(11), 7:e8029. https://doi.org/10.7717/peerj.8029

Roberti, J. W. (2004). A review of behavioral and biological correlates of sensation seeking. *Journal of Research in Personality*, *38*(3), 256–279. https://doi.org/10.1016/S0092-

6566(03)00067-9

Rodrigues, D., & Lopes, D. (2017). Sociosexuality, commitment, and sexual desire for an attractive person. *Archives of Sexual Behavior, 46*(3), 775–788. https://doi.org/10.1007/s10508-016-0814-3

Rogol, A. D., Tkachenko, N., & Bryson, N. (2016). Natesto™, a novel testosterone nasal gel, normalizes androgen levels in hypogonadal men. *Andrology*, *4*(1), 46–54. https://doi.org/10.1111/andr.12137

Ronay, R., & von Hippel, W. (2010). The presence of an attractive woman elevates testosterone and physical risk taking in young men. *Social Psychological and Personality Science, 1*(1), 57–64. https://doi.org/10.1177/1948550609352807

Roney, J. R., & Gettler, L. T. (2015). The role of testosterone in human romantic relationships Introduction: the biological functions of testosterone. *Current Opinion in Psychology*, *1*, 81–86. http://www.elsevier.com/authorsrights%5Cnhttp://dx.doi.org/10.1016/j.copsyc.2014.11.003

Rose, R. M., Kreuz, L. E., Holaday, J. W., Sulak, K. J., & Johnson, C. E. (1972). Diurnal variation of plasma testosterone and cortisol. *The Journal of Endocrinology*, *54*(1), 177–178. https://doi.org/10.1677/joe.0.0540177

Saad, G., & Vongas, J. G. (2009). The effect of conspicuous consumption on men's testosterone levels. *Organizational Behavior and Human Decision Processes*, *110*(2), 80–92. https://doi.org/10.1016/j.obhdp.2009.06.001

Salmimies, P., Kockott, G., Pirke, K. M., Vogt, H. J., & Schill, W. B. (1982). Effects of testosterone replacement on sexual behavior in hypogonadal men. *Archives of Sexual Behavior*, *11*(4), 345–353. https://doi.org/10.1007/BF01541595

Salonia, A., Rastrelli, G., Hackett, G., Seminara, S. B., Huhtaniemi, I. T., Rey, R. A., Hellstrom, W. J. G., Palmert, M. R., Corona, G., Dohle, G. R., Khera, M., Chan, Y. M., & Maggi, M. (2019). Paediatric and adult-onset male hypogonadism. *Nature Reviews Disease Primers*, *5*(1), 1–49. https://doi.org/10.1038/s41572-019-0087-y

Schmitt, D. P. (2005). Sociosexuality from Argentina to Zimbabwe: A 48-nation study of sex, culture, and strategies of human mating. *Behavioral and Brain Sciences*, *28*(2), 247–275. https://doi.org/10.1017/S0140525X05000051

Scott-Sheldon, L. A. J., Carey, K. B., Cunningham, K., Johnson, B. T., & Carey, M. P. (2016). Alcohol use predicts sexual decision-making: A systematic review and meta-analysis of the experimental literature. *AIDS and Behavior*, *20*, 19–39. https://doi.org/10.1007/s10461-015-1108-9

Seal, D. W., & Agostinelli, G. (1994). Individual differences associated with high-risk sexual behaviour: Implications for intervention programmes. *AIDS Care*, *6*(4), 393–397. https://doi.org/10.1080/09540129408258653

Sheeran, P., & Taylor, S. (1999). Predicting intentions to use condoms: A meta-analysis and comparison of the theories of reasoned action and planned behavior. *Journal of Applied Social Psychology*, *29*(8), 1624–1675. https://doi.org/10.1111/j.1559-1816.1999.tb02045.x

Shlykova, N., Davidson, E., Krakowsky, Y., Bolanos, J., Traish, A., & Morgentaler, A. (2020). Absent diurnal variation in serum testosterone in young men with testosterone deficiency. *The Journal of Urology*, *203*(4), 817–823. https://doi.org/10.1097/JU.0000000000000630

Simpson, J. A., & Gangestad, S. W. (1991). Individual differences in sociosexuality: Evidence for convergent and discriminant validity. *Journal of Personality and Social Psychology*, *60*(6), 870–883. https://doi.org/10.1037/0022-3514.60.6.870

Snyder, M., Simpson, J. A., & Gangestad, S. (1986). Personality and sexual relations. *Journal of Personality and Social Psychology*, *51*(1), 181–190. https://doi.org/10.1037/0022-3514.51.1.181

Stanton, S. J. (2017). The role of testosterone and estrogen in consumer behavior and social & economic decision making: A review. *Hormones and Behavior*, *92*, 155–163. https://doi.org/10.1016/j.yhbeh.2016.11.006

Stanton, S. J., Liening, S. H., & Schultheiss, O. C. (2011). Testosterone is positively associated with risk taking in the Iowa Gambling Task. *Hormones and Behavior*, *59*(2), 252–256. https://doi.org/10.1016/j.yhbeh.2010.12.003

Stanton, S. J., Welker, K. M., Bonin, P. L., Goldfarb, B., & Carré, J. M. (2021). The effect of testosterone on economic risk-taking: A multi-study, multi-method investigation. *Hormones and Behavior*, *134*(May). https://doi.org/10.1016/j.yhbeh.2021.105014

Strauss, E., & Spreen, O. (1998). *A compendium of neuropsychological tests: Administration, norms, and commentary (2nd ed.)*. Oxford University Press.

Takahashi, T., Sakaguchi, K., Oki, M., Homma, S., & Hasegawa, T. (2006). Testosterone levels and discounting delayed monetary gains and losses in male humans. *Neuroendocrinology Letters*, *27*(4), 439–444.

Timmers, A. D., & Olivers, M. L. (2012). Sociosexuality and sexual arousal. *Canadian Journal of Human Sexuality*, *21*(3–4), 135–146.

