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DEPARTMENT OF ANTHROPOLOGY

ANALYZING TESTOSTERONE, CORTISOL, ESTROGEN, AND PROGESTERONE AS PREDICTORS OF SOCIOSEXUALITY

STEVEN MAKKAR
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Reviewed and approved* by the following:

David Puts
Associate Professor of Anthropology
Thesis Supervisor

Timothy Ryan
Associate Professor of Anthropology
Honors Adviser

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

In various species, males are more eager to mate than females. Across human cultures, men are also consistently found to have a less restricted sociosexuality (stronger interest in casual sex) than do women. Testosterone promotes male-typical behavior, but the extent to which adult testosterone concentrations mediate sociosexuality in humans is still actively studied. Previous research showed evidence for a negative feedback loop wherein elevated testosterone levels promoted sociosexuality, and successful sexual behavior decreased testosterone. Meanwhile, cortisol exhibits a masking effect against testosterone, an idea sometimes referred to as the "dual-hormone" hypothesis. Other steroid hormones, estrogen and progesterone, have been associated with sociosexuality in women. To delve deeper into these hormones' activity, we examined SOI survey data and salivary hormone levels in men and women. For men, we gathered testosterone and cortisol levels; and for women – separated into those taking hormonal contraception (HC women) and those naturally cycling (NC women) – we also gathered estrogen and progesterone. Our data did not replicate previous studies showing evidence for a negative feedback loop, nor did we find evidence supporting the dual-hormone hypothesis. When other hormone concentrations were statistically controlled, SOI psychology and testosterone were positively associated in NC women. This study highlights the complex relationship between steroid hormones and sociosexuality.

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Chapter 1

INTRODUCTION

The theory and mechanisms behind men's willingness to participate in casual sex (sociosexuality) has been a field of interest since the sexually suppressive 1960's (Simon & Gagnon, 1968). The Sociosexual Orientation Inventory (SOI; Simpson & Gangestad, 1991) was developed to measure individuals' self-reported mating strategy. The inventory measures three dimensions: attitudes, behaviors, and desires in reference to uncommitted, brief sexual relationships, with higher scores indicative of a greater propensity towards uncommitted mating (Penke & Asendorpf, 2008) Although research on sociosexuality in women has been inconclusive, previous between-subjects research in men found that testosterone positively predicted SOI (Edelstein, Chopik, & Kean, 2011; McIntyre et al., 2006; Puts et al., 2015; van Anders, Hamilton, & Watson, 2007). Testosterone has been shown to promote male-typical behavior in non-humans. Also, men typically score higher on the SOI than women. Across the globe, sex differences in sociosexuality are more substantial in demanding reproductive environments while sex differences are more moderate in politically and economically sound cultures with more gender equality (Schmitt, 2005). For example, Pedersen's "sex ratio theory" posits that cultures with more men than women should have lower levels of sociosexuality and therefore be more monogamous (Pedersen, 1991). Conversely, in cultures with less men than women, higher levels of sociosexuality is expected since men are scarce and can use this as leverage to fulfill desires of promiscuous sex. The SOI has been shown to be reliable and valid both within and across many modern cultural scenes (Schmitt, 2005).

The SOI was the only operationalization of sociosexuality in literature until Penke and Asendorpf (2008) formulated a Revised Sociosexuality Inventory (SOI-R) to reliably show 3 separate subscales for Attitude, Desire, and Behavior. Edelstein et al. (2011) used the SOI-R to find positive associations between men's sociosexual Attitude and Desire scores and no relationship between sociosexuality subscales and testosterone in women. Earlier studies have shown that testosterone can somewhat mediate between- and within-sex variation within this area (Puts et al., 2015). Puts et al. found that, when controlling for sociosexual psychology, testosterone negatively predicted both measurements of sociosexual behavior - men's number of sex partners and their sociosexual behavior subscale.

Testosterone and cortisol levels in males have been shown to increase during interactions with a young woman, yet remain constant or decrease after interactions with a young man (J. R. Roney, Simmons, & Lukaszewski, 2010). Sexual activity is significantly associated with androgens such as testosterone. Correlations between number of sex partners, levels of disinhibition, hypermasculinity, and testosterone have all been found (Bogaert & Fisher, 1995; Davidson, Camargo, & Smith, 1979). Other studies have shown positive relationships between testosterone and sociosexual behavior in partnered men (McIntyre et al., 2006). Testosterone and sociosexual psychology likely have a bidirectional relationship (Archer, 2009). While testosterone could create more unrestricted sociosexuality, sexual arousal and desire could also influence testosterone levels. In men, testosterone levels have been found to rise during sexual interest and after sexual activity (Hellhammer et al., 1985; Lopez et al., 2009; Roney et al., 2007; vander Meij et al., 2008). Sakaguchi et al. (Sakaguchi, Oki, Honma, Uehara, & Hasegawa, 2007) hypothesized sexual activity's negative feedback loop on testosterone levels, while Exton et al. showed that increases in men's testosterone levels are associated with timespans lacking sexual

