Relationships between implicit power motivation, implicit sexual motivation, and gonadal steroid hormones: Behavioral, endocrine, and fMRI investigations in humans

by

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This dissertation is dedicated to Samantha, my perfect love.

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Table of Contents

Chapter

List of Figures

List of Tables

List of Appendices

Chapter 1

Introduction

Motivation: concepts and methods

Motivation is a fundamental component of adaptive behavior and motivational psychology tries to explain aspects of "why" we engage in behavior. Motivation can be based upon factors intrinsic to an individual like thirst, as well as the presence of motivational stimuli in the environment like a cigarette to a smoker. The biopsychology of motivation attempts to identify and understand the biological influences on motivated behavior (Schultheiss & Wirth, 2007). The personality psychology of motivation attempts to understand why individuals have differences in motivation and how those differences in personality can be measured (McClelland, 1987).

A great deal of motivation research has focused on motivational incentives, both positive and negative, and how individuals respond to those incentives (Berridge, 1996; Berridge & Robinson, 2003). Incentive motivation can be divided functionally and behaviorally into two categories: approach and avoidance (Craig, 1918). Approach motivation is defined by the pursuit of positive incentives, where individuals literally "go after" the positive incentive, which can be food, water, a sexual partner, the opportunity to be dominant, and many other incentive stimuli. Avoidance motivation is the

1

"avoidance" of negative incentives, such as pain or stress. However, that which

constitutes an incentive or disincentive can vary widely between individuals (Rolls,

1999). Adding to the complexity, motivation is mediated by several motivational brain

structures (i.e. the striatum, amygdala, orbitofrontal cortex, and others), as well as several

different hormones (steroids, peptides) and neurotransmitters (amines, amino acids,

neuropeptides); i.e. there is not one simple motivational system that functions in the same

manner for all motives (LeDoux, 2002).

Due to the complexity of motivational systems, researchers have employed

several different methods in the study of human motivation in an effort to capture the

multiple aspects of motivational processes from biology to behavior. I will highlight a

few methods that are relevant to the studies described in this thesis. One method is to

look at the activity of specific neural substrates that have been linked to motivational

processes when in the presence of motivational stimuli. In humans, this can be achieved

with brain imaging which can localize the activity of particular neural substrates.

Additionally, researchers can place subjects in environments with motivational incentives

and measure changes in physiology as a function of the motivational situation. For

example, one can measure changes in hormone levels after being shown an incentive

stimulus like an erotic image. Lastly, researchers also measure behavior in an effort to

capture motivational processes. For example, by the ability for humans to learn complex

sequences of keystrokes to achieve a reward can be used as a marker of motivation

(Schultheiss et al., 2005a). Principally in humans, researchers can also attempt to

measure motivation through individual differences in one's personality, which

subsequently map onto their physiology and behavior when in motivational situations (McClelland, 1987; cf. Mehta & Gosling, 2006; for personality differences in animals).

In humans, motivation (as well as emotion and cognition) can be further divided into two distinct domains: implicit and explicit (Berridge & Robinson, 2003). Stated simply, implicit motivation refers to motivation that operates outside of one's conscious awareness, but is still propelling one toward environmental incentives (McClelland, 1987). In many ways, implicit motives (such as those for dominance and affiliation) are shared across mammalian species and are regulated by similar hormones and physiological systems (Schultheiss, 2007). For example, male mammals that pursue dominance status and have high rank tend to have high levels of testosterone (T). Human males high in T also tend to pursue high rank and have high levels of implicit power motivation (nPower) (Mazur & Booth, 1998; Schultheiss, 2007). In contrast to implicit motivation, explicit motivation can be conceptualized as one's goals and cognitions about what one wants and consciously chooses to pursue (McClellend et al., 1989).

Individual differences in motivation can also be measured via physiological markers of motivational states, and these physiological markers are much like implicit measures of personality. Physiological markers (i.e. hormones) of motivational states are also implicit measurements, because people cannot tell you what their levels of hormones are, yet their hormone levels predict their behavior. For example, Sellers and colleagues (2007) argue that baseline levels of T in humans act as trait markers of dominance motivation, and T levels share the characteristics of valid personality measures like test-retest stability, convergent validity, and discriminant validity. In another study, Josephs and colleagues (2006) showed that high-T individuals showed emotional arousal and

3

poor cognitive function when placed in a low-status position, and low-T individuals showed emotional arousal and poor cognitive performance when placed in a high-status position. The Josephs et al. (2006) study demonstrated that motivational factors intrinsic to individuals (T levels) interact with situational factors (the environment) to predict psychological outcomes and behavior. That study mirrors classical personality psychology by looking at the interaction of the individual and the situation, which makes it an excellent example of how individual differences in biology can be much like individual differences in personality.

The studies in this thesis expanded upon past motivation research by further exploring relationships between motivation, biology, and behavior. The first study of this thesis used fMRI to explore the relationship between endogenous T levels and human brain responses to dominance signals and suggests that T moderates the way one responds to a dominance challenge at the level of the brain. The second study of this thesis explored relationships between nPower and sex steroids in women and suggests that gonadal steroid hormones and the need for dominance are linked differently in women than they are in men. Lastly, sexual motivation is a motive commonly discussed in biopsychology but is curiously absent from the list of implicit motives that have received attention from personality psychologists. The last study of this thesis examined how sexual motivation, measured indirectly like other implicit motives, predicts behavioral pursuit of visual sexual reward. Before presenting these three studies in full detail as the main chapters of my dissertation, the remainder of this first chapter will provide a detailed conceptual background for these three studies.

Testosterone and neural responses to dominance signals

T primes individuals to pursue dominance (Kemper, 1990; Mazur & Booth, 1998). The best evidence for this phenomenon is derived from studies that measure the actual behavior or physiology of individuals. For example, in a randomized, placebo-controlled study, Pope and colleagues (2000) found that men given T had both increased aggression and symptoms of mania when compared to controls. van Honk and colleagues (2001) showed that subjects who were administered T had greater cardiac acceleration in response to dominance signals than those given placebo. These studies of the causal effects of T on aggressive and dominance-related behavior are consistent with findings from correlational studies on T and behavior. For instance, trial lawyers who visibly argue in front of judge and jury are more likely to have high T levels than lawyers not representing their clients in court (Dabbs et al., 1998). Prisoners with high T are more likely to have a history of violent crime and to have other prisoners rate their behavior as more aggressive (Dabbs et al., 1991; Kreuz & Rose, 1972). These and many other findings document that generally, high levels of T prime individuals to pursue dominance and status in socially acceptable ways, but that in some cases they can also lead to aggression, antisocial behavior, and sometimes violent crime (Mazur & Booth, 1998).

While there has been considerable research on T's priming of dominance pursuit, which is the appetitive aspect of attaining dominance, there is little research examining how T influences individuals' responses to dominance challenges. How individuals perceive, process, and respond to dominance-related signals communicated by others are important aspects of dominance interactions. Much like T's influence on one's

motivation to attain dominance, T also influences how individuals behaviorally and physiologically respond to dominance stimuli in the environment like facial expressions of anger (Keltner & Haidt, 1999; Keltner et al., 2003; van Honk et al., 1999). For example, the amount of attention paid to anger faces depends on T levels (van Honk et al., 1999). Women have greater cardiac acceleration when shown anger faces if they are pre-treated with T versus placebo (van Honk et al., 2001). However, a question that has yet to be answered is how endogenous T levels influence brain activation patterns when individuals view facial expressions of anger.

In the first study of my dissertation, I tested the hypothesis that differences in brain activation patterns in response to facial expressions of anger are a function of participants' basal T levels. In humans, amygdala responses to interpersonal dominance threats (anger faces) have been observed, but not consistently (Murphy et al., 2003). In an effort to clarify these previously inconsistent findings, I tested the effect of individual differences in endogenous T levels on amygdala responses to anger stimuli. My goal was to see whether the results corroborated the behavioral and physiological studies on T and anger. This study used T as an implicit, physiological marker of motivation, whereas the last two studies of my thesis used differences in personality as implicit markers of motivation.

Implicit motivation in humans

Implicit motives have been the focus of much psychological research over several decades (Schultheiss, in press). Several personality psychologists have argued that implicit motives are a fundamental dimension of an individual's personality (McClelland,

1987; Winter, 1996). The most current tool used to measure implicit motives is called the Picture Story Exercise (PSE) (Smith, 1992). To administer the PSE, a research participant is shown a picture of an individual or group of people and is asked to write a creative story about that picture. Participants write several stories in response to several pictures. A trained coder then codes the stories for motivational imagery, which upon aggregating the themes for all stories yields a motivational profile for the participant. The three most heavily researched implicit motives are the need for power (nPower), need for affiliation (nAffiliation), and the need for achievement (nAchievement) (Winter, 1996). Those who are power-motivated are rewarded by having impact on others, those who are affiliation-motivated are rewarded by having warm relationships with others, and those who are achievement-motivated are generally rewarded by good performance and improvement (Winter, 1994). As noted earlier, implicit motives operate outside of our conscious awareness (Schultheiss, in press). Thus, people cannot accurately report on their implicit motives, which means that what they self-report on a questionnaire measure of motivation does not correlate with one's implicit motives (King, 1995; Schultheiss & Brunstein, 2001; Schultheiss & Pang, 2007). Implicit motives predict a range of phenomena including biology (i.e. neurotransmitter and hormone release in individuals), cognition (attention; pavlovian and operant learning), and behavior (communication styles) (Schultheiss, 2007, in press). In the case of biology, implicit motives have recently been linked to steroid hormones, both basally and dynamically (Schulthiess et al., 1999, 2002, 2003, 2004, 2005b; Wirth et al., 2006).

N Power and testosterone

In men, nPower is positively correlated with baseline T, suggesting that high baseline levels of T not only motivate one to pursue dominance as reflected in their behavior but also manifest themselves in aspects of an individual's personality (Schultheiss, 2007; Winter, 1973). Importantly, nPower also positively predicts many of the same dominance behaviors that high levels of T are associated with (e.g., entering influential occupations, spousal abuse, drug abuse, risk taking, and sexual promiscuity) (McClelland, 1987). However, it is notable that the positive relationship between T and nPower has only been reported in men (Schultheiss, 2007).

T levels also change as a function of dominance contest outcomes in male animals (Mazur, 1985; Sapolsky, 1987). However, attempts to predict T changes in human subjects on the basis of situational outcomes have yielded inconsistent results. While some studies have shown that T rises in dominance contest winners and falls in losers (Booth et al., 1989; Campbell et al., 1988; Elias 1981; Mazur & Lamb, 1980), other studies have failed to report main effects of dominance contest outcomes on T change (Edwards et al., 2006; Gonzales-Bono et al., 1999; Kivlighan et al., 2005; McCaul et al., 1992; Mehta & Josephs, 2006; Salvador et al., 1987).

nPower (but not questionnaire measures of power motivation) consistently moderates the effect that dominance contest outcomes have on T changes (Schultheiss, 2007). To go beyond correlational links between nPower and hormones, studies have used experimental variation of dominance contest outcome to examine the effects of nPower on hormone changes (Schultheiss & Rohde, 2002; Schultheiss et al., 2005b; Wirth et al., 2006). These studies placed two same-sex participants together to have them

compete face-to-face on variations of implicit learning tasks. The results were

experimentally varied: the winner would win a majority of the rounds and loser would

lose the same proportion of rounds. When individuals engage in these dominance

competitions, the resulting changes in their T levels depend not only on whether they win

or lose, but also on their level of n Power (Schultheiss, 2007). Studies with male German

(Schultheiss & Rohde, 2002) and US students (Schultheiss et al., 2005b) found that

nPower predicted T increases after a contest victory and T decreases after a defeat.

Notably, in one study the mere anticipation of a dominance victory was sufficient to

make power-motivated men's T levels rise (Schultheiss et al., 1999).

nPower is also linked to dynamic T changes in women, but the directions of the

relationship are different than in men, there has been far less research on nPower and T

change in women, and the endocrine mechanisms of driving T change remain unclear

(Schultheiss, 2007). After a dominance contest, women high in nPower show an increase

in T that is largely independent of whether they have won or lost, which does not match

the findings for men (Schultheiss et al., 2005b). It has been proposed that estradiol has a

more direct connection to dominance motivation in women (Cashdan, 1995, 2003;

Schultheiss, 2007).

N Power and estradiol in women

Estradiol's relationship to dominance, unlike T, has barely been explored in

humans. The majority of behavioral endocrinology research on dominance in humans

has focused on T and principally used male subjects (Mazur & Booth, 1998). However,

animal research has demonstrated that estradiol can positively influence dominance

behavior in females of several mammalian species (Boissou, 1990; Farruzzi et al., 2005; Michael & Zumpe, 1993; Zehr et al., 1998; Zumpe & Michael, 1989). These animal studies demonstrated that estradiol positively facilitates the pursuit of dominance or the motivation to attain dominance. A desire to pursue dominance is exactly what n Power measures in humans. While there have been a few studies on the relationship between dominance and estradiol in women, these studies have employed self-reports of dominance motivation and have reported inconsistent findings where some studies have positively linked estradiol to dominance, other studies have failed to find a relationship, and other studies have suggested that estradiol is negatively linked to dominance (Cashdan, 1995; 2003; Gladue, 1991; Purifoy & Koopmans, 1979).

The second study of my dissertation aimed to explore the relationships between nPower and estradiol in women with the hope of finding clear and consistent relationships that parallel the findings that exist between nPower and T in men. One previous study by Schultheiss and colleagues (2003) reported a positive correlation between nPower and estradiol in women, but it was only in a sub-group of their entire sample. Theirs is the only finding linking nPower and estradiol, which left open the possibility of more research in this area. Thus, I set out to further examine the relationship between basal estradiol and nPower.

With this project I also aimed to push beyond past research on estradiol and dominance by placing women in a dominance contest, experimentally fixing the outcome, and then examining changes in estradiol as a function of both contest outcome and participants' levels of nPower. Dominance contest studies are common in the T and dominance literature using male participants, but studies using women are very rare and

10

those examining changes in estradiol are non-existent. Thus, this study presented a more complete picture of the relationships between nPower and estradiol by documenting not only basal relationships, but also dynamic changes in estradiol that result from an experimentally-manipulated dominance contest.

Implicit sexual motivation: A new frontier in implicit motive research

Sexual motivation has been surprisingly absent from the list of motives that have received much research attention within personality psychology. Research on implicit sexual motivation never made it beyond initial work by Clark and Sensibar (1955), as well as Beardslee and Fogelson (1958). Sexual motivation seems ideally suited for implicit motive research, because sexual motivation exists without a need for conscious awareness or cognitive regulation across all non-human mammalian species, is a very strong motivational drive, and is regulated by similar brain structures and hormones (Pfaff, 1999; Short, 1984). Nonetheless, sexual motivation research has been largely dependent on self-report measures (Carter, 2002). With sensitive issues like sexual motivation, value-laden self-reports can fall victim to response sets biased by cultural norms, positive self-presentation, social desirability, anxiety, defensiveness, and participant attrition (Winter, 1991). Additionally, self-reports of sexual motivation often fail to predict sexual behavior (Bancroft, 1989; 2003; 2005; Graham et al., 2004). The limited availability and success of self-report measures of sexual motivation suggests that other, more indirect measures of sexual motivation need to be used to accurately predict behavioral and physiological correlates of sexual motivation in humans.