Trafimow, D., Sheeran, P., Conner, M., & Finlay, K. A. (2002). Evidence that perceived behavioural control is a multidimensional construct: Perceived control and perceived difficulty. *British Journal of Social Psychology*, *41*(1), 101–121. https://doi.org/10.1348/014466602165081

Tyson, M., Covey, J., & Rosenthal, H. E. S. (2014). Theory of planned behavior interventions for reducing heterosexual risk behaviors: A meta-analysis. *Health Psychology*, *33*(12), 1454–1467. https://doi.org/10.1037/hea0000047

Van Anders, S. M. (2012). Testosterone and sexual desire in healthy women and men. *Archives of Sexual Behavior*, *41*(6), 1471–1484. https://doi.org/10.1007/s10508-012-9946-2

van Anders, S. M., Goldey, K. L., Conley, T. D., Snipes, D. J., & Patel, D. A. (2012). Safer sex as the bolder choice: Testosterone is positively correlated with safer sex behaviorally relevant attitudes in young men. *Journal of Sexual Medicine*, *9*(3), 727–734. https://doi.org/10.1111/j.1743-6109.2011.02544.x

van Anders, S. M., Hamilton, L. D., & Watson, N. V. (2007). Multiple partners are associated with higher testosterone in North American men and women. *Hormones and Behavior*, *51*(3), 454–459. https://doi.org/10.1016/j.yhbeh.2007.01.002

van der Meij, L., Buunk, A. P., van de Sande, J. P., & Salvador, A. (2008). The presence of a woman increases testosterone in aggressive dominant men. *Hormones and Behavior*, *54*(5), 640–644. https://doi.org/10.1016/j.yhbeh.2008.07.001

van Honk, J., Will, G. J., Terburg, D., Raub, W., Eisenegger, C., & Buskens, V. (2016). Effects of testosterone Administration on Strategic Gambling in Poker Play. *Scientific Reports*, *6*(December 2014). https://doi.org/10.1038/srep18096

Verbruggen, F., & Logan, G. D. (2008). Automatic and controlled response inhibition: Associative learning in the Go/No-Go and Stop-Signal paradigms. *Journal of Experimental Psychology: General*, *137*(4), 649–672. https://doi.org/10.1037/a0013170

Virkkunen, M., Rawlings, R., Tokola, R., Poland, R. E., Guidotti, A., Nemeroff, C., Bissette, G., Kalogeras, K., Karonen, S.-L., & Linnoila, M. (1994). CSF biochemistries, glucose

metabolism, and diurnal activity rhythms in alcoholic, violent offenders, fire setters, and healthy volunteers. *Arch Gen Psychiatry*, *51*(1), 20–27.

Welker, K., Roy, A., Geniole, S., Kitayama, S., & Carré, J. (2017). Taking risks for personal gain: An investigation of self-construal and testosterone responses to competition. *Social Neuroscience*, *14*(1). https://doi.org/10.1080/17470919.2017.1407822

Wingfield, J. C., Hegner, R. E., Dufty, A. M., & Ball, G. F. (1990). The "challenge hypothesis'': theoretical implications for patterns of testosterone secretion, mating systems, and breeding strategies." *American Naturalist*, *136*(6), 829–846. https://doi.org/10.1086/285134

Winters, S. J. (1991). Diurnal rhythm of testosterone and luteinizing gormone in hypogonadal men. *Journal of Andrology*, *12*(3), 185–190. https://doi.org/10.1002/j.1939-4640.1991.tb00247.x

Wong, T., Singh, A., Mann, J., Hansen, L., & McMahon, S. (2004). Gender differences in bacterial STIs in Canada. *BMC Women's Health*, *4*(Suppl 1), S26. https://doi.org/10.1186/1472-6874-4-s1-s26

World Health Organization. (2018). Report on global sexually transmitted infection surveillance, 2018. In *WHO Library Cataloguing*. https://apps.who.int/iris/rest/bitstreams/1170799/retrieve

Wu, Y., Liu, J., Qu, L., Eisenegger, C., Clark, L., & Zhou, X. (2016). Single dose testosterone administration reduces loss chasing in healthy females. *Psychoneuroendocrinology*, *71*, 54–57. https://doi.org/10.1016/j.psyneuen.2016.05.005

Wu, Y., Shen, B., Liao, J., Li, Y., Zilioli, S., & Li, H. (2020). Single dose testosterone administration increases impulsivity in the intertemporal choice task among healthy males. *Hormones and Behavior*, *118*, Article 104634. https://doi.org/10.1016/j.yhbeh.2019.104634

Zuckerman, M. (1991). Sensation seeking: The balance between risk and reward. In L. P. Lipsitt & L. L. Mitnick (Eds.), *Self-regulatory behavior and risk taking: Causes and consequences* (pp. 143–151). Ablex Publishing Corporation.

Zuckerman, M. (1994). *Behavioral expressions and biosocial bases of sensation seeking*. Cambridge University Press.

Appendix A

Informed Consent Form

NIPISSING UNIVERSITY

CONSENT FORM

Title of Study: Effects of testosterone on executive functioning

Principal Investigators: Justin M. Carré, Ph.D. — Department of Psychology, Nipissing University — justinca@nipissingu.ca

Neil V. Watson, Ph.D. — Department of Psychology, Simon Fraser University — nwatson@sfu.ca

Co-Investigators: Brian M. Bird, MA — Department of Psychology, Simon Fraser University — bmbird@sfu.ca

Shawn Geniole, Ph.D. — Department of Psychology, Nipissing University — shawng@nipissingu.ca

Rachel Norman, B.A. — Department of Psychology, Nipissing University — racheln@nipissingu.ca

Research Coordinator Triana Ortiz, BA — Department of Psychology, Nipissing University — trianao@nipissingu.ca

Medical Supervisor Bernard Goldfarb, M.D. — Family Medicine, Northern Ontario School of Medicine — drgoldfarb@bellnet.ca

Funding Source: NSERC Discovery Grants (to JM Carré and NV Watson)

Purpose: You are being asked to be in a research experiment examining the effects of testosterone administration on executive functioning and decision making because you are male, between the ages of 18 and 45, and are fluent in English. This experiment is being conducted in the Social Neuroendocrinology Lab at Nipissing University under the medical supervision of Dr. Bernard Goldfarb. The estimated number of study participants to be enrolled in this experiment is 300. **Please read this form and ask any questions you may have before agreeing to be in the study.**

In this research experiment we will be examining the extent to which a single dose of testosterone influences executive functioning and decision-making. As such, you will be asked to perform a number of computer-based executive functioning and decision-making tasks.

Study Procedures: This study involves one experimental session lasting 2 hours.