activity (Exton et al., 2001). Puts et al. showed testosterone was negatively related to men's sociosexual behavior (the number of sex partners) with sociosexual psychology statistically controlled, and suggested that testosterone is inhibited when sexual desires are fulfilled yet drives sociosexual psychology (Puts et al., 2015). Testosterone levels declining in committed romantic relationships and after child rearing emphasizes the role of testosterone in mating-related behaviors. Increased sociosexuality may be associated with increased risk of injury from aggressive/risky actions, more energy consumption, oxidative stress, a slightly compromised immune function, and decreased pair-bonding (Archer, 2004, 2006, 2009; Bouman, Jan Heineman, & Faas, 2005; McIntyre et al., 2006; Wingfield, Lynn, & Soma, 2001).

Cortisol, a glucocorticoid hormone, is also associated with male-typical behaviors like aggression, dominance, social avoidance, and stress and has been found to mediate the association between extraversion and unrestricted sociosexuality (Popma et al., 2007; Wilson et al., 2015). The extent of cortisol's influence on sociosexual psychology is still to be determined. Mehta showed that testosterone and cortisol interact – whereas testosterone's positive relationship with dominance is present in individuals with lower levels of cortisol, testosterone's positive association is blocked or reversed in individuals with high levels of cortisol (Mehta & Josephs, 2010). Only when cortisol is low is there a positive association between male-typical behaviors like aggression and dominance. This phenomenon wherein higher testosterone may decrease dominance when cortisol levels are increased is referred to as the dual-hormone hypothesis.

While Mehta's dual-hormone was found across men and women, evidence of the negative feedback loop for testosterone, sociosexual behavior, and sociosexual psychology proposed in Puts et al. (2015) was found only in men; when tested in women on oral

contraceptive pills, these same relationships were not statistically significant. However, it is possible that estradiol would be implicated in such a feedback mechanism in women. Previous research into the role of hormones on women's sexual desire had many limitations such as the focus on sexual behavior rather than desire, the lack of distinction between solitary (individual) and dyadic (partnered) sexual desire, and not including women both on and off oral contraceptive pills. Similarly, research into testosterone's and cortisol's influence on men's sociosexual psychology has been characterized by small sample sizes and single-visit hormone levels.

A wide array of studies has supported estrogen's role in increasing women's sexual desire. Women have reported decreased sexual desire after surgical menopause and chemically-induced menopause (Schmidt et al., 2009). In studying treatments that restore peri-ovulatory estrogen levels in postmenopausal women, sexual desire was increased in the estrogen treatment groups and not in the placebo treatment groups (Cappelletti & Wallen, 2016; Davis, McCloud, Strauss, & Burger, 1995; Dennerstein, D Burrows, Wood, & Hyman, 1980; Dow, Hart, & Forrest, 1983; Sherwin, 1991; Sherwin & Gelfand, 1987). When salivary hormone data were obtained daily, within-women changes in sexual desire (but not sexual behavior) were negatively associated with changes in progesterone and positively associated with estradiol. There was no association with testosterone and women's sexual desire (James R. Roney & Simmons, 2013).

Puts et al.'s study in 2015 lacked participants' cortisol levels and hormone data from women not using oral contraceptives. This study aims to remedy these limitations to explore the relationships among testosterone, cortisol, and men's sociosexual psychology and adding estradiol and progesterone to the analysis for women. Better understanding the relationship between sociosexuality and hormone levels in women and men, at both the within- and between-

individuals level, will shed light on recent work examining various types of sexual desire. Based on previous studies observing relationships between hormones and sexuality in men and women, we hypothesized that relationships would be evident in men and naturally cycling women, but not women on hormonal contraceptives.