11

In my fourth chapter, I will describe a study that used content coding of implicit sexual motivation from PSE stories to predict participants' behavior on an implicit learning paradigm. This implicit learning paradigm involved participants learning sequences of keypresses that were operantly associated with particular stimuli, including sexual and neutral stimuli, with the hypothesis that sexually motivated participants would show better learning for the sexual stimulus reward. In affirmation of this hypothesis, I showed that when using sexual stimuli as operant rewards, individuals higher in sexual motivation implicitly learn procedural behaviors that lead to rewarding sexual stimuli, better than do those low in implicit sexual motivation.

Summary

In my dissertation, I will describe three strides toward innovative research on motivation, behavior, and biology. To review, Chapter 2 of my dissertation will describe the basal and dynamic relationships between nPower and estradiol. Chapter 3 will describe the moderating effects of endogenous T levels on brain activation patterns in response to facial expressions of anger. Chapter 4 will discuss implicit sexual motivation and its implicit behavioral correlates. Chapter 5 will conceptually tie the findings of the studies together.

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Chapter 2

Endogenous testosterone levels predict amygdala response to dominance signals in men

Abstract

Testosterone is positively linked to dominance behavior in men. However, little is known about the moderating effects of testosterone in the human brain in the context of dominance. We used fMRI to measure amygdala BOLD response to interpersonal dominance signals of threat (anger faces) as a function of endogenous testosterone levels in 24 participants (10 men). Men's, but not women's, amygdala BOLD response to anger faces was negatively correlated with their endogenous testosterone levels. It is plausible that high levels of testosterone may reduce the perceived threat of dominance signals in men as reflected by reduced amygdala reactivity to dominance signals.

Introduction

High testosterone levels are linked to dominance behavior and pursuit of dominance status in men (Mazur & Booth, 1998). Men's testosterone levels also rise as a function of winning dominance contests and feedback to the brain to prime future dominance behavior (Archer, 2006). Dominant male primates respond to dominance challenges with smaller cortisol changes (stress responses) and greater testosterone increases than non-dominant males, suggesting that dominant males find dominance signals less stressful and are more primed to engage in a dominance challenge (Sapolsky, 1987; 2005). In humans and animals, testosterone also reduces central fear responses and stress axis reactivity (Hermans et al., 2006, 2007; Rubinow et al. 2005; van Honk et al., 2005; Viau, 2002). It is plausible that testosterone acts on specific neural substrates in humans to reduce avoidance responses to threatening dominance signals.

In mammals, the amygdala is the "centerpiece of the subcortical networks involved in detecting and responding to threats" (LeDoux, 2000, p.301). In humans, amygdala responses to interpersonal dominance threats (anger faces) have been observed, but not consistently (Murphy et al., 2003, Schultheiss, 2007). Studies have shown that individual differences can moderate amygdala responses to affective stimuli, thereby clarifying previously inconsistent findings (Canli et al., 2002; Hariri et al., 2002). Testosterone's positive effects on men's dominance behavior and physiology, as well as reduction of physiological responses to threat, make testosterone levels a plausible moderator of amygdala response to dominance signals in humans. Moreover, this is supported by evidence in male mammals showing that testosterone acts on the amygdala

in conjunction with peptide hormones to mediate dominance behavior (Delville et al., 1996; de Vries & Miller, 1998; Ferris & Delville, 1994).

On the basis of fear- and stress-reducing properties of testosterone in response to threat, we hypothesized that high-testosterone men, to whom a dominance signal is possibly less threatening (Schultheiss, 2007), would show a lesser amygdala BOLD response to anger faces than low-testosterone men. We also hypothesized that this effect will not hold for women, because research has not established a consistent link between endogenous testosterone and dominance in women (Mazur & Booth, 1998; Stanton & Schultheiss, 2007).

Methods

Participants

Participants consisted of 14 women and 10 men, with a mean age of 20.96 years (SD = 2.18), who were prescreened for mental and physical health problems that would have excluded them from fMRI testing. Participants were originally selected for high and low levels of a personality variable, implicit power motivation, in order to investigate other hypotheses (Schultheiss et al., submitted). However, participants' implicit power motivation was not correlated with testosterone levels (r = -0.18, p = 0.62) and did not predict the presently reported effects.

Stimuli and task design

Stimuli consisted of pictures of 20 individuals (10 male, 10 female) x 3 expressions: surprised (open mouth), angry (bared teeth), and neutral (MacBrain Face

Stimulus Set; Tottenham et al., in press). Faces were presented on a black background for 250 ms, followed by variable-duration interstimulus intervals (ISI; mean duration: 350 ms; range: 200 to 500 ms) consisting of fixation crosses centered at the height of the eyes in the presented faces. Blocks of each facial expression consisted of pictures from all 20 posers presented in randomized order and were presented in alternating order with blocks in which grey squares (same dimensions as faces) were presented in lieu of faces. During some ISIs, an X was randomly presented instead of a fixation cross (once per block in one half of the blocks, and twice in the other half).

On a passive-viewing task, participants were instructed to keep their eyes directed at the fixation cross in the middle of the screen and to pay attention to all presented stimuli. On an oddball task, participants were instructed to respond with a button press whenever an X appeared instead of the fixation cross. Both the passive-viewing and oddball tasks consisted of two consecutive runs of 36 blocks each, and their order was counterbalanced across participants. Two tasks were chosen due to conflicting literature regarding more robust BOLD responses to facial expressions of emotion when participants are focused on the emotion versus performing a "distraction" task (Critchley et al., 2000, Lieberman, 2003; Lieberman et al., 2007; Quirk, et al., 2003; Taylor, et al. 2003).

Scanning parameters

Participants lay supine in a 3.0 Tesla magnet (General Electric, standard quadrature head coil). We acquired functional images with a spiral in-out pulse sequence (repetition time [TR]: 2500ms; echo time [TE]; 30ms; flip angle: 90º). Twenty-nine contiguous horizontal slices of 4 mm thickness were acquired, encompassing the whole brain (field of view [FOV]: 220 x 220mm; voxel size: 3.44 mm x 3.44 mm x 4 mm).

Structural images were acquired in the same slice locations using a T1-weighted gradient echo pulse sequence, with TR = 200 ms, TE = 3.6 ms, FOV = 220 x 220 mm, voxel size = 0.86 mm x 0.86 mm x 4 mm, and flip angle = 90º. Due to a programming error, volume acquisition stopped during the last block (surprise faces) on each run. Data from this block were therefore discarded from image analyses.

Image processing and data analysis

Images were motion-corrected, realigned, normalized to the Montreal Neurological Institute (MNI) template (Evans et al. 1994), and then smoothed with an [8 8 8] mm kernel. We used SPM2 for data analyses (Wellcome Department of Cognitive Neurology, London, UK). Data were high-pass filtered at 100s (.01 Hz) and fitted to a canonical hemodynamic response function. Contrast images were created for each participant (Anger vs. Neutral; Surprise vs. Neutral; Neutral vs. Grey) and submitted to 2nd level random effects analyses. The amygdala ROI was defined using a mask from the AAL library (Tzourio-Mazoyer et al., 2002). Results were thresholded using a combination of alpha ($p < .005$) and cluster size ($k = 5$).

Salivary sampling and testosterone assessment

Saliva samples were collected from participants directly before scanning sessions (range: 8:00am - 1:00pm) and stored using standard procedures (Schultheiss & Stanton, in press). Salivary testosterone levels were assessed with solid-phase Coat-A-Count ^{125}I radioimmunoassays for testosterone from Diagnostic Products Corporation following the protocol described in Schultheiss, Wirth, & Stanton (2004). Analytical sensitivity (B_0 -3 SD) was 4.78 pg/mL. Analytical recovery was 118.55% for low (24.90 pg/mL) and 108.40% for high (151.8 pg/mL) testosterone levels. Mean intra-assay CV was 6.04%.

Participants' testosterone concentrations were (mean, ± SEM): Men: 88.51 ± 17.15 pg/mL; Women: 17.28 ± 1.52 pg/mL. Men's testosterone values were log transformed to correct for skewed raw values.

Results

Figure 1 shows that men's endogenous testosterone levels correlated negatively with left and right amygdala BOLD response to anger-neutral face contrasts in the passive viewing task; there was no effect of testosterone in women. In the oddball task, we also found a bilateral, negative correlation between testosterone and anger-neutral contrast BOLD activation in the amygdala in men (left: $x = -36$, $y = 2$, $z = -2$, $r = -0.84$, $p = 0.002$), (right: $x = 24$, $y = 0$, $z = -12$, $r = -0.74$, $p = 0.014$), and again there was no effect for women.

Discussion

In confirmation of our first hypothesis, amygdala BOLD responses to dominance signals in both tasks were negatively correlated with endogenous testosterone levels in men. In confirmation of our second hypothesis, testosterone levels did not moderate amygdala BOLD responses to dominance signals in women.

Our results complement findings in males of mammalian species that have revealed functional links between testosterone and the amygdala in mediating dominance behavior (Delville et al., 1996; Ferris & Delville, 1994). Our results provide evidence in

humans of a neural substrate where testosterone may drive differential responses in the brain in response to dominance signals and challenges. We speculate that the negative correlation between testosterone and men's amygdala response to anger suggests that high-testosterone men are less threatened by dominance challenges, and hence stimuli that are indicative of such challenges are perhaps less salient to them than to low-testosterone men. There is converging behavioral evidence showing that individuals with high testosterone levels attend toward anger faces (van Honk et al., 1999), which suggests that anger faces might be less aversive stimuli to high testosterone individuals. This is also supported by the observation that high-testosterone individuals show less behavioral aversion to angry faces in an instrumental learning task (Wirth & Schultheiss, 2007). This lack of perceived threat may make high-testosterone men more likely to engage in testosterone-facilitated dominance behavior and approach dominance challenges.

Our failure to find a relationship between amygdala BOLD response to dominance signals and testosterone levels in women neurologically corroborates behavioral research that has failed to document a consistent relationship between testosterone and dominance in women (Mazur & Booth, 1998; Stanton & Schultheiss, 2007). Estradiol, which has been implicated in dominance motivation and responses to dominance contests in female primates and recently in women, also acts on the amygdala and could be examined in future research on women's brain responses to dominance signals (Cottingham & Pfaff, 1986; Michael & Zumpe, 1993; Stanton & Schultheiss, 2007).

Acknowledgements

Figure 2-1

Correlations between men's log-transformed testosterone levels (in pg/mL) and amygdala BOLD response to anger-neutral face contrasts in the passive viewing task. Anger-neutral contrasts were computed by subtracting percentage BOLD signal change to neutral faces from percentage BOLD signal change to anger faces (left: x = -26, y = 0, z = -12), (right: x = 22, y = -6, z = -4).
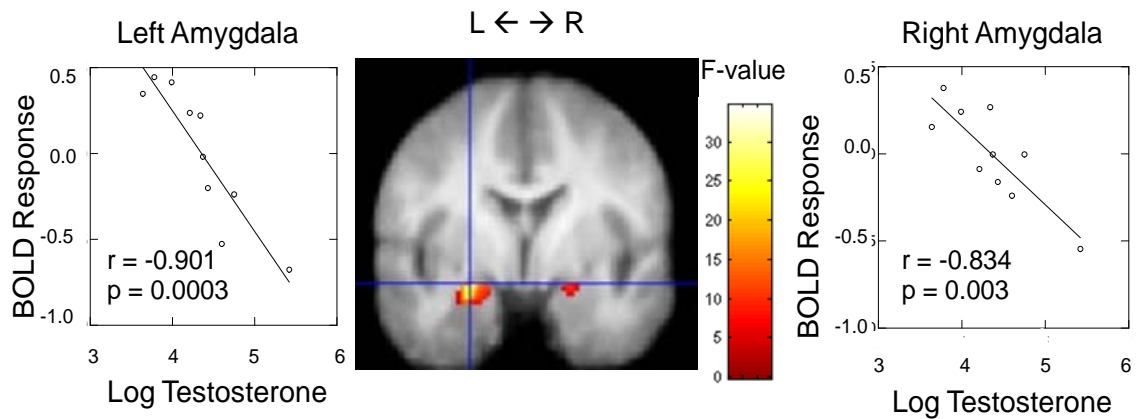
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Chapter 3

Basal and dynamic relationships between implicit power motivation and estradiol in women

Abstract

This study investigated basal and reciprocal relationships between implicit power motivation (n Power), a preference for having impact and dominance over others, and both salivary estradiol and testosterone in women. 49 participants completed the Picture Story Exercise, a measure of n Power. During a laboratory contest, participants competed in pairs on a cognitive task and contest outcome (win vs. loss) was experimentally varied. Estradiol and testosterone levels were determined in saliva samples collected at baseline and several times post-contest , including one day post-contest. n Power was positively associated with basal estradiol concentrations. The positive correlation between n Power and basal estradiol was stronger in single women, women not taking oral contraceptives, or for women with low-CV estradiol samples than

in the overall sample of women. Women's estradiol responses to a dominance contest were influenced by the interaction of n Power and contest outcome: Estradiol increased in power-motivated winners but decreased in power-motivated losers. For power-motivated winners, elevated levels of estradiol were still present the day after the contest. Lastly, n Power and estradiol did not correlate with self-reported dominance and correlated negatively with self-reported aggression. Self-reported dominance and aggression did not predict estradiol changes as a function of contest outcome. Overall, N Power did not predict basal testosterone levels or testosterone changes as a function of dominance contest outcome.

Introduction

In mammals and many non-mammalian species, estradiol has well-documented effects on reproductive physiology, behavior, learning, and memory (Beach, 1981; Becker et al., 2002). It has also been suggested that it plays a role in dominance behaviors ranging from dominant posturing to physical aggression, particularly in primates (Michael & Zumpe, 1993; Zumpe & Michael, 1989). But, with few exceptions, its role in female dominance in humans remains largely unexplored (Cashdan, 2003). A facilitating role of testosterone in human dominance, on the other hand, has been documented extensively for men (Mazur & Booth, 1998). But, as Mazur and Booth (1998) have pointed out, research findings have not documented a consistent role for testosterone in women's dominance striving (see also Bateup et al., 2002; Booth & Dabbs, 1995; Cashdan, 1995; Gladue, 1991; Kemper, 1990; Kivlighan et al., 2005; Purifoy & Koopmans, 1979). In the present research, we therefore tested the assumption that

estradiol plays a critical role for women's dominance motivation, just as testosterone has been shown to do for men's dominance motivation.