Testing: After providing informed consent, you will complete a series of self-report questionnaires assessing demographic information and personality traits. These questionnaires take approximately 15 minutes to complete. Next, we will ask you to provide a saliva sample for the assessment of testosterone levels. After providing these samples, you will receive either 11 mg of testosterone nasal gel (brand name is Natesto) or placebo. The testosterone nasal gel has been approved by Health Canada and the Food and Drug Administration (USA) for the treatment of male hypogonadism (low testosterone levels). This drug will temporarily increase your testosterone levels (returning to baseline within about 4 hours). Approximately 30 minutes after receiving the drug (testosterone gel or placebo gel) you will be asked to provide a second saliva sample. The purpose of the second saliva sample is to confirm the increase in testosterone concentrations after receiving testosterone gel, or the lack of testosterone increase after receiving placebo gel. After receiving testosterone (or placebo), you will be asked to perform several computer-based tasks assessing executive functioning and decision-making. The executive functioning and decision-making tasks involve asking you to do the following: select certain items on screen or click a button on a keyboard quickly, remember a string of numbers, solve a digital puzzle, and select card decks from which you can earn or lose money. Additionally, you will be asked to read a vignette about a hypothetical date with a woman and answer questions about how you might feel in that situation. The entire testing session takes approximately 2 hours to complete.

All information collected during this experiment will be assigned a code and saved on a password-protected computer or locked in a filing cabinet. Your saliva samples will be securely stored in the Central Analytical Facility at Nipissing University and will also be assigned a code. Upon analysis, saliva samples will be disposed according to good laboratory practice standards. Thus, self-report and biological (saliva) data will not contain any personal identifying information. Data collected from you will be kept for 5 years after the completion of the study and will then be destroyed. Anonymized electronic datasets (i.e., with all personal identifying information removed) will be kept indefinitely and may be shared with other researchers (e.g., through the Open Science Framework).

Benefits: As a participant in this research study, there may be no direct benefit to you; however, the information gained from this study may benefit other people now or in the future.

Risks*:* By taking part in this study, you may be subject to the following risks:

1) Dry mouth when providing saliva samples.

2)Psychological risk/harm may come from answering some of the questionnaires. These measurements may include social issues that could be distressing (e.g., sexual activity, aggression). Please note that you are free to skip any question(s) that you feel uncomfortable answering.

3) Testosterone side-effects: Clinical trials involving the use of testosterone for a prolonged period of time (more than 90 days) have found the following adverse events that were possibly,

probably, or definitely related to the use of testosterone (in parentheses are percentages of participants experiencing the side-effects): acne (8%), alopecia (i.e., hair loss; 1%), application site reaction (5%), asthenia (i.e., weakness; 3%), depression (1%), emotional lability (3%), gynecomastia (i.e., enlargement of breasts; 3%), headache (4%), hypertension (3%), abnormal lab tests (e.g., elevated hemoglobin or hematocrit, hyperlipidemia, triglycerides, glucose, creatinine, and total bilirubin; 6%), nervousness (3%), breast pain (3%), prostate disorder (5%) and testis disorder (3%). The following side effects were seen in less than 1% of patients; hirsutism (i.e., excessive hair growth), peripheral edema, impaired urination, dizziness, anxiety, hostility, amnesia, penis disorder, dry skin, discolored hair, sweating, paresthesia, and vasodilation. Notably – the above side effects have been observed in studies involving long-term administration of testosterone. Specific side-effects reported with the use of Natesto include: parosmia (distortion of sense of small; 4%), dysgeusia (distortion of sense of taste; 0.7%), rhinorrhea (runny nose; 4.2%), epistaxis (bleeding of nose, 2.8%), nasal discomfort (2.8%), nasal dryness (3.5%), nasal congestion (0.7%), and scab (2.1%). To date, there is no evidence that a single application of testosterone has any major physical side-effects.

4) Loss of confidentiality: You will be required to sign/date a form upon receipt of financial payment. We are required to obtain a signature from you for accounting purposes and for proof of financial disbursement in the case of a financial audit. Thus, in the case of a financial audit, there is the possibility of a breach of confidentiality (i.e., someone may find out that you participated in the current study). Please note that we will store the signed receipts in a locked file cabinet separate from the data that we collected from you.

In addition to the risks listed above, there may also be additional physical, psychological, and/or behavioural risks involved from taking part in this study that are not known to researchers at this time.

Study Costs: Participation in this study will be of no financial cost to you.

Remuneration: You will receive $20/hour of participation in the study (i.e., $40). Also, there are tasks that you perform during the study where you can earn additional money depending on your performance. You can earn up to $15 for these additional tasks. Therefore, you can earn $40 to $55 for this study.

Confidentiality: All information collected during the course of this study will be kept confidential to the extent permitted by law. You will be identified in the research records by a code name or number. Information that identifies you personally will not be released without your written permission.

Results of the study: The results of the study will be presented in group format, and thus, your name will never be disclosed. We expect to present our findings at professional conferences and to submit the results for publication in peer-reviewed academic journals. We expect to have results compiled by August of 2019. If you are interested in learning about the results of the study, please contact Dr. Justin Carré (Phone: 705-474-3450, Ext. 4669; Email; justinca@nipissingu.ca) or visit his personal website at https://carrelab.nipissingu.ca for up-to-date access to published and/or unpublished results from this study.

Voluntary participation/withdrawal: Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you decide to take part in the study you can later change your mind and withdraw from the study. You are free to only answer questions that you want to answer or perform computer tasks that you want to perform. You are free to withdraw from participation in the study, or participation in any of the tasks of the study at any time without any penalty. Your decisions will not change any present or future relationship with Nipissing University. Also, should you withdraw from the study before its completion, you will be compensated based on number of hours that you participated in the study. For example, if you withdraw from the study after 60 minutes of participation, you will be paid $20.

Adverse reactions to experiment: If any of the questionnaires and/or behavioural tasks performed during this experiment cause you any emotional and/or psychological distress, please contact Nipissing University's Counseling Services (Room B210, Phone: 705-474-3450, Ext. 4507; Email: counseling@nipissingu.ca) or Community Counselling Centre of Nipissing (361 McIntire Street East, North Bay; Phone: 705-472-6515; Email: info@cccnip.com). In the unlikely event that you experience side-effects from the gel, please contact Dr. Goldfarb, 107 Shirreff Ave, North Bay, ON, Phone: 705-474-0992, Email: drgoldfarb@bellnet.ca.