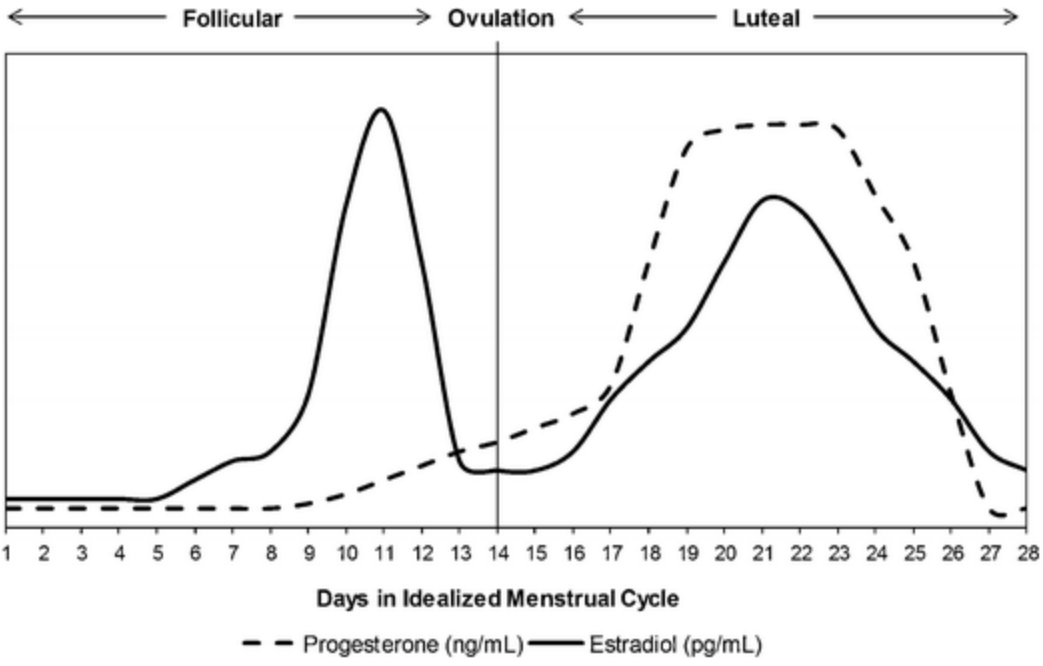
Chapter 2

METHODS

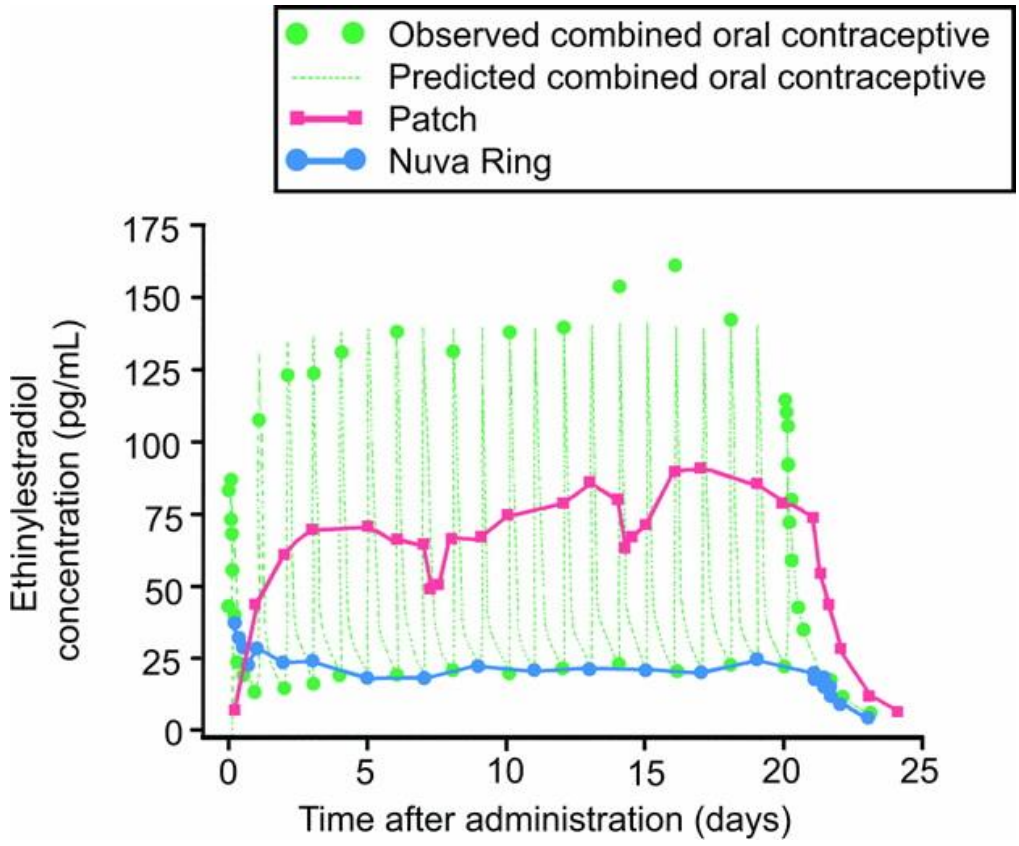
2.1 Participants

Participants in this study were recruited via radio, newspaper advertisements, social media recruitment campaigns, Craigslist, and research volunteer listserv emails run by The Pennsylvania State University. Participant data were gathered as part of a larger study on pubertal development and psychology. Eligible participants needed to be 18 years of age or older, fluent in English for full comprehension of the survey questionnaires, and not pregnant at the time of the study. Participants received either course credit if they were recruited through the university's volunteer research website, or monetary compensation. Women were classified into two groups: those taking a hormonal contraceptive (HC group) and those women who were naturally cycling (NC group). Women who are not on hormonal contraceptives go through a natural and predictable cycle of testosterone, estradiol, and progesterone levels. Meanwhile, women who take hormonal contraceptives such as birth control pills and patches maintain a more constant state of ovarian hormones throughout the cycle (Garner & Michel, 2016). Hormonal contraceptives provide a leveled dose of synthetic estrogens and progestins during the 21 days of the menstrual cycle after menses, then allow hormone levels to return to their natural state. Figure 1 shows the cyclical fluctuation in progesterone and estrogen. Because of these hormonal discrepancies, women were grouped into HC and NC groups according to self-reports.

(a)


Follicular
Ovulation
Luteal
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Days in Idealized Menstrual Cycle
Progesterone (ng/mL)
Estradiol (pg/mL)

(b)


Observed combined oral contraceptive
Predicted combined oral contraceptive
Patch
Nuva Ring
Ethinylestradiol concentration (pg/mL)
0
25
50
75
100
125
150
175
0
5
10
15
20
25
Time after administration (days)

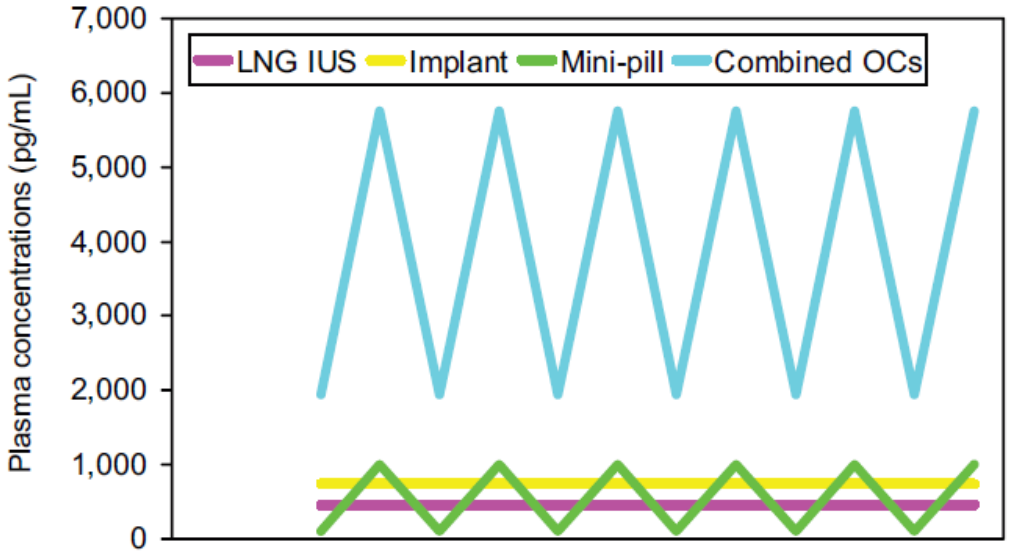