More specifically, we explored the relationship between estradiol and the degree to which women have a nonconscious preference for dominance (implicit need for power motivation, or n Power). Implicit power motivation, a personality measure of dominance in humans, is defined as an enduring preference for having impact on and dominating others (Schultheiss, 2001; Winter, 1973). From a motivational perspective, women high in n Power are more likely to be aroused by affectively charged cues associated with an opportunity to have dominance, to engage in dominance behaviors once aroused by the predictive cue, and to be rewarded by having impact or dominance (Schultheiss et al., 2005a, 2005b). n Power is implicit in the sense that it operates outside of individuals' conscious awareness, is assessed indirectly with the Picture Story Exercise (PSE) (Smith, 1992), and does not correlate with self-report measures of dominance (McClelland, 1987; McClelland et al., 1989; Schultheiss, in press). In numerous studies, the PSE measure of n Power has been found to predict individuals' testosterone, cortisol, and norepinephrine responses to a variety of dominance challenges and outcomes (McClelland, 1982; McClelland et al., 1980, 1985; Schultheiss & Rohde, 2002; Schultheiss et al., 2004; Schultheiss et al., 2005a; Wirth et al., 2006).

In exploring the relationship between n Power and estradiol in women, we examined both basal and dynamic relationships between these measures. Regarding the basal relationship, we expected n Power and estradiol to be positively correlated. If high levels of estradiol facilitate a greater preference for dominance, this may also facilitate greater access to mates. High or rising levels of estradiol have also been shown to

32

increase sexual motivation and activity (Adams et al., 1978; Grammer et al., 2004; Haselton et al., 2007; Udry & Morris, 1968). The combination of estradiol-facilitated dominance preference and sexual motivation could potentially lead to greater reproductive success. Preliminary support for this hypothesis comes from Schultheiss, Dargel, and Rohde (2003a), who reported a positive relationship between menstrual-cycle-phase estradiol and n Power in single women. Although this relationship is consistent with the hypothesis that estradiol is linked to n Power in women, it requires replication.

Moreover, despite the fact that oral contraceptives reduce endogenous estradiol levels, Schultheiss et al. (2003a) failed to find an effect of oral contraceptive use on the relationship between n Power and estradiol, perhaps due to small sample size. However, other studies examining the link between estradiol and behavioral measures of dominance report a stronger correlation between estradiol and outcome measures for normally cycling women than for women using oral contraceptives (e.g. Grammer et al., 2004). We therefore expected the hypothesized basal relationship between n Power and estradiol to be stronger for normally cycling women than for women on the pill.

Finally, because free estradiol concentrations in saliva and serum are extremely low, measurement error tends to be higher than for other steroid hormones, with average intra- and inter-assay CV's in the 10 to 20% range (Lipson & Ellison, 1996; Schultheiss et al., 2003a; Yang et al., 2004). Because measurement error can attenuate the true relationship between two variables, we also examined whether the hypothesized relationship between n Power and basal estradiol would be stronger for saliva samples with low measurement error than for samples with high measurement error.

In the present research, we also examined for the first time dynamic relationships between n Power and estradiol in humans, using a dominance-contest paradigm that has been exploited successfully in studies on the relationship between dominance and testosterone in human males (e.g., Mazur & Booth, 1998; Schultheiss & Rohde, 2002). Research on testosterone has shown that its relationship with dominance is not restricted to a basal correlation, but testosterone concentrations also change as a function of dominance interactions and contests, with winners showing increases, and losers decreases, in testosterone (Booth et al., 1989; Mazur, 1985; Rose et al., 1975). Often, post-contest hormone changes also depend on an individual's motivation to attain dominance (Sapolsky, 1987). In men and women, testosterone and cortisol post-dominance contest changes are the function of an interaction between the individual's n Power and the contest outcome (Schultheiss et al., 2005a; Wirth et al., 2006; cf. Josephs et al., 2006, for related findings). For men, power-motivated winners have increases in post-contest testosterone, whereas power-motivated losers have decreases in testosterone. However, this pattern does not hold for women. Among female participants, both power-motivated winners and losers shows increases in testosterone, a finding that Schultheiss et al. (2005a) explained as a byproduct of adrenal activation during the contest.

Extrapolating the hypothesis that estradiol is critically involved in power motivation in women, we hypothesized that in power-motivated women, estradiol changes induced by the outcome of a dominance contest outcome would mirror those of testosterone in power-motivated men. We reasoned that surging levels of estradiol after a dominance victory will prime the power-motivated individual to further assert her dominance, whereas falling estradiol levels after a defeat may serve to transiently

34

decrease dominance motivation and thereby the likelihood of further losses (for similar arguments related to the functional role of contest-induced testosterone changes see Mazur, 1985). We therefore expected that n Power would predict estradiol increases in dominance contest winners and estradiol decreases in dominance contest losers. In men, power-motivation-dependent effects of dominance contests on testosterone changes are observable 15 minutes post-contest, but not before or after (Schultheiss, 2007). To explore whether similar time-course changes can be observed in women's post-contest estradiol levels, we measured salivary estradiol repeatedly after the contest, including one measurement the day after the contest.

As Mazur and Booth (1998) have pointed out, self-report measures of dominance motivation frequently fail to predict testosterone levels and testosterone-related outcomes in men. In contrast, indirect measures of dominance motivation like the PSE n Power measure reliably predict both basal testosterone levels and testosterone responses to dominance contest outcomes in men (Schultheiss, 2007). In the present research, we explored whether this dissociation between self-report and indirect measures of dominance motivation also holds for the hypothesized link between dominance motivation and estradiol in women.

Finally, we also chose to assay salivary testosterone to test discriminant effects of n Power on basal estradiol and testosterone as well as changes in estradiol and testosterone as a function of dominance contest outcome. The inclusion of both testosterone and estradiol provides a more complete picture of the basal and dynamic relationships between the putative dominance hormones and n Power in women.

Methods

Subjects

Data were collected from a subsample of 53 female graduate and undergraduate students at the University of Michigan (19.96 ± 0.27 years old) who participated in a larger study on the effects of power motivation on hormonal responses to dominance contests (see Wirth, Welsh, & Schultheiss (2006, Study 2) for details on the full sample and findings related to contest-dependent cortisol changes). Four participants' data were incomplete and were omitted from the analysis; hence, $N = 49$ for all analyses. Students majoring in Psychology were not allowed to participate. On average, participants reported to be 17.47 days past the onset of their last menstruation. Fourteen women reported taking hormonal oral contraceptives. Participants refrained from eating and oral hygiene for at least one hour prior to the start of the study.

Design

For the following analyses, basal salivary estradiol, basal salivary testosterone, post-contest changes in salivary estradiol, and post-contest changes in salivary testosterone were the dependent variables and implicit power motivation, experimentally-varied contest outcome (win versus lose), and self-reported needs for dominance and aggression were the independent variables.

Procedure

Sessions were run by a single male or female experimenter. As part of hypotheses unrelated to those reported here, participants were administered, in a double-blind fashion, 200 mg caffeine or placebo (vitamin C) at the beginning of the study. Caffeine

condition did not have an effect on any of the analyses reported here. In the pre-contest phase, participants provided a saliva sample (T1, at 0 min), then completed a PSE (25 min duration), a questionnaire containing dominance and aggression scales, and other tasks. Next, the experimenter announced that participants would compete against each other in a contest based on a serial response task (SRT), described below. Participants then provided a second saliva sample (T2, at 52 min), listened to a 10-min tape-recorded goal imagery exercise vividly describing the course of the ensuing contest from the winner's perspective (cf. Schultheiss, 2001), and provided a third saliva sample (T3, at 64 min) while working on another task.

During the subsequent contest phase, participants competed against each other on 10 rounds of the SRT, with a total duration of 10 min. The SRT required participants to quickly and accurately respond to asterisks (*) presented sequentially in four different screen positions by pressing one of four response keys mapped to those screen positions. The experimenter explained to participants that after each round, the computers would calculate their performance scores based on their speed and accuracy on the SRT and then compare their results to determine the winner of a round. Each round started with a screen announcing the round number, followed by a countdown. Participants then worked on the SRT for 50 sec. After that, they saw a black screen featuring the words "Calculating and comparing scores..." for 2 sec, followed by either a green screen with the words "You have won this round" and accompanied by a jubilant jingle or a red screen with the words "You have lost this round" and accompanied by a low-frequency snarling tone for 2 sec, followed by a blank screen that retained the color of the feedback screen (3 sec). Participants in the winning condition "won" all rounds except for the

37

second and the fifth, and participants in the losing condition correspondingly "lost" all rounds except for the second and the fifth.

In the post-contest phase, participants collected fourth, fifth and sixth saliva samples (T4, at 78 min, 0 min post-contest; T5, at 93 min, 15 min post-contest; T6, at 108 min, 30 min post-contest) while completing other tasks unrelated to the results reported here. Finally, they completed a background-data questionnaire, and a suspicion check in the form of an open-ended questionnaire asking for anything they had noted about the study. Participants returned the following day and provided a seventh saliva sample (T7). No participants demonstrated awareness that the contest outcome was experimentally manipulated. Participants were paid for their participation and fully debriefed about the study's hypotheses and manipulations at the end of the second session.

Implicit Power Motivation (n Power)

Implicit power motivation was assessed with the PSE with instructions specified by Schultheiss and Pang (2007). Participants were given five minutes to write creative stories in response to pictures. Five pictures were chosen for the PSE stories: *women in laboratory*, *ship captain*, *boxer*, *protester hurling a stone*, and *bicycle race* (for further description of these pictures see Schultheiss & Pang, 2007). PSE stories were coded for motivation Power in accordance with Winter's (1994) Manual for Scoring Motive Imagery in Running Text by a trained coder. The themes in participant's PSE stories coded for implicit power motivation include strong, forceful actions that have impact over others, controlling others, influencing or persuading others, offering unsolicited help or advice, impressing others, fame, prestige, reputation, and actions that elicit a strong emotional response in others. The trained coder had reached 85% agreement with expert

38

coding in the Winter Manual training materials. On average when added together, participants' five PSE stories were 553 ± 17 words long and contained 5.62 ± 0.33 power images. PSE word count was significantly correlated with n Power scores ($p < .05$) and were therefore corrected for PSE word count through regression. Power motive residuals were converted to z scores, which were used in subsequent analysis.

Self-reported dominance and aggression

We measured self-reported needs for dominance and aggression using the correspondingly named scales from the Personality Research Form (PRF, Form E; Jackson, 1984), a self-report inventory of motivational needs. Each scale had 16 likert-scaled items, and each scale had 8 reverse-coded items. "I have been known to fly into a rage if things didn't go as I had planned" is an example item from the aggression scale and "I seldom feel like hitting anyone" is an example of a reverse-coded item from the aggression scale. "I would like to be an executive with power over others" is an example item from the dominance scale and "I avoid positions of power over other people" is an example of a reverse-coded item from the dominance scale. These scales were chosen for their similarity to the coding categories for n Power, enabling us to directly compare implicit and explicit measures of dominance motivation in our analyses. In validation samples, both the dominance and aggression scales showed satisfactory internal consistency, Cronsbach's α's = 0.67 and 0.63, respectively (Jackson, 1984).

Salivary sampling

For each of the seven salivary samples participants provided, participants used a stick of sugar-free chewing gum to collect up to 7.5 ml saliva in a sterile polypropylene vial and then discarded the chewing gum (Dabbs, 1991). Participants sealed the vials

immediately after each collection. The experimenter placed the vials in frozen storage

immediately after the experimental session was complete. Samples were freed from

mucopolysaccarides and other residuals by three freeze thaw cycles followed by

centrifugation. Salivary 17ß-Estradiol levels were assessed with solid-phase Coat-A-

Count ^{125}I radioimmunoassays for 17ß-Estradiol (TKE2) provided by Diagnostic Products

Corporation (Los Angeles).

Salivary estradiol

To determine salivary estradiol concentrations, we prepared water-based 1:80

dilutions of all standards (with a resulting range of 0.625 to 20 pg/mL) and controls (see

Schultheiss et al., 2003a, for validation data). 800 uL of the saliva samples, standards,

and controls were pipetted into antibody-coated tubes and allowed to incubate overnight.

Next, 1 ml radiotracer was added to each tube and allowed to incubate overnight.

Finally, tubes were aspirated and counted for 3 minutes. Assay reliability was evaluated

by including control samples with known hormone concentrations in each assay (Bio-Rad

Lyphochecks from Bio-Rad Laboratories, Hercules, CA). The assay manufacturer

documents that its assay does not cross-react with estrogens in oral contraceptives.

Analytical sensitivity (B_0 -3 SD) was at 0.20 pg/mL. Analytical recovery was 91.67% for

low (2.25 pg/mL) and 107.33% for high (5.14 pg/mL) estradiol levels. Inter-assay CV

for these measurements was 5.07% and 5.11%, respectively. Participants' seven saliva

samples were counted in duplicate and had a mean intra-assay CV of 24.62%.

Salivary testosterone

To determine salivary testosterone concentrations, we prepared water-based

dilutions of all standards (with a resulting range of 5 to 400 pg/mL) and controls. 400 uL

of the saliva samples, standards, and controls were pipetted into antibody-coated tubes

and allowed to incubate overnight. Next, 1 ml radiotracer was added to each tube and

allowed to incubate overnight. Finally, tubes were aspirated and counted for 3 minutes.

Assay reliability was evaluated by including control samples with known hormone

concentrations in each assay (Bio-Rad Lyphochecks from Bio-Rad Laboratories,

Hercules, CA). Analytical sensitivity (B_0 -3 SD) was at 2.44 pg/mL. Analytical recovery

was 113.41% for low (8.20 pg/mL) and 92.44% for high (18.20 pg/mL) testosterone

levels. Inter-assay testosterone CV was 13.02% for saliva pools collected from female

participants. Participants' seven saliva samples were counted in duplicate and had a

mean intra-assay CV of 12.29%.

Data Analysis

SYSTAT 10.0 statistical software was used for all analyses, including regression.

Descriptive statistics are shown as mean (± SEM). See Table 1 for sample characteristics

of n Power, PRF scales, salivary estradiol, salivary testosterone, and age.

Results

Estradiol measurement stability at times 1 & 2

Due to the high average intra-assay CV, we first determined the stability of the

estradiol measurements for the 43 participants that had samples at both T1 and T2. We

found a significant and highly positive correlation between the first two estradiol

measurements (see Figure 1), suggesting high retest stability of our estradiol measure.

Given this high stability, we averaged the first two estradiol measurements to increase

reliability for the basal estradiol analysis. Participants' mean basal estradiol concentration (average T1 and T2) was 2.02 ± 0.33 pg/mL.

Regression of n Power and basal estradiol

A regression of estradiol on n Power scores revealed a highly significant effect of n Power on basal estradiol (see Figure 2). In this analysis of all 49 participants, we included six participants for whom we had data from only one saliva sample due to insufficient saliva volume on the other.