Questions: If you have any questions about this study now or in the future, you may contact Dr. Carré (Phone: 705-474-3450 Ext. 4669; Email; justinca@nipissingu.ca).

This study has been reviewed and received ethics clearance through Nipissing University's Research Ethics Board. If you have questions regarding your rights as a research participant, contact: Ethics Administrator, Nipissing University, 100 College Drive, North Bay, ON P1B 8L7 or ethics@nipissingu.ca.

Consent to Participate in a Research Study: To voluntarily agree to take part in this study, you must sign on the line below. If you choose to take part in this study you may withdraw at any time. You are not giving up any of your legal rights by signing this form. Your signature below indicates that you have read, or had read to you, this entire consent form, including the risks and benefits, and have had all of your questions answered. You will be given a copy of this consent form.

_____ _____

Signature of participant / Legally authorized representative * Date

_____ _____

Printed name of participant / Legally authorized representative * Time

_____ _____

Signature of person obtaining consent Date

_____ _____

Printed name of person obtaining consent Time

Appendix B

Participant Debriefing Letter

DEBRIEF LETTER

Dear participant,

Recently, you participated in a study titled “Effects of testosterone on executive functioning”. This research was conducted by Nipissing University Professor Dr. Justin Carré. We are writing to give you a detailed debriefing about the main purposes of this study.

One of our primary aims was to investigate the extent to which a single application of testosterone would influence decision-making on basic economic tasks. Notably, you were led to believe that you were playing the decision-making games with other research participants. In reality, you were not playing with anyone, but instead, a pre-programmed computer program simulated the decisions made by the other ‘participants’. The primary reason for deceiving you about this aspect of the study was that if we told you that it was only a computer program simulating behaviour of others, your behaviour on these tasks would likely have been much different.

We apologize for deceiving you in this study. We hope that you understand the necessity of using deception in this type of research. If you would like to have your data removed from our database, please contact Dr. Justin Carré at 705-474-3450 or justinca@nipissingu.ca. Alternatively, you may contact the Research Ethics Coordinator at ethics@nipissingu.ca.

We sincerely thank you for participating in our study. Your time and commitment to research will greatly enhance our understanding of the basic mechanisms underlying variation in human social behaviour.

Sincerely,

Justin Carré, Ph.D.
Associate Professor
Department of Psychology
Nipissing University
Email: justinca@nipissingu.ca

Appendix C

Ethics Approval Letter

MEMORIAL UNIVERSITY

Norman, Rachel Elizabeth <renorman@mun.ca>

ICEHR Clearance # 20200443-ED – EXTENDED

1 message

dgulliver@mun.ca <dgulliver@mun.ca> Wed, Jun 22, 2022 at 9:03 AM
To: "Norman Rachel(Principal Investigator)" <renorman@mun.ca>
Cc: "Harris Greg(Supervisor)" <gharris@mun.ca>, dgulliver@mun.ca

MEMORIAL UNIVERSITY

Interdisciplinary Committee on
Ethics in Human Research (ICEHR)

ICEHR Approval #:	20200443-ED
Researcher Portal File #:	20200443
Project Title:	*Testosterone and Sexual Risk-Taking*
Associated Funding:	Not Funded
Supervisor:	Dr. Greg Harris
Clearance expiry date:	**June 30, 2023**

Dear Mrs. Rachel Norman:

Thank you for your response to our request for an annual update advising that your project will continue without any changes that would affect ethical relations with human participants.

On behalf of the Chair of ICEHR, I wish to advise that the ethics clearance for this project has been extended to **June 30, 2023**. The *Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans* (TCPS2) requires that you submit another annual update to ICEHR on your project prior to this date.

We wish you well with the continuation of your research.

Sincerely,

DEBBY GULLIVER
Interdisciplinary Committee on Ethics in Human Research (ICEHR)
Memorial University of Newfoundland
St. John's, NL | A1C 5S7
Bruneau Centre for Research and Innovation | Room IIC 2010C
T: (709) 864-2561 |
www.mun.ca/research/ethics/humans/icehr | https://rpresources.mun.ca/

Table 1
Sociodemographic Characteristics of Participants at Baseline

Baseline characteristic	Testosterone (*n* = 49)		Placebo (*n* = 61)		Total (N = 110)	
	n	*%*	*n*	*%*	*N*	*%*
Sexual Orientation						
Heterosexual	46	93.9	54	88.6	100	90.90
Bisexual	0	0	5	8.2	5	4.55
Other/Prefer not to say	3	6.1	2	3.2	5	4.55
Relationship Status						
Single	25	51	36	59	61	55.5
In a relationship	24	49	25	41	49	44.5
Educational or Work Status						
College	16	32.7	19	31.1	35	31.8
University	30	61.2	35	57.4	65	59.1
Other	3	6.1	7	11.5	10	9.1
Ethnicity						
White/Caucasian	34	69.4	39	63.9	73	66.4
South Asian	9	18.4	6	9.8	15	13.6
Southeast Asian	0	0	2	3.3	2	1.8
Black	3	6.1	2	3.3	5	4.5
Arab/West Asian	2	4.1	1	1.6	3	2.7
Asian	1	2	4	6.6	5	4.5
Indigenous	0	0	2	3.3	2	1.8
Other	0	0	5	8.2	5	4.5

Note. Participants who failed to complete the questionnaire for the vignette task were excluded (n = 2), as were those who identified as exclusively homosexual (n = 8) since the vignette was a heterosexual scenario. Participants were on average 23.3 years old (*SD* = 5.1) and weighed an average of 176.4 pounds (*SD* = 35.13). Participant age or weight did not differ by condition.