Figure 1. (a) Progesterone and estradiol levels throughout the menstrual cycle in naturally cycling women (Wetherill, Franklin, & Allen, 2016) and (b) observed and predicted ethinylestradiol (a synthetic derivative of estradiol) and progestin levels throughout the menstrual cycle in women using hormonal contraceptives (Blumenthal & Edelman, 2008). LNG IUS, levonorgestrel intrauterine system; OCs, oral contraceptives.

2.2 Procedure

Participants' informed consent was obtained prior to each data collection session. Since testosterone levels undergo a diurnal pattern (Montanini et al., 1988), sessions were scheduled between 9 AM and 12 PM to minimize the effect that time of day has on testosterone concentrations. Participants provided informed consent, received a study identification number, and provided a saliva sample via passive drool to a trained research assistant. Participants were

then instructed to complete the study's online questionnaire which was hosted on a private website. First, demographic information and information on the participant's current and past use of any form of hormonal contraception within the past month six months was obtained. Then, participants responded to the Sociosexuality Orientation Inventory (SOI-R; Penke & Asendorpf, 2008). The inventory contains questions that specifically measure three components of sociosexuality: attitudes, behaviors, and desires. Attitude is measured by questions such as "Do you believe that sex without love is OK?"; behavior by questions like "With how many different partners have you had sexual intercourse on *one and only one* occasion?"; and desire with questions like "How often do you have fantasies about having sex with someone you are *not* in a committed romantic relationship with?" Each question's response is scaled on the 9-point Likert scale, so each component results in its own subscale for the SOI-R. Each subscale's score is calculated as an average of its questions' responses.