Testing effects of CV levels on the nPower-estradiol correlation

Next, we split the sample at the median average coefficient of variation (CV) for basal estradiol into a low-CV ($10.22\% \pm 1.06$) and a high-CV group ($40.92\% \pm 5.43$) to examine the effect of measurement error on the association between n Power and estradiol. The regression of estradiol on n Power scores for the low-CV group showed a stronger correlation with n Power ($R = 0.50$, $P = 0.01$, $N = 25$) than for the high-CV group ($R = 0.24$, ns, $N = 24$; see Figure 3, Panel A). This finding indicates that high measurement error can attenuate the association between n Power and estradiol.

Testing effects of oral contraceptives on the nPower-estradiol correlation

Analysis of hormonal contraceptive use showed that the positive relationship between n Power and estradiol is stronger in normally cycling women ($R = 0.44$, $P = 0.009$, $N = 35$) than in women who are taking hormonal contraceptives ($R = 0.12$, $P = $ ns, $N = 14$; see Fig. 3, Panel B).

Testing effects of relationship status on the nPower-estradiol correlation

Schultheiss and colleagues (2003a) reported a significant positive relationship between n Power and estradiol in single women, but not in women in close relationships.

42

This study replicated their finding. When grouping the women into those who were in close relationships and those who were not, we found that there is a highly significant, positive correlation between n Power and estradiol for single women ($R = 0.55$, $P = 0.004$, $N = 25$), but not for women in a close relationship ($R = 0.08$, ns, $N = 24$; see Figure 3, Panel C). In this sample, women in a close relationship were significantly more likely to use oral contraceptives ($\chi^2(1, N = 49) = 6.87$, $p < 0.01$).

Testing effects of contest outcome and n Power on estradiol changes

Because measurement error was an important factor in the correlation between n Power and basal salivary estradiol, we continued to divide the sample into high CV and low CV groups for the dominance contest analysis to see if measurement error continued play a role in the relationship between n Power and estradiol. We split participants into two groups at the median of the averaged CV of combined pre-contest (T3) and post-contest (T4, T5, T6) estradiol samples. Examining the low-CV group ($12.47\% \pm 0.70$) using ANCOVA, we did not find significant main effects of n Power or contest outcome, $Ps < 0.10$. But there was a highly significant interaction of n Power and contest outcome on residualized average estradiol levels (variance in post-contest estradiol after controlling for pre-contest estradiol) ($B = 1.38$, $SE = 0.48$, $t (1,20) = 2.84$, $P = 0.01$). The within-subjects, Contest Outcome x n Power x Time interaction on estradiol residuals was not significant documenting that the effect is not driven by differential changes across post-estradiol levels. This allowed us to average the three post-contest estradiol measurements (T4, T5, T6) (2.64 pg/mL ± 0.29). For winners, the positive correlation between n Power and residualized average estradiol was significant ($R = 0.35$, $P = 0.05$, $N = 16$). For losers, we found a negative correlation between n Power and

estradiol residuals that approached the level of a trend (R = -0.42, P = 0.125, N = 9; cf. Fig. 4). There were no effects for the high-CV group (32.30% ± 2.76; N = 24). Despite the fact that time was not a significant factor, we also ran the analyses for each post-contest time point. After controlling for pre-contest estradiol, the n Power x Contest Outcome interaction was significant at T4 (B = 1.25, SE = 0.43, t (1,20) = 2.93 , P < 0.01), T5 (B = 1.07, SE = 0.39, t (1,20) = 1.95 , P = 0.065), and T6 (B = 1.79, SE = 0.80, t (1,20) = 2.25 , P = 0.036). At each time point, the direction of the correlation between n Power and residualized estradiol for the groups of winners and losers was the same as in the analyses that aggregated over timepoints T4, T5, and T6. These findings suggest that the n Power x Contest Outcome effect on post-contest estradiol did not vary substantially from immediately after the contest to 30 min post-contest.

For the analysis on estradiol changes as a result of the contest outcome from immediately before the contest (T3), to the day after the contest (T7), we split the sample at the averaged median CV of combined estradiol samples T3 and T7. Examining the group with low estradiol CV (14.91% ± 2.60; N = 24), there was still a significant, positive correlation in winners between n Power and the estradiol residuals (variance in day-after estradiol (T7) controlling for pre-contest estradiol (T3)) (R = 0.44, P = 0.02, N = 14; cf. Fig. 5). This effect is similar in direction and magnitude as the effect showing estradiol changes immediately post-contest. For losers, there was no relationship between n Power and estradiol residuals (R = 0.07, ns, N = 10). There were no day-after effects for the high-CV group (34.41% ± 3.59; N = 25).

Discriminant prediction of basal and dynamic estradiol concentrations by n Power and self-report measures of dominance

The last set of analyses, for which results are presented in Table 2, compared the validity of n Power against PRF questionnaire scales of dominance and aggression in predicting basal estradiol and contest-induced estradiol changes. The correlation between the questionnaire measure of dominance and basal estradiol was not significant. However, analyses did reveal a negative trend between the questionnaire scale of aggression and estradiol. We also examined the relationships between n Power and the scales and found that n Power was unrelated to the questionnaire measure of dominance, but that higher levels of n Power were significantly related to lower PRF aggression scores. Just as in the n Power analyses, we tried to predict changes in post-contest estradiol as a function of contest outcome and self-reported dominance or aggression for the low estradiol CV group. Using ANCOVA, neither the dominance (B = -0.48, SE = 0.87, t (1,20) = -1.35, ns) nor the aggression scales (B = -0.11, SE = 0.17, t (1,20) = -.68, ns), in interaction with contest outcome, significantly predicted post-contest estradiol residuals using pre-contest estradiol (T3) as a covariate.

Testing basal and dynamic relationships between testosterone and n Power

To test associations between n Power and salivary testosterone in the same sample in which we had evaluated the associations between n Power and salivary estradiol, we yoked the analyses by using the same participant groups (divided by low versus high estradiol CV) for the testosterone analyses. Participants' mean basal testosterone concentration (average T1 and T2) was 17.25 ± 1.38 pg/mL. We found a highly significant positive correlation between basal testosterone (T1 & T2) and basal estradiol

(see Table 2). However, basal testosterone was not correlated with n Power (see Table

2). We found that there was not a significant relationship between n Power and basal

testosterone for women with low estradiol CVs (R = 0.02, ns, N = 25) or women with

high estradiol CVs (R = -0.20, ns, N = 24). For single women, we found that there was

not a significant relationship between n Power and basal testosterone (R = 0.16, ns, N =

25), but that for women in close relationships, there was a trend negative correlation

between basal testosterone and n Power (R = -0.39, P = .06, N = 24). For both normally-

cycling women and women taking oral contraceptives, there was not a significant

relationship between n Power and basal testosterone, R = -0.02, ns, N = 35 and R = -0.40,

ns, N = 14, respectively. For women with low estradiol CVs, the interaction of n Power

and contest outcome was not significant for averaged post-contest testosterone levels (B

= 2.34, SE = 2.57, t (1,20) = 0.91, ns) and for day-after testosterone levels (B = 2.76, SE

= 3.25, t (1,19) = 0.85, ns), after controlling for pre-contest testosterone in each case.

We also employed bi-partial correlation analysis, which measures the co-

variation between post-contest (T4, T5, T6) estradiol and testosterone after controlling

for pre-contest (T3) levels of estradiol and testosterone, to determine the relationship

between post-contest estradiol changes and post-contest testosterone changes,

independent of n Power. Post-contest estradiol and post-contest testosterone did not co-

vary (R = -0.01, ns).

Discussion

Our hypothesis that women's n Power and basal estradiol levels would be positively correlated was confirmed. Across all participants, a higher nonconscious preference for dominance was associated with higher basal estradiol levels. This finding is consistent with research from the primate literature that documents a link between estradiol and dominance (Michael & Zumpe, 1993; Zumpe & Michael, 1989). It also replicates an earlier finding by Schultheiss et al. (2003a), who found a positive correlation between n Power and estradiol. However, like in that earlier study, we found that the positive correlation is particularly strong in single women, but not in women engaged in close relationships.

Past research has linked high levels of n Power to sexual activity (McClelland, 1975; Winter, 1973), and this finding holds both for men and for women (Schultheiss et al., 2003b). Moreover, high or rising levels of estradiol have also been found to be associated with behavioral indicators of mate pursuit (Grammer et al., 2004; Haselton et al., 2007) and increased sexual activity in women (Adams et al., 1978; Udry & Morris, 1968). We therefore speculate that the link between n Power and estradiol we observed in the present research may account for the greater likelihood of high-n Power women to engage in sexual activity. The difference between single women and women engaged in close relationships may suggest that in single women, n Power is closely aligned with estradiol's role in attracting a sexual partner (cf. Grammer et al., 2004), but that this link is less important for women who have already found a partner (for related findings from the literature on testosterone and relationship status in men, see Booth & Dabbs, 1993;

47

Gray et al., 2002; Mazur & Michalek, 1998; McIntyre et al., 2006; van Anders & Watson, 2006).

The current study also expanded upon past research by showing that, as expected, measurement error and oral contraceptive use are important factors to consider when examining the relationship between n Power and salivary estradiol. When we divided our sample at the median CV for the basal estradiol measurement, we found that the low-CV group showed a significant positive correlation between n Power and estradiol, while the high-CV group did not, suggesting that salivary estradiol measurement error can mask the association. A similar finding emerged from our analyses of dynamic relationships between n Power and estradiol in the context of a dominance contest: the hypothesized interaction between n Power and contest outcome on post-contest estradiol changes emerged only in the low-CV group, but not in the high-CV group. Finally, women with normal cycles had a stronger positive correlation between n Power and basal estradiol, suggesting that suppression of endogenous estradiol production might also mask the link between motivational dispositions and hormone levels. However, oral contraceptive use and relationship status are highly confounded in the present study, and further studies need to disentangle the respective effects of these variables.

Consistent with our prediction of a dynamic relationship between n Power and estradiol, we also found that estradiol changes after winning or losing a dominance contest depend on women's n Power. Winners high in n Power had post-contest increases in estradiol and losers high in n Power had decreases in estradiol, a result that closely resembles the pattern of testosterone responses in high-n Power men to victory and defeat in dominance contests (Schultheiss & Rohde, 2002; Schultheiss et al., 2005a).

48

Moreover, elevated estradiol levels in high-n Power winners could even be documented one day after the contest. This latter finding parallels past work by Mazur and colleagues (1992), who reported that male winners of chess competitions showed elevated testosterone levels for weeks.

What is the mechanism driving the quick estradiol responses to the dominance contest we observed in high-n Power women in the present study? Our results do not appear to fit the adrenal-activation model proposed by Schultheiss and colleagues (2005a) to account for high-n Power women's testosterone responses to dominance contests (see introduction). Wirth et al. (2006) found in the larger sample from which we drew our female subject pool that high n Power predicts decreased cortisol after a contest victory and increased cortisol after a defeat, a pattern that is the exact opposite of the increased estradiol in high n Power winners and decreased estradiol in high n Power losers we observed in the present study. We therefore think it is unlikely that the changes in estradiol we documented in the present study represent a byproduct of adrenal steroid production.

One possible mechanism that may account for rapid situation-induced changes in gonadal steroid production has been proposed by Sapolsky (1987) for the case of male testosterone responses to dominance challenges. Sapolsky found that dominant baboons respond to a challenge by releasing norepinephrine, which stimulates testicular steroid release within minutes. In contrast, non-dominant baboons respond to similar challenges with increased cortisol levels, which inhibit steroid release from the testes equally quickly. While Sapolsky's model is very suitable for explaining the effects of n Power on men's testosterone responses to winning and losing a contest (Schultheiss, 2007), the

49

question to what extent sympathetic vs. HPA-axis responses to dominance challenges can have similar effects on the female ovaries and hence on estradiol release have, to our knowledge, not been explored so far. It is interesting to note, however, that estradiol changes could be under sympathetic control through direct vagal innervation and stimulation of the ovaries, which would allow rapid modulation of estradiol production (Gerendai & Halasz, 2001). Moreover, consistent with our observation that in high-n Power individuals estradiol and cortisol change in opposite directions, gonadal steroid release is inversely related to adrenal activation (e.g. Viau, 2002). It remains to be determined, though, whether the mechanisms involved in this inverse relationship can account for the rapid estradiol changes we observed in the present research.

Yet another possible mechanism is suggested by recent evidence that shows that social interactions, such as dominance contests, can rapidly modulate aromatase activity driving fast changes in estradiol concentrations in the CNS (Balthazart & Ball, 2006). However, this effect takes place locally in target tissues of the brain and it remains unclear to what extent this effect could be detected peripherally (e.g., in saliva).

We also sampled salivary testosterone in our study to examine the degree to which testosterone and estradiol had similar effects. We found that testosterone and estradiol were positively related at baseline. However, testosterone was not related to n Power at baseline, and testosterone changes were not predicted by n Power in interaction with contest outcome. Thus, in this sample, estradiol was the hormone that was related to a preference for dominance, and estradiol was also the hormone that was responsive to dominance contest outcomes in interaction with individuals' preference for dominance. Additionally, despite the baseline correlation between the two hormones, we found that

changes in estradiol and testosterone as a function of the contest outcome were not related. Thus, our data suggest that the two hormones have non-overlapping functions with regard to dominance in women. Our data provide support for the hypothesis that estradiol may be more closely related to dominance in women than testosterone.

Finally, in the present research we also tested the hypothesis that implicit and self-report measures of dominance motivation are differentially associated with salivary estradiol measures. As hypothesized, n Power was not related to the self-report PRF dominance scale, and this self-report measure did not predict estradiol concentrations. Moreover, while n Power predicted estradiol changes in interaction with contest outcome, neither self-reported dominance or aggression predicted estradiol changes in interaction with contest outcome. These findings further corroborate the idea that implicit measures of dominance motivation are better predictors of endocrine processes than self-report measures of dominance. Schultheiss (2007) argued that the influence of sex steroids on motivation and behavior exists in many species without any need for conscious awareness and that conscious beliefs about one's motivational needs are not "read-outs" of, or identical with, the output of core motivational brain systems. Other research groups have also shown that even in humans, steroid hormones can cause physiological and behavioral changes outside of conscious awareness (VanHonk et al. 1999, 2001, 2005).

The negative correlation between estradiol and self-reported aggression replicates earlier research by Cashdan (2003) and Gladue (1991). However, in humans, aggression is typically *not* a socially acceptable outlet for the need for dominance. Winter (1988) reported that successful outlets for n Power in women are often subtle forms of

dominance that are shaped by social responsibility, education, and socialization and that these expressions of n Power rarely include physical aggression. Moreover, in humans, aggressive behavior may reflect defensiveness and not dominance, and it is notable that in animals, defensive aggression is not dependent on circulating levels of gonadal steroids whereas dominant aggression is (cf. Albert et al., 1992; Schultheiss & Wirth, in press). The current findings, along with those of Cashdan (2003) and Gladue (1991), might point to the possibility that those high in n Power and estradiol have learned successfully to channel their dominance motivation into socially acceptable outlets and not into aggression.