Table 2

Overall Correlation Coefficients and Descriptive Statistics for Study Variables

Variables	n	Mean(*SD*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Behaviour SOI [a]	110	2.78(1.79)	—													
2. Attitude SOI [a]	110	5.84(2.23)	.416***	—												
3. Desire SOI [a]	110	4.07(2.05)	.189*	.433***	—											
4. Total SOI [a]	110	4.23(1.53)	.676***	.840***	.732***	—										
5. Cognitive attitudes [b]	110	3.15(1.43)	-.104	.141	.078	.060	—									
6. Affective attitudes [b]	110	5.50(1.38)	-.009	.136	.166	.134	.499***	—								
7. Subjective norms [b]	110	3.61(1.17)	.035	.274**	.123	.204*	.563***	.452***	—							
8. Intention [b]	109	4.57(1.94)	.032	.297**	.261**	.272**	.648***	.641***	.427***	—						
9. Sexual arousal [b]	110	6.03(1.12)	-.107	.156	.228*	.137	.203*	.307**	.172	.255**	—					
10. Trust sex partner [b]	109	4.16(1.49)	-.145	-.074	.007	-.089	.623***	.366***	.363***	.427***	.275**	—				
11. Controllability [b]	110	4.47(1.67)	.185	.254**	.128	.252**	-.244*	.084	-.037	-.181	-.061	-.301**	—			
12. Self-efficacy [b]	109	4.25(1.83)	.091	.202*	.120	.190*	.562***	.525***	.615***	.579***	.203*	.370***	-.035	—		
13. Realism [b]	108	4.59(1.78)	.156	.156	.251**	.25**	.265**	.37***	.121	.342***	.242*	.256**	.046	.324***	—	
14. Past behaviour [b]	110	3.09(2.01)	.34***	.250**	.188*	.337***	.161	.338***	.243*	.297**	.117	.149	.003	.194*	.187	—

[a] Variable measured pre drug administration

[b] Variable measured post drug administration

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 3

Means, Standard Deviations, and Intercorrelations for Outcome Variables by Drug Condition

Variables	CA	AA	SN	Int	SA	TR	Con	SE	Rea	PB	n	Mean(*SD*)
Cognitive attitudes (CA)	—	.532***	.641***	.654***	.242	.540***	-.147	.560***	.273*	.178	110	3.15(1.43)
Affective attitudes (AA)	.464***	—	.620***	.649***	.312*	.382**	.189	.618***	.477***	.255*	110	5.50(1.38)
Subjective norms (SN)	.451**	.249	—	.528***	.395**	.383**	-.045	.610***	.354**	.301*	110	3.61(1.17)
Intention (Int)	.651***	.621***	.303*	—	.304*	.371**	-.024	.707***	.386**	.264*	109	4.57(1.94)
Sexual arousal (SA)	.152	.276	-.132	.159	—	.338**	-.068	.317*	.127	.154	110	6.03(1.12)
Trust in partner (TR)	.736***	.365*	.335*	.523***	.214	—	-.149	.332**	.343**	.231	109	4.16(1.49)
Controllability (Con)	-.379**	-.047	-.028	-.397**	-.048	-.494***	—	.057	.206	.116	110	4.47(1.67)
Self-efficacy (SE)	.568***	.417**	.623***	.419**	.056	.414**	-.154	—	.398**	.170	109	4.25(1.83)
Realism (Rea)	.278	.227	-.117	.274	.348*	.187	-.125	.263	—	.213	108	4.59(1.78)
Past behaviour (PB)	.144	.427**	.184	.329*	.041	.063	-.134	.232	.135	—	110	3.09(2.01)

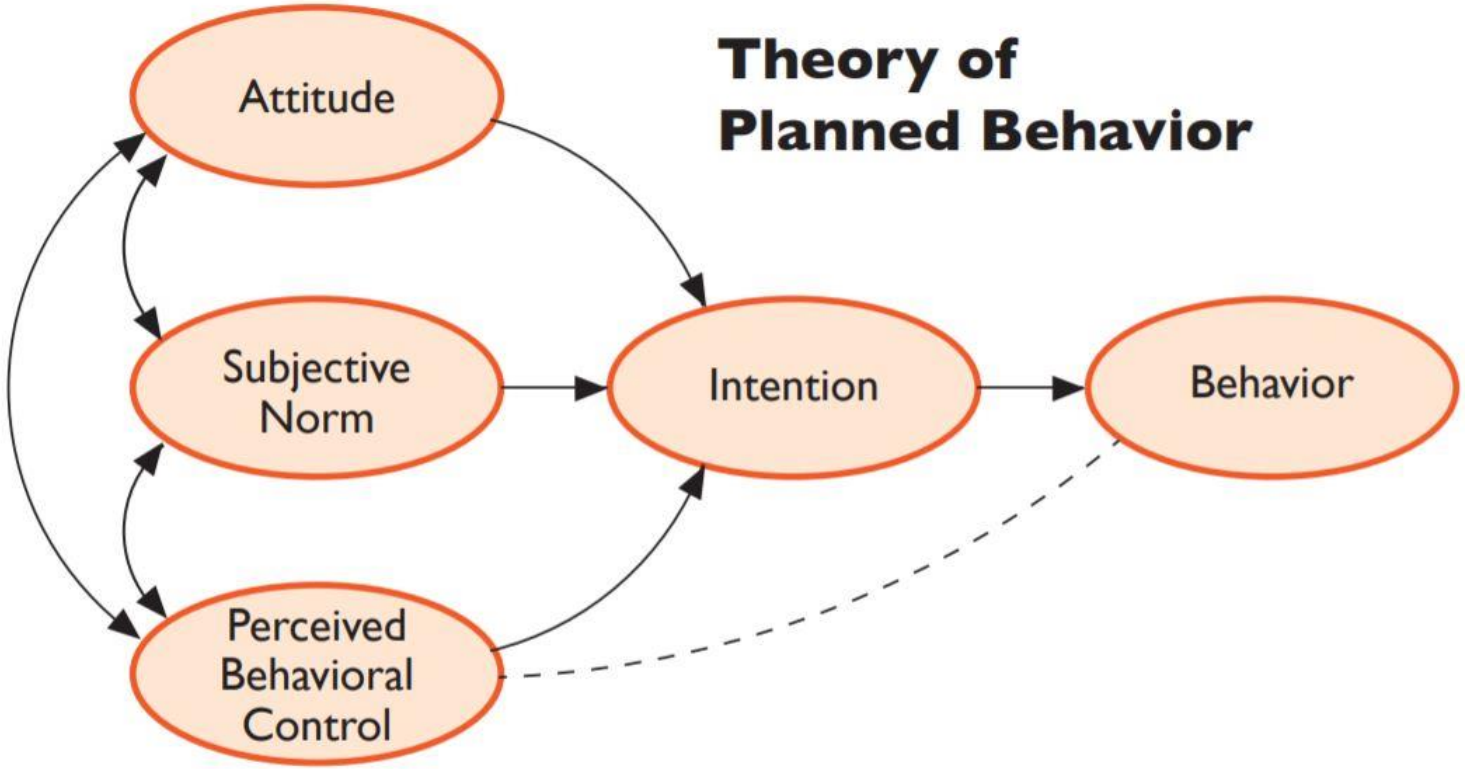
Note. Intercorrelations for the placebo condition are displayed above the diagonal (n=61), and those for the testosterone condition are displayed below the diagonal (n=49). $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 4