When surveys were finished, second saliva samples via passive drool were provided to research assistants. Pre- and post-survey samples were combined to minimize the effects of pulsatile secretion on measured hormone concentrations. The combined samples were stored at -20º Celsius until they were sent for analysis.

2.3 Data analysis

2.3.1 Hormone quantification

Saliva samples were sent to Nipissing University Biomarkers Lab (Nipissing University, North Bay, Ontario) for hormone analysis. Commercially available enzyme immunoassay kits purchased from DRG International were used to assay the samples. These assays had the

following sensitivities: progesterone = 3.8 pg/mL, testosterone = 1.9 pg/mL, and estradiol = 0.4 pg/mL. CVs for progesterone, testosterone, and estradiol are found in Table 1. The CVs present in this study are similar to values previously published (such as Grebe, Emery Thompson, & Gangestad, 2016; Prasad et al., 2014). Hormones for each participant group were log-transformed to reduce skew and then z-scored, and scores greater than 3 SD from the mean were excluded from analyses.

2.3.2 Statistical analyses

Analyses for men, HC women, and NC women were run separately, as previous work has shown SOI-hormone associations may exist in some groups and not in others (e.g., in men but not in HC women; Puts et al., 2015). We first sought to replicate Puts et al. (2015), using SOI psychology scores as the only predictor of testosterone. Linear regressions were run with testosterone as the dependent variable, first with SOI psychology as the only predictor, and next with SOI psychology and SOI behavior entered as predictors simultaneously. The next set of analyses are the same as those described above, this time with cortisol entered as an additional covariate. Finally, these analyses were repeated with estradiol, progesterone, the estradiol x progesterone interaction, and cortisol entered as covariates. As estradiol and progesterone were measured in NC and HC women only, these analyses were not conducted on men. Time of day was controlled for in all analyses. Significance levels were set a priori to $p<0.05$.

Chapter 3

RESULTS

Data on hormonal contraceptive use, SOI-R subscales, and hormone questions were obtained from 165 men, 249 HC women, and 332 NC women. Descriptive information on the sample can be found in Table 1.

		Mean	**Standard Deviation**
NC women	Age	19.38	1.487
	[Progesterone] (pg/mL)	44.56	54.73
	[Cortisol] (pg/mL)	5.61	1.96
	[Testosterone] (pg/mL)	28.22	6.65
	[Estradiol] (pg/mL)	3.57	2.23
	SOI-R psychology	3.61	1.81
	SOI-R behavior	1.96	1.50
	SOI-R attitude	3.93	2.35
	SOI-R desire	3.30	1.84
	SOI-R	3.06	1.57
HC women	Age	19.53	1.606
	[Progesterone] (pg/mL)	32.11	38.41
	[Cortisol] (pg/mL)	5.79	1.78

	[Testosterone] (pg/mL)	27.06	7.78
	[Estradiol] (pg/mL)	3.77	2.10
	SOI-R psychology	4.27	1.79
	SOI-R behavior	2.48	1.48
	SOI-R attitude	4.86	2.35
	SOI-R desire	3.68	1.83
	SOI-R	3.67	1.54
Men	Age	20.07	1.779
	[Progesterone] (pg/mL)	-	-
	[Cortisol] (pg/mL)	4.68	1.44
	[Testosterone] (pg/mL)	53.16	16.01
	[Estradiol] (pg/mL)	-	-
	SOI-R psychology	5.61	1.90
	SOI-R behavior	2.56	1.68
	SOI-R attitude	5.91	2.35
	SOI-R desire	5.32	2.05
	SOI-R	4.6	1.61

Table 1. Descriptive statistics.

3.1 Replicating Puts et al. (2015)

Summary of these analyses can be found in Table 2. Briefly, none of the models including SOI psychology as the sole predictor of testosterone concentrations were significant, nor were any of the models including both SOI psychology and SOI behavior (measured as the SOI behavior composite or as number of sex partners in the last 12 months) as predictors of testosterone.

	Coefficient	**Model r^2**	**Model *F***	**Model *p***	**Coefficient β**	***p***	***n***
NC women		0.01	1.85	0.138			331
	SOI psychology				0.07	0.321	
	SOI behavior				0.04	0.546	
HC women		0.01	1.47	0.223			249
	SOI psychology				0.12	0.13	
	SOI behavior				-0.04	0.613	
Men		-0.01	0.93	0.427			165
	SOI psychology				0.02	0.827	
	SOI behavior				-0.05	0.580	
NC women		0.01	1.66	0.175			329
	SOI psychology				0.08	0.234	
	SOI behavior Q1				0.01	0.789	

Table 2. Linear regressions predicting testosterone.

3.2 Analyses with cortisol as an additional covariate

Summary of these analyses can be found in Table 3. Though several of the models were statistically significant, this was likely due to the fact that cortisol was significantly correlated with testosterone in men and NC women; SOI psychology and SOI behavior (again, whether

measured as the subscale composite or as number of sex partners in the last 12 months) were not significantly correlated with testosterone concentrations.