To sum up, we have found that estradiol, but not testosterone, and a nonconscious need for dominance are positively related in women. This positive relationship is strongest in single women, women not taking oral contraceptives, and in the absence of high salivary estradiol measurement error. Additionally, we have documented for the first time that changes in estradiol after a dominance contest depend on the interplay between the outcome of the contest and individual's power motivation.

Acknowledgements

Figure 3-1

Correlation of basal salivary estradiol measurements at T1 (0 min) and T2 (52 min).
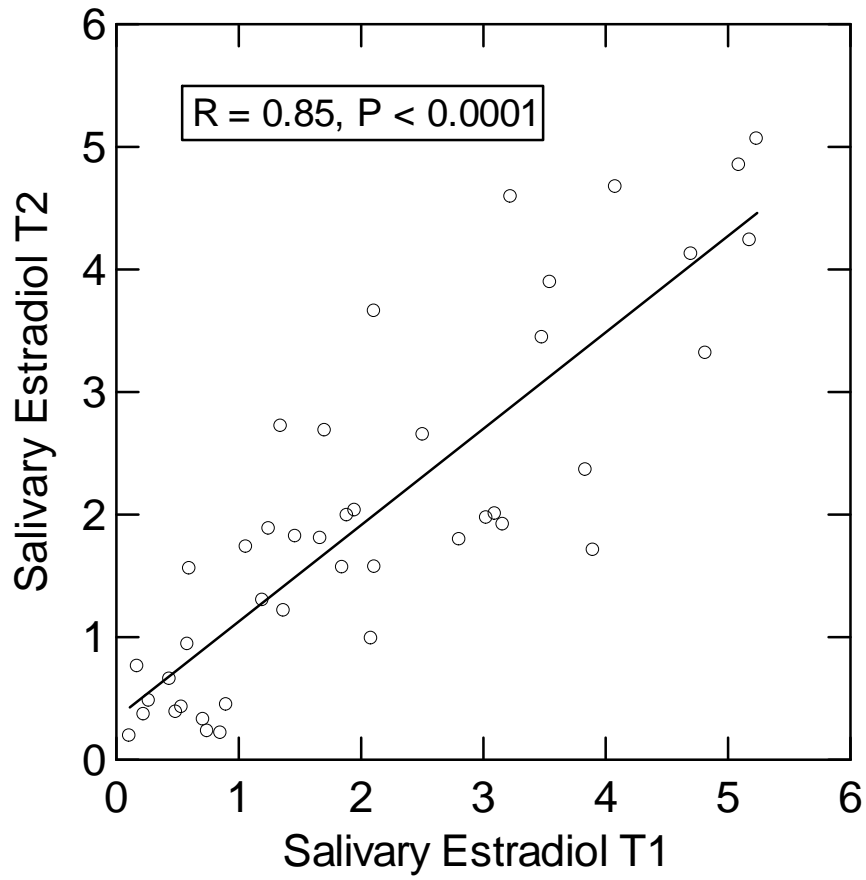
Figure 3-2

Correlation between n Power and basal salivary estradiol (average of T1 and T2).
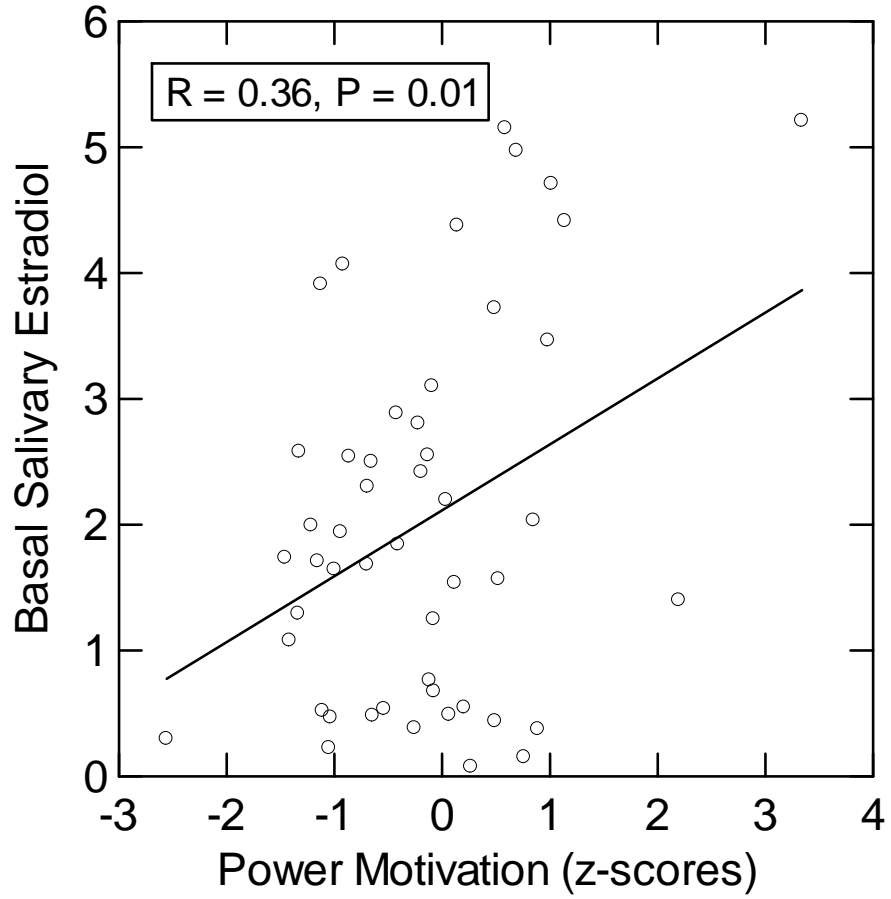
Figure 3-3

Correlations between n Power and basal salivary estradiol (average of T1 and T2).
Panel A depicts the correlations for groups of high (dashed line) and low (solid line)
estradiol measurement error (CV). Panel B depicts the correlations for women who do
(solid line) and do not (dashed line) use oral contraceptives. Panel C depicts the
correlations for the single women (dashed line) and for women in close relationships
(solid line).
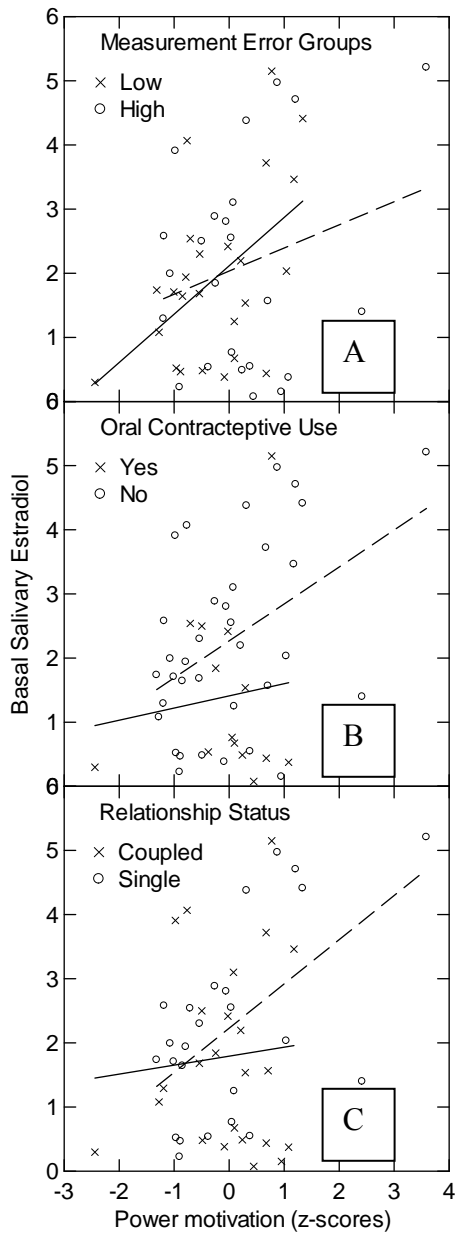
Figure 3-4

Estradiol residuals (average post-contest estradiol (T4, T5, & T6) adjusted for pre-contest estradiol (T3)) as a function of n Power and contest outcome for participants in the low-CV group (N = 25). The contest losers are represented by the dashed line and the winners by the solid line.
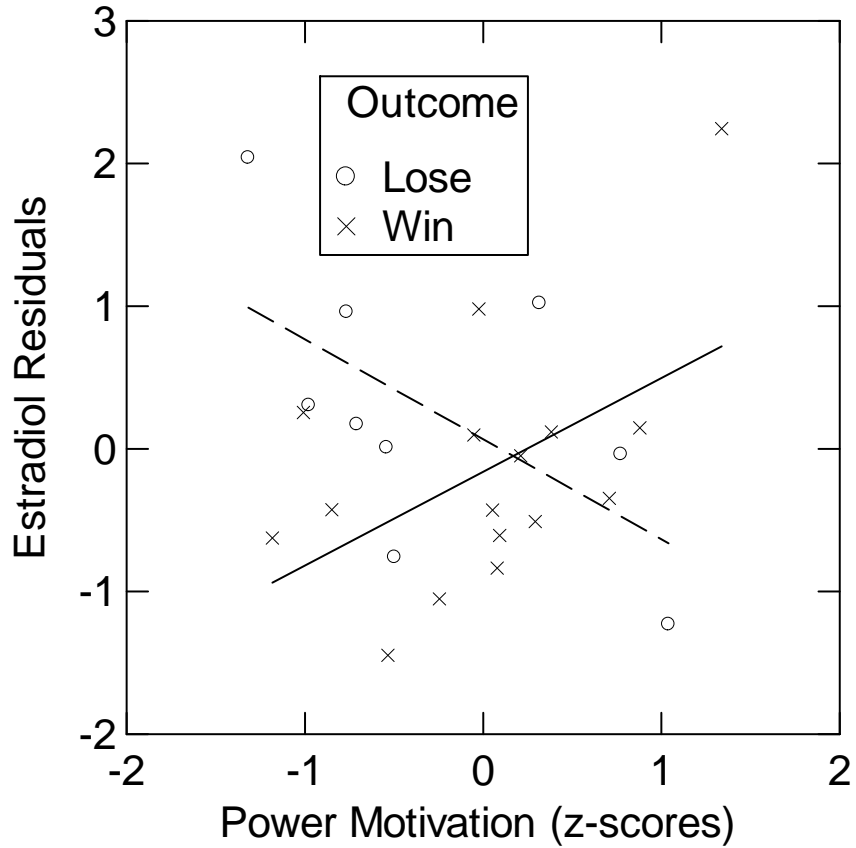
Figure 3-5

Estradiol residuals (day-after contest estradiol (T7) adjusted for pre-contest estradiol (T3)) as a function of n Power and contest outcome for participants in the low-CV group (N = 24). The contest losers are represented by the dashed line and the winners by the solid line.
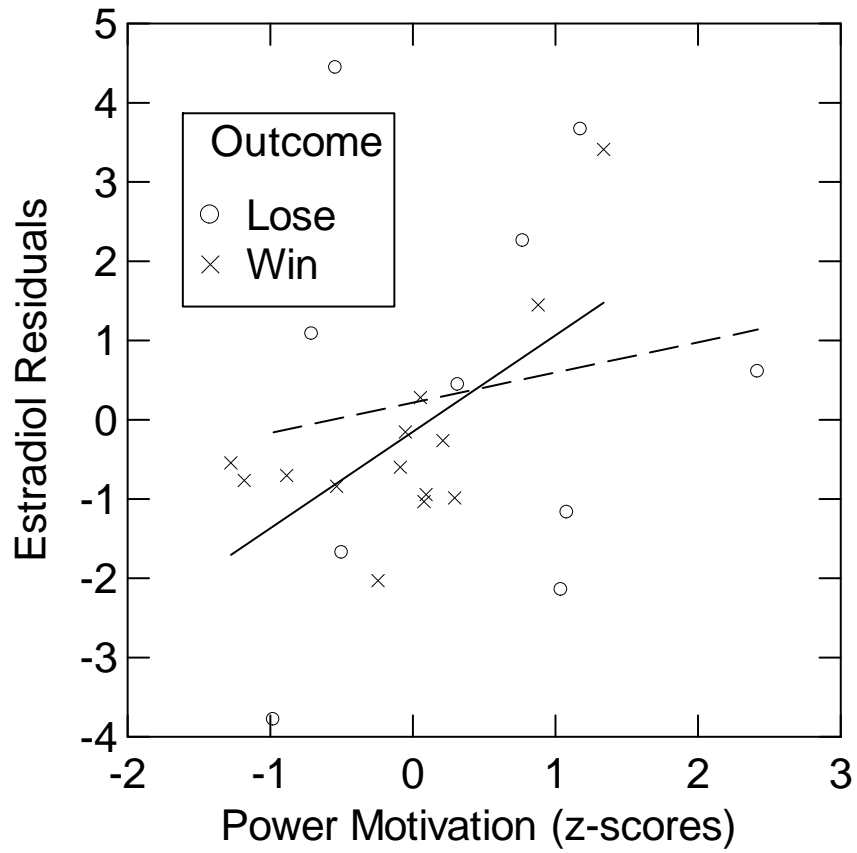
Table 3-1

Sample characteristics for n Power (word-count corrected *z* scores), PRF dominance scale, PRF aggression scale, salivary estradiol (in pg/mL), salivary testosterone (in pg/mL), and age (in years)

	Mean	SEM	CV
n Power	0.00	0.14	
PRF Aggression	7.73	0.34	
PRF Dominance	9.60	0.64	
Salivary estradiol			
T1	2.08	0.22	21.92%
T2	2.01	0.22	27.41%
T3	1.88	0.21	24.29%
T4	2.03	0.25	20.45%
T5	1.99	0.24	25.07%
T6	2.20	0.28	18.60%
T7	2.25	0.28	24.70%
Salivary testosterone			
T1	19.62	1.69	10.90%
T2	15.01	1.21	12.98%
T3	15.36	1.13	13.49%
T4	15.75	1.15	13.16%
T5	15.42	1.18	13.44%
T6	14.87	1.06	12.08%
T7	20.40	1.35	9.97%
Age	19.96	0.27	

Table 3-2

Correlations between n Power (z scores), PRF dominace scale, PRF aggression scale, basal salivary estradiol (average of T1 and T2), and basal salivary testosterone (average of T1 and T2)

	n Power	PRF Aggression	PRF Dominance	Basal salivary estradiol
n Power	-			
PRF Aggression	-0.36***	-		
PRF Dominance	-0.21	0.19	-	
Basal salivary estradiol	0.36***	-0.27*	0.07	-
Basal salivary testosterone	-0.04	0.07	0.08	0.44****

P-values
* .10
** .05
*** .01
**** < .01

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Chapter 4

Implicit Sexual Motivation: Measurement and behavioral validation

Abstract

Coding thematic imagery in creative stories has been a long-standing method of measuring implicit motivation in humans and one commonly used instrument is the Picture Story Exercise (PSE). In this study, implicit sexual motivation themes were coded in stories written by participants in response to pictures suggesting heterosexual intimacy. This study also examined the effects of visual sexual primes on the themes in participants PSE stories and found that themes associated with implicit sexual motivation, but not other classes of motivation, were increased via sexual priming. To assess the predictive validity of coding sexual motivation in PSE stories, an operant conditioning paradigm was employed, which assessed the rewarding properties of visual sexual stimuli. Implicit sexual motivation was positively associated with implicit learning to achieve visual sexual reward, and this effect was particularly strong in men.