Means, Standard Deviations, and Independent Samples T-test results for the Effect of Drug Condition on Outcome Variables

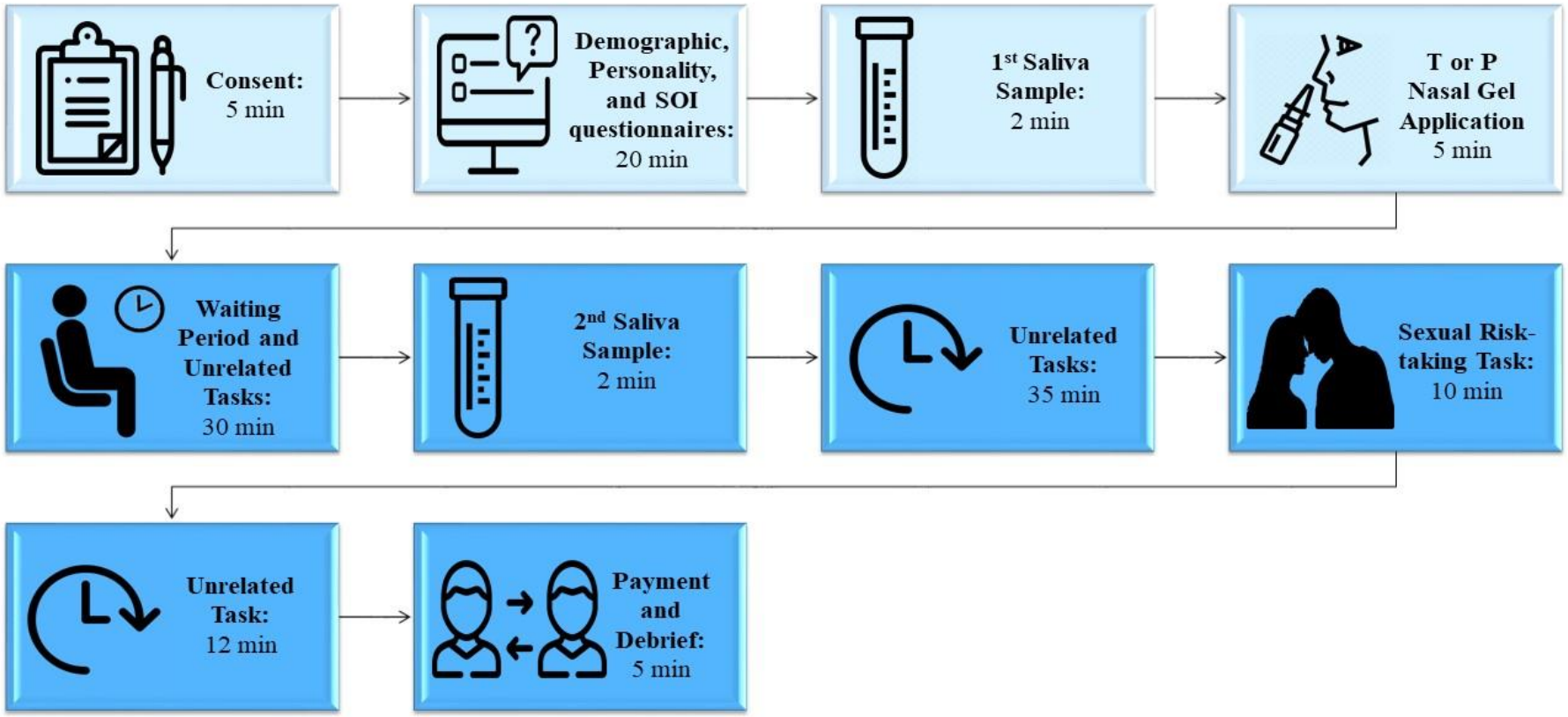
Outcome Variables	Placebo		Testosterone				
	n	*M(SD)*	*n*	*M(SD)*	*t*	*p*	Cohen's *d*
Cognitive attitudes	61	3.17(1.50)	49	3.13(1.37)	0.126	0.900	0.029
Affective attitudes	61	5.36(1.40)	49	5.67(1.35)	1.194	0.235	0.269
Subjective norms	61	3.67(1.20)	49	3.54(1.13)	0.596	0.552	0.124
Intention to have sex	61	4.39(1.99)	48	4.79(1.86)	1.067	0.288	0.286
Sexual arousal	61	5.90(1.17)	49	6.18(1.05)	1.316	0.191	0.267
Trust in the woman	61	4.23(1.45)	48	4.06(1.55)	0.578	0.564	0.137
Controllability	61	4.49(1.69)	49	4.45(1.67)	0.133	0.895	0.033
Self-efficacy	61	4.28(1.84)	48	4.21(1.84)	0.20	0.843	0.038
Realism of scenario	60	4.35(1.66)	48	4.90(1.89)	1.597	0.113	0.411
Past sexual behaviour	61	2.92(1.99)	49	3.31(2.02)	1.01	0.316	0.195

Figure 1
Theory of Planned Behaviour



Note. Adapted from Theory of Planned Behavior: An HC3 Research Primer by Health Communication Capacity Collaborative (2014). https://www.healthcommcapacity.org/wp-content/uploads/2014/03/theory_of_planned_behavior.pdf.