	Coefficient	Model r^2	Model F	Model p	Coefficient β	p	n
NC women		0.09	11.63	<0.01			332
	SOI psychology				0.08	0.131	
	Cort				0.3	<0.001	
HC women		0.01	1.80	0.148			249
	SOI psychology				0.09	0.165	
	Cort				0.07	0.272	
Men		0.06	4.49	0.005			165
	SOI psychology				0.00	0.993	
	Cort				0.26	0.001	
NC women		0.09	8.85	<0.01			31
	SOI psychology				0.08	0.272	
	SOI behavior				0.01	0.939	
	Cort				0.30	<0.01	
HC women		0.01	1.41	0.232			249
	SOI psychology				0.11	0.157	
	SOI behavior				-0.0	0.611	
	Cort				0.074	0.272	
Men		0.06	3.39	0.011			165
	SOI psychology				0.02	0.842	
	SOI behavior				-0.03	0.697	
	Cort				0.26	0.001	
NC women		0.09	8.75	<0.01			329
	SOI psychology				0.08	0.249	
	SOI behavior Q1				0.00	0.955	
	Cort				0.30	<0.01	
HC women		0.01	1.35	0.254			248
	SOI psychology				0.11	0.171	
	SOI behavior Q1				-0.03	0.693	
	Cort				0.07	0.281	
Men		0.05	3.35	0.254			164

	SOI psychology				0.012	0.810	
	SOI behavior Q1				-0.033	0.692	
	Cort				0.257	0.001	

Table 3. Linear regressions with cortisol as a covariate (Cort = cortisol).

3.3 Analyses with cortisol, estradiol, progesterone, and the estradiol x progesterone interaction as additional covariates

Summary of these analyses can be found in Table 4. Estrogen and progesterone were centered before their interaction was calculated. When all hormones and SOI psychology were entered as predictors, there was a significant association between SOI psychology and testosterone in NC women ($p = 0.008$) as well as in HC women ($p = 0.036$). When SOI behavior was entered as an additional covariate, these relationships were no longer statistically significant.

	Coefficient	Model r^2	Model *F*	Model *p*	Coefficient β	*p*	*n*
NC women		0.22	15.91	<0.01			327
	SOI psychology				0.13	0.008	
	P				0.03	0.575	
	Cort				0.23	<0.01	
	E				0.36	<0.01	
	E x P				0.08	0.109	
HC women		0.22	12.27	<0.01			244
	SOI psychology				0.12	0.036	
	P				0.31	<0.01	
	Cort				-0.03	0.642	
	E				0.28	<0.01	
	E x P				0.01	0.903	
NC women		0.22	13.81	<0.01			326
	SOI psychology				0.12	0.074	
	SOI behavior				0.03	0.675	
	P				0.03	0.555	
	Cort				0.24	<0.01	
	E				0.37	<0.01	
	E x P				0.08	0.106	
HC women		0.21	10.51	<0.01			244
	SOI psychology				0.10	0.159	
	SOI behavior				0.03	0.651	
	P				0.31	<0.01	
	Cort				-0.03	0.633	
	E				0.28	<0.01	
	E x P				0.01	0.899	
NC women		0.22	13.65	<0.01			324
	SOI psychology				0.10	0.097	
	SOI behavior Q1				0.04	0.489	
	P				0.03	0.586	
	Cort				0.24	<0.01	
	E				0.37	<0.01	
	E x P				0.08	0.096	
HC women		0.22	10.48	<0.01			243
	SOI psychology				0.10	0.159	
	SOI behavior Q1				0.04	0.572	
	P				0.32	<0.01	

	Cort				-0.03	0.581	
	E				0.28	<0.01	
	E x P				0.01	0.902	

Table 4. Linear regressions with various interactions as covariate (Cort = cortisol; E = estrogen; P = progesterone)

Chapter 4

DISCUSSION

The present study examined the relationship between steroid hormone levels (testosterone, estrogen, progesterone, and cortisol) and sociosexuality in men and women, aiming to replicate the findings in Puts et al. (2015) and dive deeper with an analysis of cortisol levels and data of naturally cycling women. Previous studies (Mantzoros, Georgiadis, & Trichopoulos, 1995; Puts et al., 2015) have shown that testosterone positively predicts sociosexual psychology in men but not HC women, likely explained by different reproductive strategies between sexes (Gangestad & Simpson, 2000). The association between sociosexual psychology and testosterone in men, as well as the association between testosterone and SOI behavior in men, was not replicated in the current study. Sociosexuality and testosterone were also unrelated in HC women. It is possible the sample populations resulted in differing results between the 2015 study and this one. In one of the two studies reported in Puts et al. (2015), data were collected from fraternity and sorority members. Members of fraternities tend to accept stereotypical beliefs about women and endorse casual sex, therefore increasing the likeliness that members think about and engage in casual sex regardless of hormonal or environmental influences (Robinson, Gibson-Beverly, & Schwartz, 2004). Fraternities with high levels of testosterone were more rambunctious and behaved more crudely (e.g. had more parties, lower grade point averages, fewer academic awards, fewer community service projects, and fewer member smiling in yearbook photographs) than fraternities with lower testosterone (Dabbs, Hargrove, & Heusel, 1996). The social influence and the risk of judgement from other members of the fraternity or sorority could have affected reported levels of sociosexuality to corroborate with this crude behavior. Here, individuals from the Pennsylvania State University were