65

Introduction

Sexual motivation has been a central topic of research in psychology for well over 100 years (Beach, 1981; Kinsey et al. 1948, 1953; Masters & Johnson, 1966). Sexual motivation is instrumental in the initiation of sexual pursuit and subsequent performance. Levels of sexual motivation are not the same for every individual, but rather individuals' levels of sexual motivation can vary widely (Carter, 2002). In humans only, sexual motivation can be measured through introspection and self-report. Some have argued that differences in sexual motivation manifest themselves in aspects of one's personality (McClelland, 1987). Within personality psychology, two fundamentally different approaches to measuring motivation have been commonly used: self-report questionnaires that directly ask individuals to report on their motivation, and implicit measures which try to capture one's motives without ever asking them directly about motivation (Larsen & Buss, 2002). An indirect method used successfully to capture other motives like power and affiliation is the Picture Story Exercise (PSE) (Smith, 1992), which requires participants to write creative stories about ambiguous pictures of people interacting. Participants' stories are then coded for motivational themes (i.e. power and affiliation), which are subsequently quantified. Within personality psychology, motivation research has consistently found that motives like power and affiliation, which are conserved across mammalian species via the same biological roots, are more validly assessed with implicit measures like the PSE (Schultheiss, 2007). One plausible reason for this is that these classes of behavior (power, affiliation, and sex) exist in other species without the need for conscious self-regulation. Indeed, we often seem to have poor

66

insight into our motives via self-report (cf. Bargh, 2007; LeDoux, 1996; McClelland et al., 1989; Nisbett & Wilson, 1977; Rolls, 1999; Schultheiss, 2001, in press).

Several decades ago, there were a few attempts to measure implicit sexual motivation (nSex or need for sex) using PSE techniques. However, these attempts were shrouded in Freudian interpretation, methodologically unsound, and the mores of the era resulted in few participants actually writing about sex in PSE stories (Beardslee & Fogelson, 1958; Clark & Sensibar, 1958). For instance, Clark & Sensibar (1958) used only male participants viewing pictures of females and found that sexual imagery could be aroused in PSE stories, but only when participants were shown erotic stimuli for extended periods (i.e. minutes) and had consumed alcohol at a "fraternity beer party" to ease their inhibitions before writing stories, with no control on the amount of alcohol consumed. In the Beardslee & Fogelson (1958) study, the sexual arousal and control stimuli were different types of "movie music", as opposed to any overt sexual stimulus. Moreover, the coding of sexual motivation was heavily influenced by Fruedian theory. For example, the phrase, "bursting in a room" would have been coded as sexually suggestive, because it describes penetration, and "clapping" would be coded, because it describes a rhythmic activity. As a result of these weak studies, the field essentially dropped attempts to indirectly measure differences in sexual motivation. Under such circumstances, one might assume that there are plentiful existing examples of valid and reliable self-report measures of sexual motivation, thus making implicit measures unnecessary. However, this is and was not the case. While there are a few validated questionnaires that measure specific nuances of sexual motivation like physical sexual excitation and inhibition (Janssen et al., 2002a, 2002b), there is not a broader measure of

sexual motivation that reliably predicts a broader class behaviors related to the pursuit of sex or sex-related rewards.

Past work on implicit motives has suggested that motives can be aroused by a relevant motivational stimulus and result in greater motivational imagery in PSE stories (Schultheiss, Wirth, & Stanton, 2004). This suggests that implicit measures like the PSE capture fluctuations in motivational states when aroused by relevant stimuli. For example, if one showed participants subliminal pictures of food, they are more likely to write stories rich with hunger imagery (Atkinson & McClelland, 1948). Additionally, if participants watch movies about dominance, their power motive is aroused resulting in more power imagery in PSE stories, and the same holds for affiliation imagery in response to romantic movies (Schultheiss, Wirth, & Stanton, 2004). Moreover, PSE imagery is responsive to movies in the absence of sound, suggesting that non-verbal aspects of the images are motivationally robust in and of themselves (Klinger, 1967). In the present research, we attempted to arouse nSex by priming half of the participants with sexual images directly before they wrote PSE stories. In the priming group, participants wrote only the second half of their PSE stories after seeing sexual picture primes, which allowed for the examination of difference in sexual imagery within individuals as an effect of the sexual primes. In the control group, participants were not primed with sexual images for any PSE stories. We hypothesized that in the priming condition, participants' PSE stories would have increased quantities of sexual imagery as an effect of the sexual primes. We also chose to code participants' PSE stories for the classic three implicit motives: Power (nPower), Affiliation (nAffiliation), and Achievement (nAchievement). In doing so, we aimed to show that sexual primes would specifically

result in more sexual imagery in PSE stories and not just more motivational imagery of all varieties. If documented, this selective priming influence on sexual imagery would establish discriminant validity of coding nSex in PSE stories.

Based on the first hypothesis that sexual motivation can be aroused and would result in greater sexual imagery in PSE stories, we necessarily hypothesized that it would be possible to measure nSex using the PSE by measuring sexual themes using similar guidelines and coding categories of previous motivational coding systems (Smith, 1992; Winter, 1994). To do so, we chose PSE pictures that would potentially "pull" for nSex (Schultheiss & Pang, 2007). "Pulling" for nSex means that the PSE pictures depicted events instrumental to sexual activity or suggest the beginning of a sequence of events that will lead up to a sexual encounter. Yet, there is nothing overtly sexual about the PSE pictures, meaning that there is no depiction of nudity or sex. For example, we used a PSE picture of a couple reading together in a field and a PSE picture of a couple feeding each other spaghetti. One could potentially write a PSE story about an encounter that would lead to sexual seduction or activity and one could also write a story that had absolutely nothing to do with sex.

For a personality measure of nSex to be valid, it should also be able to predict relevant behavior. The prediction of a criterion behavior was a critical failure of the early attempts to code nSex in PSE stories. Beardslee and Fogelson (1958) did not include the prediction of any criterion in their results, and Clark and Sensibar (1958) predicted only the relationship between sexual motivation and self-reported aggression, which is not an excellent criterion behavior for sexual motivation. In the present research, to demonstrate criterion validity of coding nSex, we aimed to test the rewarding properties of visual

69

sexual stimuli, based on participants' nSex. We hypothesized that those who are more

sexually motivated as reflected through higher levels of sexual imagery in their PSE

stories will be more likely to find sexual stimuli rewarding. To test this hypothesis, we

used an operant conditioning paradigm based on the Differential Implicit Learning Task

(DILT) (Schlutheiss et al., 2005). Our modified DILT required participants to track a

cursor that appears in specific locations on a computer screen. The sequence of the

locations where the cursor appears can be programmed to be either random or fixed.

Participants can be trained on fixed sequences by using operant rewards, in the form of

pictures. Based on the accuracy of a participant's performance, the sequences can be

followed by a neutral picture or a sexual picture. During extinction, the pictures are

removed from the end of the sequences and performance on random trials versus fixed

trials can be computed as a measure of the rewarding nature of sexual stimuli. The DILT

has been used successfully in the past as a validating behavioral measure of implicit

motives where those who are high in a given implicit motive will show the greatest

learning gains to earn rewards. For example, power-motivated individuals, who enjoy

interpersonal dominance, are rewarded by low-dominance stimuli as reflected by DILT

learning gains and are punished by high-dominance stimuli as reflected by DILT learning

decrements (Schultheiss et al., 2005). Due to the previously demonstrated validity of the

DILT, we believed that it would be a suitable behavioral measure with which we could

validate the coding of nSex. We hypothesized that nSex would predict improvements in

learning as a function of sexual reinforcers, relative to non-sexual reinforcers. In other

words, the more sexually motivated participants are, the better they will learn sequences

that lead to sexual stimuli.

Methods

Participants

        Participants were 49 women and 50 men, mean age 20.88 ± 0.32 years, who were

recruited through the Undergraduate Subject Pool at the University of Michigan. The

study had received prior approval by the University of Michigan Institutional Review

Board, and all participants provided informed consent.

Procedure

        During the session of approximately two hours, subjects first completed a task

unrelated to the presently reported results. Then, they completed the Picture Story

Exercise to assess their implicit motives (Smith, 1992; Winter, 1994). Participants then

completed the Differential implicit learning task (DILT; Schultheiss et al., 2005), which

is described below, and awareness tasks related to the DILT. Lastly, they completed a

few tasks unrelated to the presently reported results as well as a demographic information

questionnaire.

Implicit motives

        Implicit motives were assessed by having participants write an imaginative story

about each of eight PSE pictures chosen to pull for nSex without overtly depicting sexual

acts. For all participants, each of the first 4 PSE pictures was primed with three

successive presentations of 60 ms visual mask stimuli (jumbled pictures). Participants

were randomly divided into two groups for their last 4 PSE stories: mask primes (control)

and sexual primes (manipulation), which were presented as three successive 60ms

unmasked primes preceding the PSE pictures. Sexual priming pictures were from the

International Affective Picture Set (picture numbers: 4611, 4651, 4652, 4656, 4658, 4664, 4669, 4670, 4672, 4677, 4690, 4800, 4810) (Lang et al., 1995).   All sexual priming stimuli depicted heterosexual couples engaging in intercourse, other sexual acts, or naked intimacy. The PSE pictures were presented using standard instructions and procedures described in Smith (1992).

PSE stories were coded for power, affiliation, and achievement motivation imagery by a trained coder using Winter's (1994) Manual for Scoring Motive Imagery in Running Text (cf. Winter, 1991). According to the manual, power motive imagery is coded whenever a story character acts forcefully; tries to persuade, manipulate, and influence others; elicits strong emotions in others; or shows a concern with prestige. Affiliation motive imagery is coded whenever a character shows a concern for being close to others by establishing, maintaining, or restoring a relationship; engaging in friendly, reciprocal activities; expressing positive affect about a relationship; or being sad about a separation.

Additionally, following the coding principles of Smith (1992) and Winter (1994) (see Appendices 1 & 2 and Table 1 for further coding guidelines, rules, procedures, and examples), overt sexual themes were coded in participants' stories and could be grouped into the following categories: physiological (sexual arousal), behavioral (sexual performance/ability, nudity/exposure, seduction/flirtation, sexual innuendo, forced sexual behavior), and psychological (sexual tension, fantasy, desire, negative emotions expressed due to lack of sex, confidence in the attainment of intercourse, sexual anticipation) (see Table 1 for examples and definitions of the coding categories). The

72

trained coder was blind with regard to participants' gender, experimental condition, and performance on all tasks.

On average when added together, participants' eight PSE stories were 782 ± 28 words long and contained 4.64 ± 0.31 power images, 10.32 ± 0.50 affiliation images, 1.38 ± 0.14 achievement images, and 4.78 ± 0.44 sexual images. PSE's from a subsample of participants ($N = 20$) were independently and blindly coded by a second trained coder using the same criteria for nSex to establish inter-rater reliability of the nSex coding criteria. The coding from the two trained coders was highly significantly correlated ($r = 0.91$, $p < .001$), which surpasses the inter-rater reliability requirements ($r > .85$) of the Winter (1994) coding system for nPower, nAffiliation, and nAchievement. PSE word count was significantly positively correlated with nPower scores, nAffiliation scores, nAchievement scores, and nSex scores, all of which were therefore corrected for PSE word count by converting scores to motive images per 1000 words, which were used in subsequent analysis. After conversion, PSE word count was negatively correlated with nAffiliation, but was not correlated with the other motives.

Differential Implicit Learning Task (DILT)

The DILT is an operant conditioning task featuring two fixed, color-coded, visuomotor sequences based on a task designed by Nissen and Bullemer (1987). For the DILT, subjects were required to press a key on a 4-button keypad corresponding to one of four screen locations, spread horizontally at 2.5cm intervals across the center of the computer screen, at which an asterisk (1cm diameter) could appear. They were instructed to respond as quickly and accurately as possible. Participants' responses were recorded with Millisecond Inquisit software, which can record participants' responses with

73

millisecond accuracy. During the DILT baseline and learning phases, asterisks appeared

in two fixed, maximally distinct, repeating sequences of 12 keypresses each (Sequence A

= ABDBACDCBCAD, Sequence B = BDACABCDBADC). Sequences were

differentiated by color of asterisks; thus, sequence color served as a discriminatory

stimulus. Subjects were simultaneously engaged in a distractor task (counting randomly

presented tones) with the intention of preventing conscious awareness of the sequences.

The difference between the baseline and learning phases is that the learning phases were

followed by operant stimuli based on participant performance. In the learning phase,

Sequence A was followed by presentation of a sexual stimulus if the participant

completed the sequence with 100% accuracy, with 100% accuracy defined as a

participant responding accurately for each of the 12 presentations of the asterisk stimulus

in that sequence. The same sequence was followed by a neutral stimulus if they

completed the sequence with less than 100% accuracy. On Sequence B, the contingency

was reversed so that if the participant completed the sequence with 100% accuracy, the

sequence was followed by the neutral stimulus, and if that sequence was followed by a

sexual stimulus if they completed the sequence with less than 100% accuracy. Sequence-

stimulus type pairings were held constant within subjects and counterbalanced across

subjects. After each sequence during the learning phase, sexual and neutral stimuli (sized

to 689 pixels high with varying widths) were presented dependent on participant

performance in the center of the screen for 180ms and were followed by a mask

(scrambled picture), presented for 70 ms, to stop visual processing. The inter-sequence

interval was 90ms. Sexual and neutral stimuli were taken from the International

Affective Picture Set (picture numbers:2312, 2360, 2370, 2391, 2530, 2579, 2590, 2595,

4605, 4610, 4611, 4617, 4622, 4626, 4651, 4652, 4656, 4658, 4664, 4669, 4670, 4672, 4677, 4690, 4800, 4810) (Lang et al., 1995). All sexual stimuli depicted heterosexual couples engaging in intercourse, other sexual acts, or naked intimacy. All neutral stimuli depicted two people interacting in non-sexual ways (Lang et al., 1995). During the learning phase, sequences were presented in 18 blocks with each sequence type presented 4 times in random order in each block for a total of 144 learning sequence presentations.