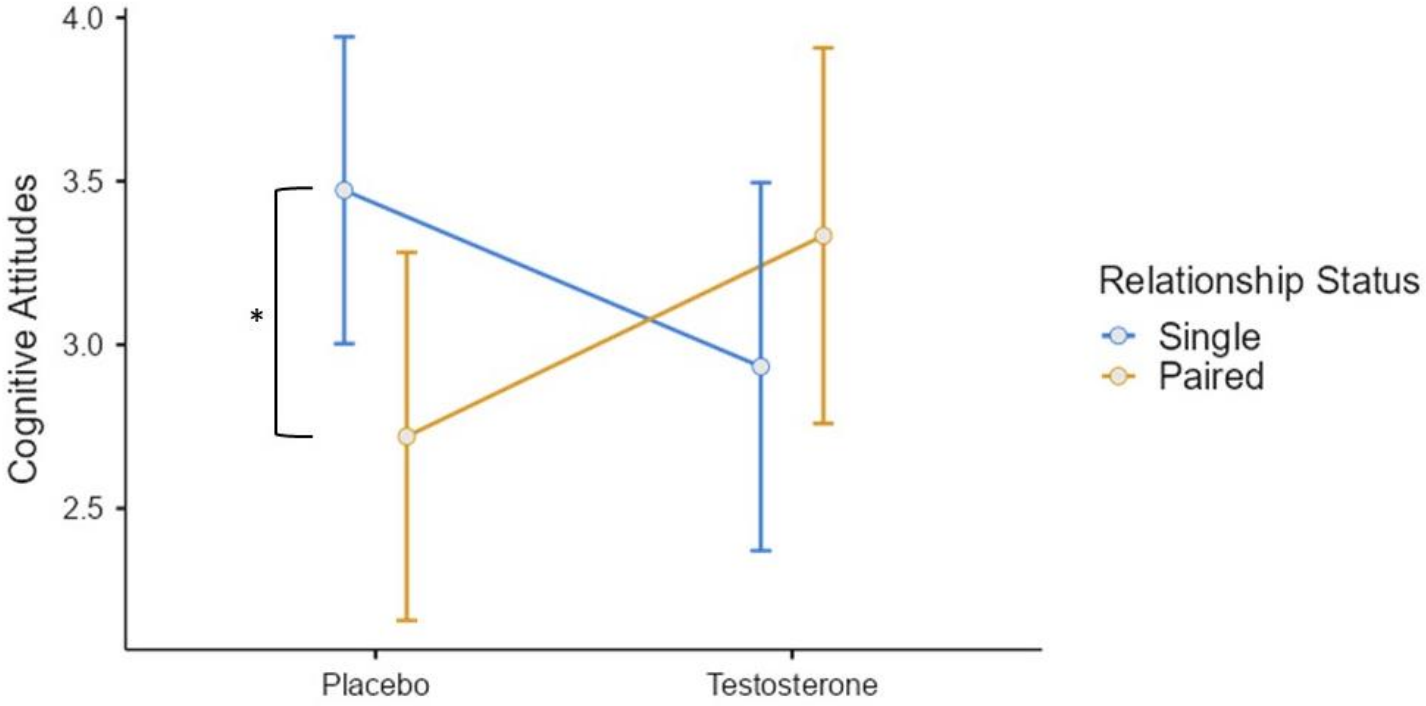
Figure 2
Procedural Timeline



Note. Lighter coloured boxes on the timeline indicate components of the procedure that took place post-T or placebo application, and darker boxes represent components that took place post-application.

Figure 3

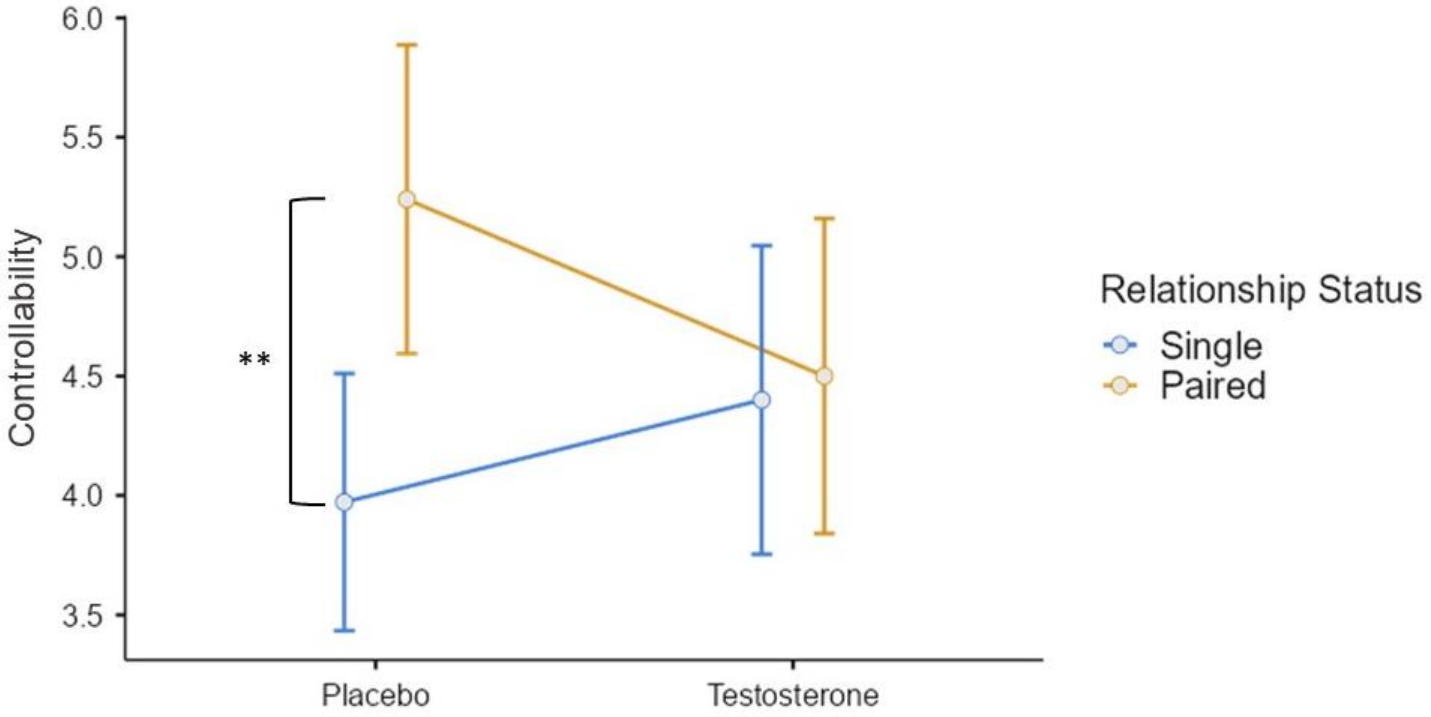
Cognitive Attitudes Reported as a Function of Drug Condition and Relationship Status