recruited without regard to membership in any other organization. Despite the larger sample sizes, we did not find significant relationships between testosterone, SOI psychology, and SOI behavior.

Puts et al.'s (2015) hypothesized negative feedback loop, whereby testosterone promotes casual sex and copulatory success sequentially down-regulates testosterone production, was also not supported by the present data. In theory, testosterone increases sociosexual psychology (Edelstein et al., 2011) and traits related to intrasexual competition (Puts, Welling, Burriss, & Dawood, 2012). The negative feedback would cease testosterone's detrimental influences. Therefore, men who successfully mate should lower their risk by decreasing testosterone production. This notion is supported by the finding that testosterone is lower in men in committed relationships (Puts et al., 2015). Although no clear association between SOI psychology and testosterone in men was found in this study, future data could study directionality and determine what other factors influence testosterone and sociosexuality.

The dual-hormone hypothesis posits that testosterone would be positively associated with male-typical behavior only in individuals with low cortisol (Mehta & Josephs, 2010). We also did not find significant relationships between testosterone and cortisol, SOI behavior, and SOI psychology. There could be several reasons for this discrepancy. Serum cortisol levels likely varied between-subject dependent on what their personal situation was at the time of saliva gathering, which could skew the associations between SOI behavior and SOI psychology since they do not fluctuate at the same frequency as steroid hormone levels. Previous studies found that testosterone and cortisol jointly contribute to social competition such as dominance and risk taking, and hormones levels can change based on contextual factors (Casto & Edwards, 2016; Mehta & Josephs, 2010; Mehta, Welker, Zilioli, & Carré, 2015). Also, studies observing the

dual-hormone hypothesis focused on testosterone's influence on some male-typical behaviors, but not its influence on sociosexuality. Although testosterone and cortisol's interplay could affect all behavioral agency of these hormones, there is no strong evidence showing its effects are encompassing of all male-typical behavior.

In both NC and HC women, the significant association between SOI psychology and testosterone adds to previous studies showing a link between these factors (Edelstein et al., 2011). Although high testosterone levels in men can be perceived by women as more attractive and increase men's sociosexuality, testosterone likely has contrasting effects in women since physical attributes associated with higher testosterone may deemed less feminine and less attractive (Campbell et al., 2009). Additionally, Boothroyd et al. found that men may perceive women who report unrestricted sociosexuality as more attractive (Boothroyd, Cross, Gray, Coombes, & Gregson-Curtis, 2011). As seen in the results, analyzing SOI psychology and testosterone with SOI behavior as a covariate eliminated the association. Therefore, high testosterone levels may increase women's desire but decrease women's potential to engage in casual sex, possibly explaining the phenomenon.

Limitations and future studies

Although the current study did not result in all of the expected results, the data collected is part of a larger study that can have many insights into men's and women's sociosexuality. The sample size was exceptional relative to those of prior studies, but perhaps a more diverse sample that includes more non-students would yield more significant results. Variance inflation factor was not calculated to test each analysis for multicollinearity, which could be a potential concern.

However, only the SOI-R psychology and testosterone interaction in HC and NC women showed significant relationships regardless of multicollinearity. While the other associations would remain insignificant, a VIF calculation for the previously mentioned relationship would establish if the true association is between SOI-R psychology and testosterone in HC and NC women or if the association is mediated by the other variables.

Hormone data should be analyzed with the study's extensive questionnaire data to see if any other associations exist. The testosterone x cortisol interaction in men and the association between testosterone, cortisol, estrogen, and progesterone are also very complicated relationships that have long-lasting effects depending on the duration of elevated/decreased levels. In men, early or prolonged exposure to elevated levels of testosterone could cause sexual development to happen earlier or to a greater extent. Androgens affect the mind, sex organs, and muscle formation and would surely shape an individual's long-term psychology and behavior due to different opportunities presenting themselves (LeVay & Baldwin, 2009). Early exposure to estrogen could similarly shape females' SOI psychology and behavior due to its prominent role in secondary sexual characteristic development. Early onset of puberty would increase the chances for one to sexualize aspects of their lives and carry these mental processes for the rest of their life, regardless of hormone level fluctuation later in life. These long-term developmental effects can cause a discrepancy between an individual's current hormone levels and their SOI subscales, especially in a university-environment where various situations cause temporary hormonal fluctuation. Also, since hormones require receptors throughout the body, and receptor concentration and activity vary between individuals, salivary hormone data represents concentrations in the body but not necessarily hormones' true effects. Further studies should

examine the longitudinal outcomes of steroid hormones on sociosexuality, or possibly studying the experimental effects of altering these hormone levels.