During the DILT extinction phase, subjects engaged in the task with no stimuli presented after the sequences. Participants performed the same two sequences on which they had previously been trained (2 blocks of "fixed" sequences A & B), as well as random sequences (2 blocks) using the same two colors of asterisks, for a total of 32 sequence presentations which were randomized. Response accuracy was recorded by the software. Following the extinction phase, subjects underwent awareness tests to examine whether they had become consciously aware of the two sequence patterns or their contingencies. Participants were asked about their beliefs about the connection between their keystrokes in the DILT and the pictures that followed the sequences during training. 74% of participants believed that their keypresses were unrelated to the nature of the pictures following the sequences. Another awareness test assessed whether participants had become consciously aware of the sequence/picture contingencies. Of all participants who completed the DILT (N = 97), only 11 were able to accurately report the nature of the sequence/picture contingencies. However, participants' awareness of the sequence/picture contingencies did not significantly moderate the presently reported results. For subsequent analyses, only participants with average accuracy scores greater than 10 correct keypresses per 12 keypress sequence were included (N = 87), which was

75

performed to filter out participants who do not pay close attention to the task and subsequently make several errors (Schultheiss et al., 2005).

Statistical analyses were conducted using SYSTAT 10 and involved regression analysis, correlation analysis, and t-tests. Descriptive statistics are reported as mean ± SEM.

Results

Priming effects on motive imagery in PSE stories

To test for changes in motivational imagery as a function of sexual priming, we created aggregate motive scores for the two sets of 4 PSE's, primed and unprimed, and both scores were computed as motive images/1000 words. In the priming condition, there was a significant increase in nSex motive imagery from unprimed ($\underline{M}$ = 5.07) to primed ($\underline{M}$ = 7.32) PSE stories; $t(59) = 2.43$, $p = 0.02$, but not for any other motive: nPower; $t(59) = -0.59$, $p = 0.56$, nAffiliation; $t(59) = -0.44$. $p = 0.67$, and nAchievement; $t(59) = -0.24$, $p = 0.81$. The increase in nSex imagery was not present in the control condition; $t(1,28) = 1.39$, $p = 0.18$.

DILT

To compute participants' learning gains based on the operant stimuli, we calculated learning scores for each sequence reinforcement contingency (Sequence A, positive reinforcement: sexual stimulus following 100% accuracy & neutral stimulus following < 100% accuracy, and Sequence B, negative reinforcement: neutral stimulus following 100% accuracy & sexual stimulus following < 100% accuracy) by subtracting log-transformed error rates on fixed sequences from log-transformed error rates on

random sequences in the extinction phase, such that a higher difference score indicates improved learning via greater accuracy on that sequence. This yielded two learning scores, one for positive reinforcement by the sexual stimulus and for negative reinforcement by the sexual stimulus (see Table 2). These two learning scores were significantly different at the trend level for all participants, with the positive reinforcement difference score being significantly higher than the negative reinforcement difference score: $t(86) = 1.76, p = 0.08$.

We then tested for effects of motive dispositions on implicit learning. To do so, we created implicit learning difference scores by subtracting the learning scores from negative reinforcement sequences from learning scores on positive reinforcement sequences. The greater the difference score, the greater the reinforcing influence of the sexual stimulus for both positive and negative reinforcement. Regression analysis revealed a highly significant, positive correlation between implicit learning (as reflected by participants learning difference scores) and aggregate nSex scores from all PSE stories (motive images/1000 words): $F(1, 72) = 6.62, r = 0.29, p = 0.01$ (see Figure 1), but not with nPower scores: $r = 0.14, p = 0.24$; nAffiliation scores: $r = 0.10, p = 0.39$; or nAchievement scores: $r = 0.04, p = 0.73$. To confirm that the results with nSex were robust, we also also ran the analyses on square root-transformed nSex scores given the presence of high-leverage cases in the analyses using nSex images/1000 words. Again, regression analysis revealed a significant, positive correlation between implicit learning and nSex scores: $F(1, 72) = 4.70, r = 0.25, p = 0.03$ (see Figure 2).

We then repeated the nSex and learning analyses separately for men and women, which revealed a highly significant, positive correlation between implicit learning (as

reflected by participants learning difference scores) and nSex scores in men: $F(1, 36) =$ 13.87, $r = 0.53$, $p = 0.001$, but not in women: $F(1, 29) = 0.03$, $r = -0.03$, $p = 0.87$ (see Figure 3). We also repeated these analyses with square root-transformed nSex scores, and also found a significant, positive correlation between implicit learning and nSex scores for men: $F(1, 36) = 6.47$, $r = 0.39$, $p = 0.02$, but not in women: $F(1, 29) = 0.41$, $r = 0.12$, $p = 0.53$ (see Figure 4). Correlations between all motives and learning scores are shown in Table 2.

Discussion

Our hypothesis that we could code nSex in participants' PSE stories was confirmed. Participants wrote stories that were rich in sexual imagery, which we were able to code, categorize, and quantify into nSex motivational scores for each participant. In doing so, we coded overt descriptions of sex, including descriptions of behavior, physiology, and psychology related to sex. In the few studies that attempted to code sexual imagery in PSE stories decades ago, few participants wrote overtly about sex (Clark & Sensibar, 1958). Our sample, which principally consisted of collegiate undergraduates, was seemingly far less inhibited. We speculate that modern social mores do not frown upon open perspectives regarding sex thus leading to participants being less guarded in the content of their PSE stories. Additionally, it is notable that nSex was not related to any other implicit motive, which suggests that psychometrically it represents a distinct motivational need.

Our hypothesis that the quantity of nSex imagery in PSE stories would be subject to sexual priming stimuli was also confirmed. In the priming group, nSex imagery in

participants' PSE stories was significantly increased as an effect of the sexual primes. This suggests that nSex operates in a similar manner to nPow, nAff, and nAch, all of which can be aroused via arousal by motivational cues and situations (cf. McClelland, 1987; Schultheiss, in press). The ability for a motive to be aroused by relevant stimuli was a critical criterion in the early development of implicit motive measures (McClelland et al., 1953). Importantly, only nSex imagery was increased by the sexual primes; the quantity of motivational imagery for nPow, nAff, and nAch were unaffected by the sexual primes. The evidence that nSex is affected by sexual priming converges with other studies which have shown that sexual primes and stimuli can elicit emotional responses, approach behavior, and memory facilitation for sexual material (Janssen & Everaerd, 1993; Spiering et al., 2003). Importantly, sexual primes have been principally documented to drive implicit processes, where the participant is unaware or not in control of the effect facilitated by the primes, such as early signs of penile erection in men (Janssen et al., 2000).

Our effort to predict a criterion behavior with nSex was also successful. We hypothesized that those high in nSex would be more likely to find sexual pictures rewarding and to have their behavior shaped by those rewards, and this was confirmed. First, we found a main effect of reinforcement type where the reinforcing effect for positive and negative reinforcement sequences was significantly different. Further, when using implicit learning scores that accounted for both positive and negative reinforcement, DILT performance was positively related to nSex levels, which means that those participants who had the highest levels of nSex showed the greatest learning changes in response to sexually rewarding stimuli. Our confidence in this result was

79

bolstered by its robustness while using 2 different techniques to correct for the positive correlation between the frequency of sexual themes in PSE stories and PSE length.

When we parsed the implicit learning result as a function of participants' gender, we found that the implicit learning effect was extremely strong in men. Men who were high in nSex showed the greatest reinforcement by sexual stimuli. When including only women in the analysis, there was essentially no relationship between nSex and implicit learning. Past research has shown that men respond more strongly to visual sexual stimuli than do women. For example, Hamann and colleagues (2004) showed that men showed greater brain activation in substrates broadly related to sex than did women when viewing erotic stimuli. Men also rank visual information as being more important in selecting a partner than do women (Herz & Cahill, 1997). In some ways, our results corroborate past research that showed men to be more motivated by sexual stimuli. However, our results do not simply point toward a main effect of gender, but actually point toward an interactive effect of gender and motivation. In future work, it would be worthwhile to explore different reinforcement stimuli that might be more effective for women.

The presently reported DILT results are aligned with earlier studies using the DILT, which demonstrated that visual incentives drive implicit learning in ways that are strongly moderated by individuals' implicit motives (Schultheiss et al., 2005). Moreover, this study adds more support to the argument that implicit motives drive behaviors and physiological responses that operate without conscious awareness or control, which has been demonstrated in a host of different studies (Schultheiss, 2001, Stanton et al., in press). For example, not only do implicit motives predict implicit learning, they also

predict attentional orienting, pavlovian conditioning, and nonverbal communication styles (Schultheiss & Hale, 2007, Schultheiss & Brunstein, 2002, Stanton et al., 2006).

While we believe that the present research suggests that nSex is a valid measure, we were limited to predicting a single criterion behavior. Future research could explore the predictive validity of nSex for other behaviors, like sexual frequency, or measures of physiology like sexual arousal or hormonal response to sexual stimuli. Moreover, future work could examine the relationship with between implicit sexual motivation and explicit measures of sexual motivation in an effort to determine if they are related and the degree to which one is more effective in predicting criterion behaviors. Future studies could also employ other classes of sexual stimuli (i.e. video and audio clips of sexual activity, varying levels of sexually explicit pictures) to examine the change in quantity and quality of nSex themes aroused by alternative manipulations. In this study, nAffiliation was the most highly-present motive across all participants' PSE stories, which suggests that PSE pictures with more overt sexual cues could be employed in an effort to draw principally sexual themes in participants' PSE stories. Through the use of different priming stimuli and PSE pictures, coding categories for nSex might emerge that were not captured in the present research. Another possibility for future research is to study the extent to which different populations would write nSex themes into their PSE stories. Despite being an implicit measure, it is plausible that some participants for whom open discussion of sex is not socially acceptable would override any aroused implicit motivation and simply not write about sex under any circumstances. Thus, to further establish the validity of nSex coding, other populations, such as those of different age groups, religious affiliations, and levels of conservatism should be assessed.

To conclude, we found that nSex can be coded from participants' creative stories. We also found that nSex is sensitive to priming via visual sexual stimuli. Lastly, we found that participants levels of nSex were positively related to implicit learning reinforced through visual stimuli.

Figure 4-1

Correlation of implicit sexual motivation (*in images per 1000 words*) and implicit learning (log-transformed error scores, where positive scores indicates greater learning as an effect of the sexual stimulus versus neutral)

Figure 4-2

Correlation of implicit sexual motivation (*square root-transformed from raw scores*) and implicit learning (log-transformed error scores, where positive scores indicates greater learning as an effect of the sexual stimulus versus neutral)

Figure 4-3

Correlation of implicit sexual motivation (*in images per 1000 words)* and implicit learning (log-transformed error scores, where positive scores indicates greater learning as an effect of the sexual stimulus versus neutral) **split by gender:** men are represented by the x symbol and the dashed line, and women are represented by the o symbol and the solid line.