Note. Error bars represent 95% CI, $^{*}p < .05$, $^{**}p < .01$

Figure 4

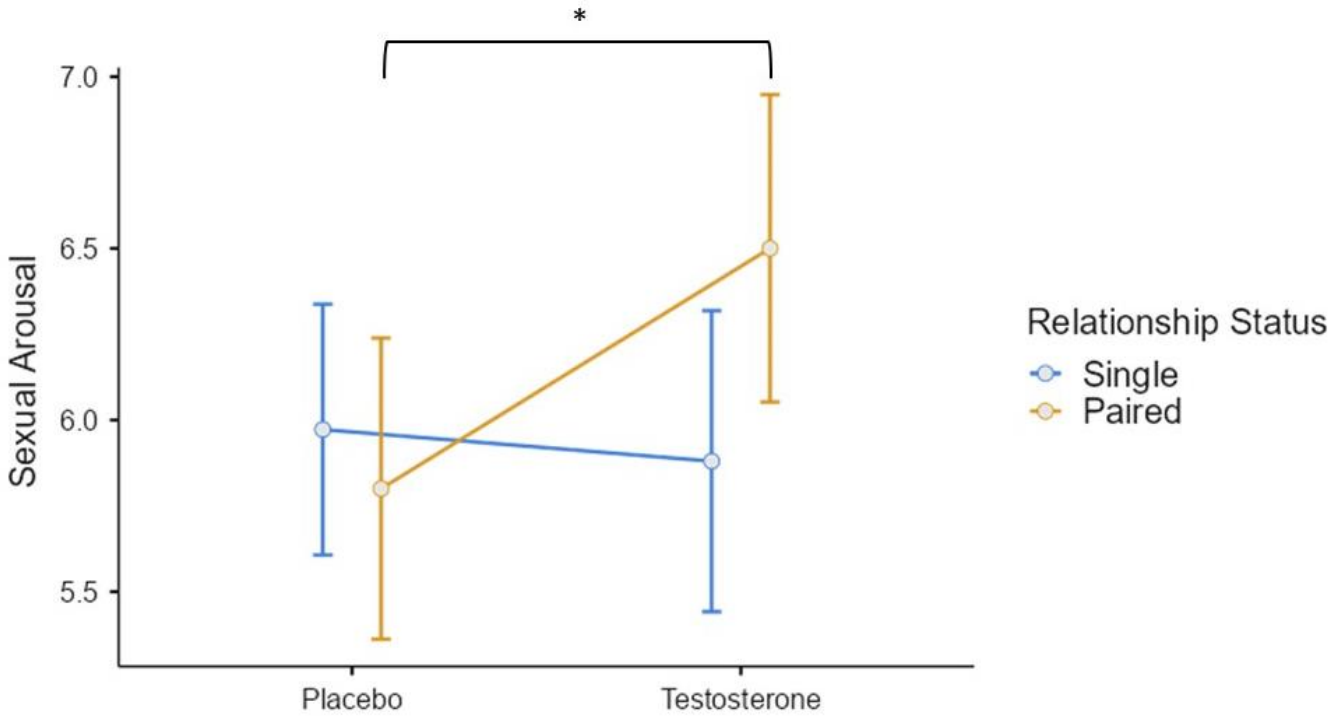
Level of Controllability Reported as a Function of Drug Condition and Relationship Status



Note: Error bars represent the 95% CI, $^{**}p < .01$.

Figure 5

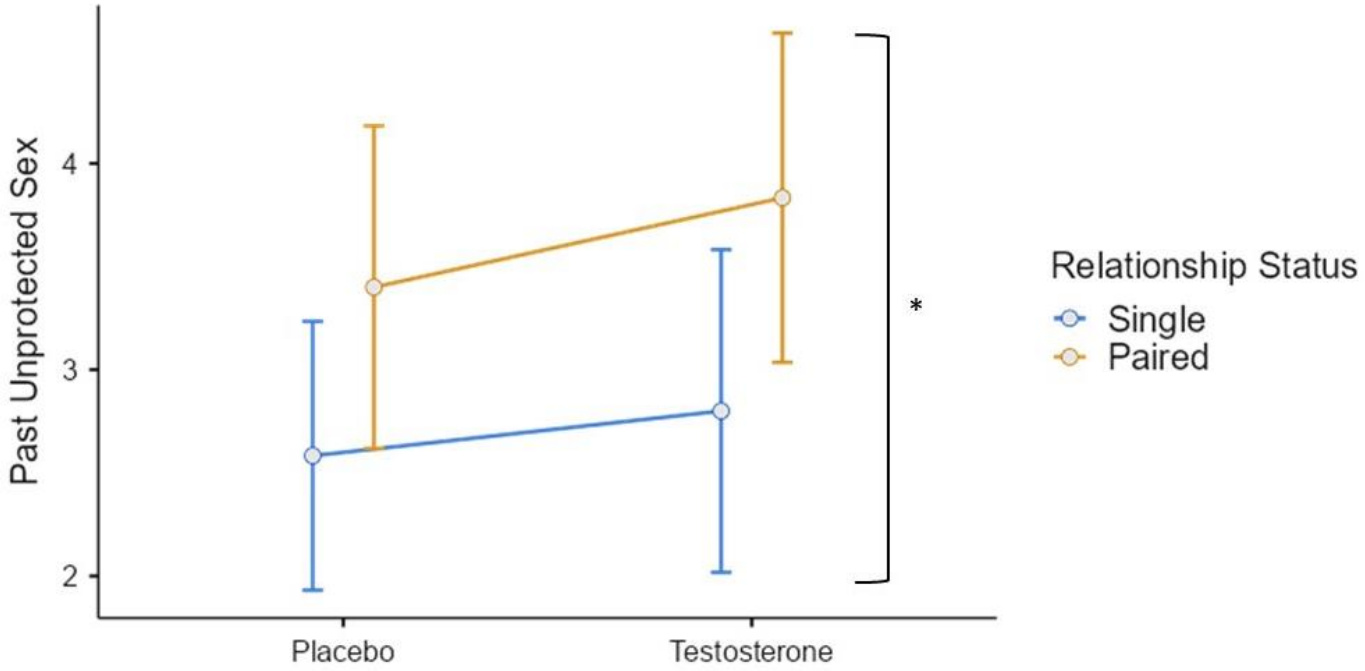
Level of Sexual Arousal Reported as a Function of Drug Condition and Relationship Status



Note. Error bars represent the 95% CI, $^{*}p < .05$.

Figure 6

Frequency of Past Unprotected Sex Reported as a Function of Drug Condition and Relationship Status



Note. Error bars represent the 95% CI, $^{*}p < .05$.