The study investigated relationships between steroid hormones and sociosexuality in men, HC women, and NC women. We found significant associations only between HC/NC women and SOI psychology while the other relationships proved inconclusive. These results do not contradict previous research but do not accomplish the goal of supporting testosterone's negative feedback loop nor the dual-hormone hypothesis.

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Academic Vita of STEVEN MAKKAR

SLM6057@GMAIL.COM

EDUCATION

Pennsylvania State University | The Schreyer Honors College — **University Park, PA**
Bachelor of Science in Genetics and Developmental Biology — *Class of 2018* | Dean's List: All Semesters
Biochemistry Minor; Business Certificate

- **International Experience:** (Summer 2017) Study abroad in Shanghai, China immersed in Chinese culture while learning about Developmental Biology
- **Relevant Coursework:** Immunology, Molecular Medicine, Molecular and Cell Biology, Genetic Analysis, Biochemistry, Molecular Biology of the Gene, Physics, Calculus, Chemistry, Organic Chemistry, Statistics, Human Sexuality, Adolescence, Psychology of Perception, Finance, Marketing, Management, Supply Chains, Human Genetics, Sociobiology

North Allegheny Senior High School — **Wexford, PA**
Class of 2014

RESEARCH EXPERIENCE

Puts Biological Anthropology Lab | *Honors Research Assistant* — **University Park, PA** | *2016 – Present*

- Examined the hormonal and genetic influences on human sexuality and sexually differentiated traits
- Organized and analyzed data comparing relationships between steroid hormone levels and sociosexual psychology and behavior in men and women to produce a paper that is suitable for publication in a peer-reviewed journal

University of Pittsburgh Cancer Institute CoSBBI Program | *Research Intern* — **Pittsburgh, PA** | *2015*

- Conducted bioinformatic analysis on mesothelioma data while training high school students for the medical research field
- Attained and used skills in R programming, ontology mapping, meta-data analysis, teamwork, and communication

LEADERSHIP EXPERIENCE

Coptic Orthodox Youth Association | *President* — **University Park, PA** | *2014 – Present*

- Planned biweekly fellowship meetings and discussions for students to practice religion
- Pioneered a monthly travel-liturgy for local students in State College in conjunction with the Altoona, PA church

Schreyer Honors College Orientation | *Team Leader* — **University Park, PA** | *2015*

- Coordinated the 3-day-long Schreyer Honors College student orientation program for 300+ incoming freshmen
- Orchestrated engaging orientation events with entertainment companies and food services
- Directed a team of 10 mentors, collectively responsible for 50 new students

SERVICE

Global Medical Brigades — **University Park, PA** | *2015 – Present*

- Organized mission trips to medically underprivileged South American and African countries to provide essential clinical healthcare and mobilize toward positive social change
- Summer 2017 travel to Ghana, Africa where responsibilities would include taking vitals, shadowing doctors, and creating medical files of all the patients that were seen

Penn State IFC/Panhellenic Dance Marathon (THON) — **University Park, PA** | *2015 – Present*

- United with over 15,000 Penn State students to raise $10+ million dollars for pediatric cancer research and to provide emotional and financial support for the children and families of+ Four Diamonds (200+ hours)
- Organized security and safety measures for the 46-hour long event

University of Pittsburgh Medical Center Passavant — **McCandless, PA** | *2013 – 2015*

- Welcomed and served patients, families, and doctors as the senior volunteer (120+ hours)

St. Mary's Coptic Orthodox Church — **Ambridge, PA** | *1996 – Present*

- Served as an ordained deacon at weekly mass for the Greater Pittsburgh area's congregation
- Taught Sunday school classes to 12-14-year-olds and chaperoned yearly trips to the Midwest Coptic Orthodox Youth Convention at Bowling Green State University in Ohio

HONORS & SKILLS

- Honors: The President's Freshman Award (awarded to top 1 % of freshman); Braddock Scholars Award (2014-present); Bunton Waller Merit Award (2014-present), Merrill Lynch Award (2014-present); Academic Excellence Award (2014-present)
- Proficient skill level in R and Microsoft Office products (Excel, PowerPoint, Word), limited proficiency of French and Arabic