Figure 4-4

Correlation of implicit sexual motivation (*square root-transformed from raw scores*) **and implicit learning** (log-transformed error scores, where positive scores indicates greater learning as an effect of th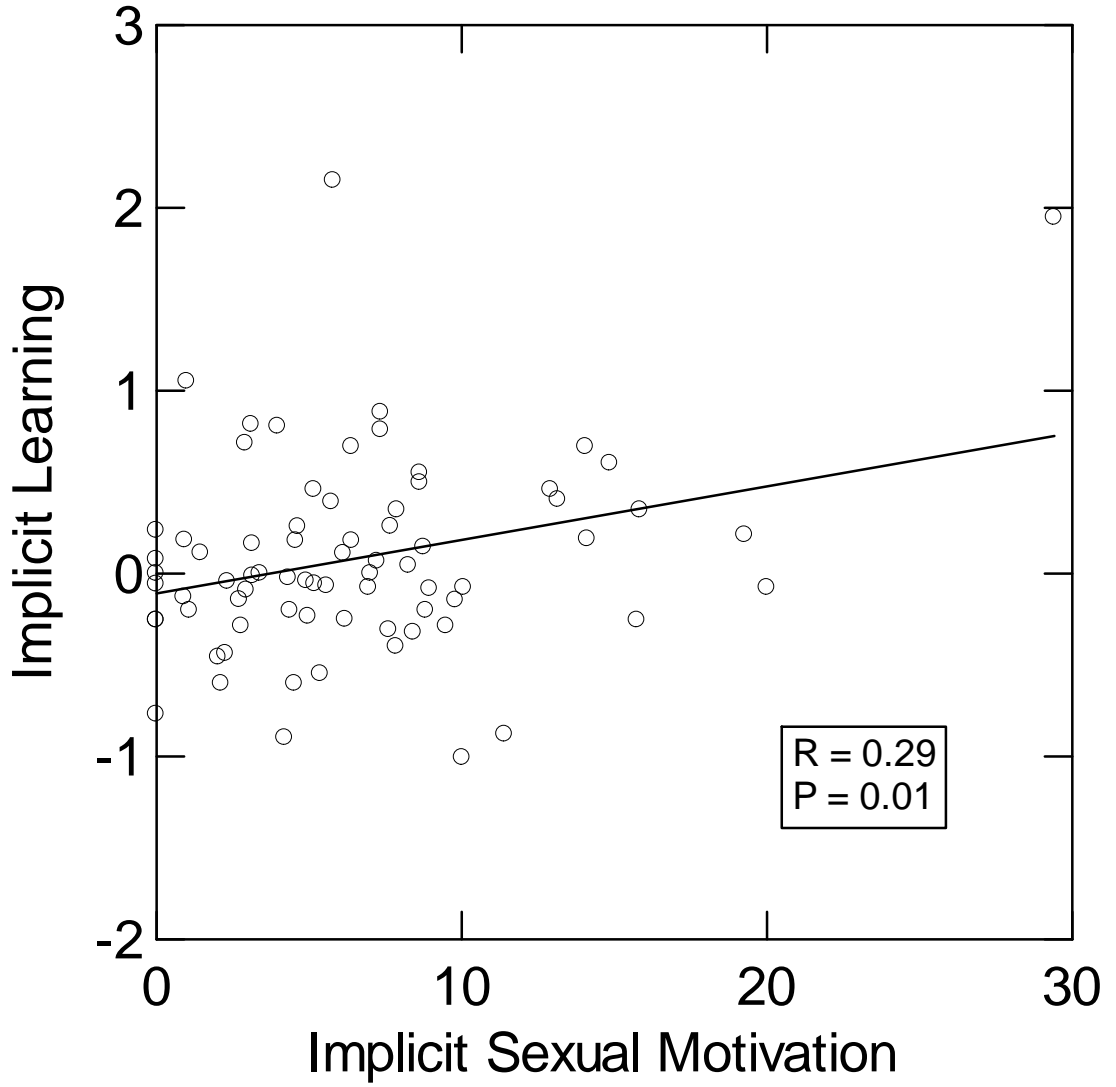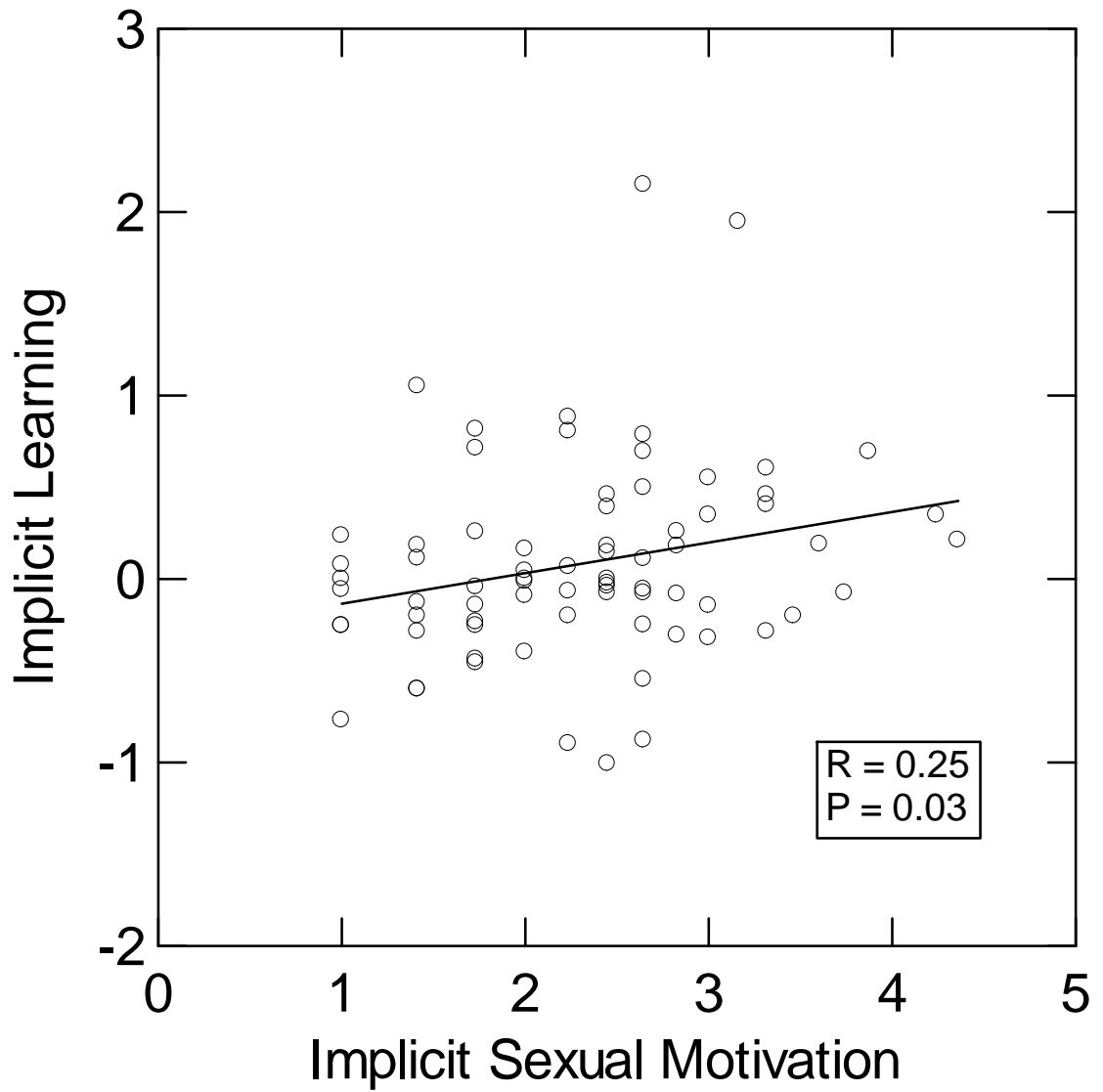e sexual stimulus versus neutral) **split by gender:** men are represented by the x symbol and the dashed line, and women are represented by the o symbol and the solid line.
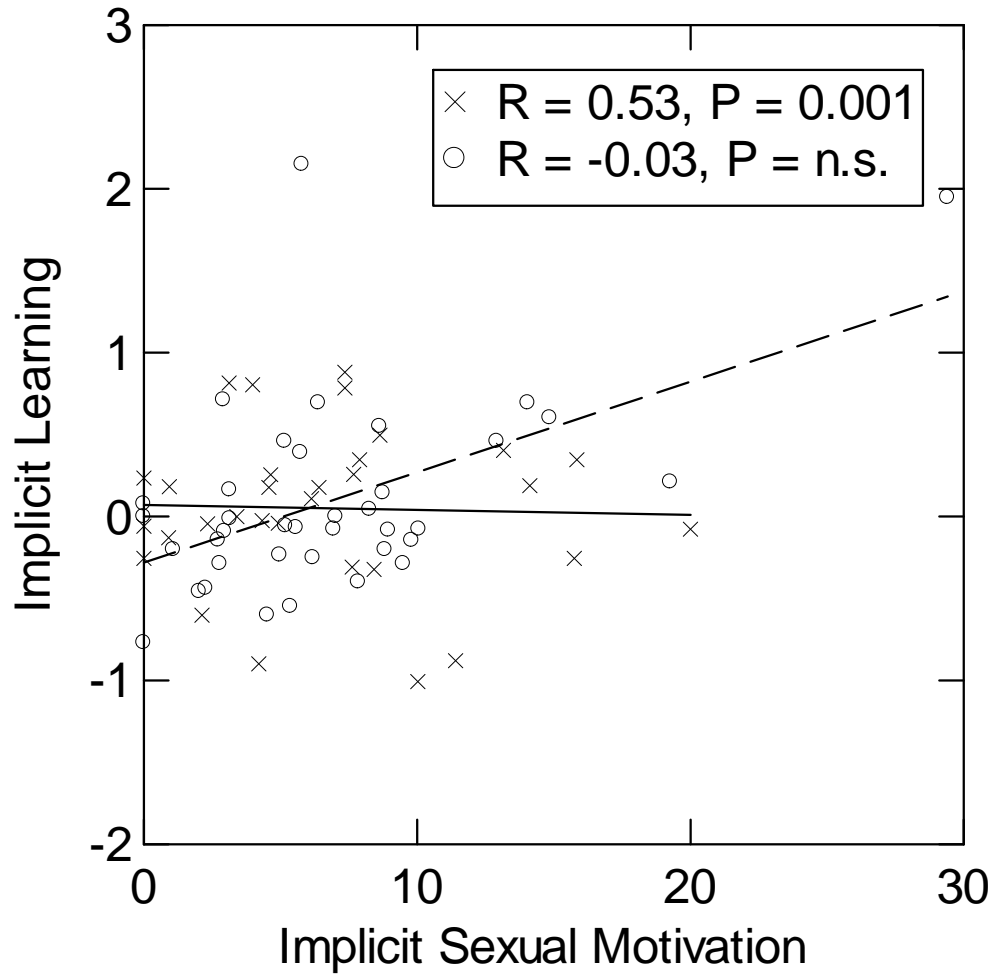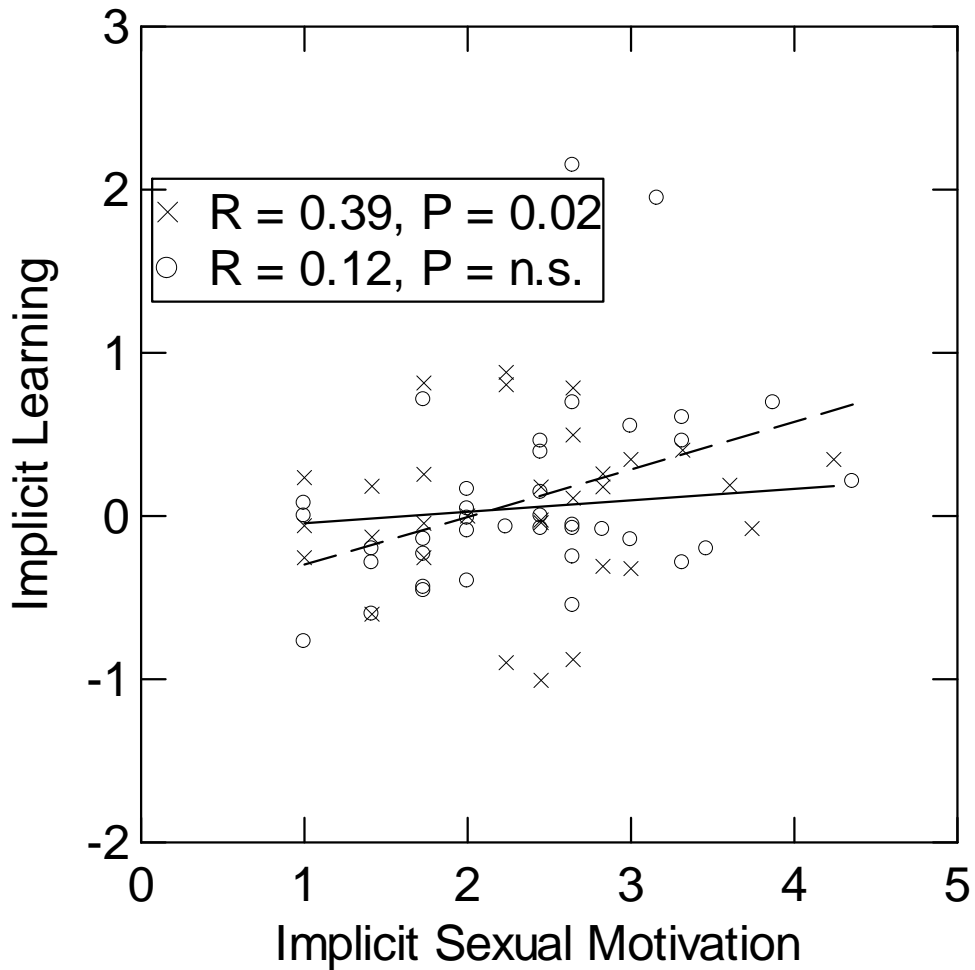
Table 4-1

Coding categories for nSex with accompanying definitions (in italics and parentheses) and examples (in quotes) taken from participants' PSE stories

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Behavioral

Sexual acts (*descriptions of physical sexual interactions*)
o "Eventually they get so wild that they have no choice but to strip clothes and make love."
Nudity/exposure (*descriptions of individuals without clothing*)
o "…the woman is stripping and trying to seduce the guy."
Seduction/flirtation (*descriptions of arousing sexual desire in others*)
o "The woman is standing in such a way, as to pose sexually, or tease the man."
Sexual innuendo (*descriptions of sexually suggestive comments*)
o "Here Annie is covering her client's eyes to cue him to the erotic nature of the painting she's about to show him."
Forced sexual behavior (*descriptions of people forced to have sex against their will*)
o "…and is tying up the man for a little dominatrix fun."

Physiological

Sexual arousal (*descriptions of physical sexual arousal*)
o "The man looks to be aroused…"
Physical descriptions of sex (*descriptions of anatomical sexual interaction*)
o "He thrust his penis into her..."

Psychological

Sexual tension (*descriptions of awkwardness regarding sexual interactions*)
o "After some funny episodes of awkwardness, they were finally able to meet each other's needs and desires."
Fantasy (*descriptions of imagining sexual scenarios or exchanges*)
o "…sexual thoughts and emotions are running through his mind."
Desire (*descriptions of wanting to have sexual interactions with another*)
o "His expression says that he might want some sexual activity…
Negative emotions expressed due to lack of sex (*descriptions of individuals who feel remorse for their lack of sexual activity or tension lack of sexual activity places on a relationship*)
o "They particularly had had trouble in the love making department, and had seen a marriage counselor for help."
Confidence in the attainment of intercourse (*descriptions of individuals feeling that they are likely to attain sexual acts with another*)
o "The major is feeling pretty lucky because he's going to get laid…"

Table 4-2

Correlations between implicit motives (images per 1000 words) and measures of implicit learning

	1	2	3	4	5	6	7	M	SEM
1: nSex	-							6.55	0.62
2: nPower	0.12	-						5.87	0.38
3: nAffiliation	0.13	-0.05	-					13.37	0.89
4: nAchievement	-0.07	0.09	-0.07	-				1.63	0.17
5: Positive Reinforcement (Δ Error)	0.06	-0.08	0.02	0.15	-			0.19	0.04
6: Negative Reinforcement (Δ Error)	-0.32**	-0.24*	-0.12	0.08	0.10	-		0.09	0.05
7: Differential Learning	0.29**	0.14	0.10	0.04	0.62***	-0.72***	-	0.11	0.06

P-values
* ≤ .05
** ≤ .01
*** ≤ .001

Appendix 4-1

Rules and procedures for coding nSex in PSE stories.

  The coding procedures were either taken directly from or adapted from Winter (1994), which were heavily influenced by prior motivation coding systems (cf. McClelland, 1987).   The following text is taken in pieces directly from Winter (1994; pp. 1-28) (mostly with relevance to power motivation as an example) and applies to the coding of nSex:

  "Definition of Motive Imagery

  In general, a motive image is an action (past, present, future, or hypothetical), a wish or concern, or some other internal state which any speaker (writer, character in a [PSE] story or drama, author of a literary work, group, institution, or impersonal entity or abstraction that is personified) attributes to people in general.

  Certain conventions and scoring rules apply to scoring motive imagery. You should be careful to base your scoring decisions upon the exact content of what is written or said. You can use the context to understand the meaning of a word or phrase, but you should avoid deeper intuitions or inferences about what the author of the material might have meant or should have said. In general verbal content should be taken seriously and literally. Phrases, slogans, or other material quoted from other sources should be scored just as if it were original. However, titles of books, laws, political programs, and so forth are an exception to this rule.

  Negations and Questions

  <u>Motive images that are denied or negated are not scored.</u> Motive images that are denied, either by the word "not' or (more hypothetically) by reference to a moral standard that restrains the actor or negates the action, are not scored. On the other hand, a moral standard characterizing an action that has already taken place does not negate it.

  Motive imagery in the form of questions is a little more complicated. First, motive imagery in simple questions is not scored. On the other hand, images in hypothetical statements ("if…then…"), instrumental questions ("how to" as opposed to "whether"), and rhetorical questions are scored for motive imagery, even when they are used to elaborate a denial.

  These rules and conventions are designed to distinguish weak cases where a motive image is merely mentioned, or mentioned only to be denied, from stronger cases where the speaker or writer endorses the image or is preoccupied with it. These particular rules given here may seem arbitrary and arguable. (Many psychoanalytic theorists, for example would ignore details and negations). However, the present scoring conventions were developed by identifying the categories of verbal imagery that actually change as a result of motive arousal.

Use of the Context

In general, scoring decisions should be based on actual words or phrases, keeping intuitions, inferences and embellishments from other parts of the story, or on the basis of the broader story context, to a minimum. However, the context can be used to "deconstruct" or figure out the precise meaning (that is, the denotative meaning) of a particular word or phrase that would otherwise be ambiguous.

When the running text scoring system is applied to written text of any kind the individual sentence is the unit for scoring motive imagery.

A single sentence can be scored only once for the imagery of any particular motive, though it can be scored for imagery of two or more different motives."

Sexual imagery is scored for any indication of sexual activity (behavioral, psychological, and physiological). Such standards are expressed in the forms described in Table 4-1 and highlighted in Appendix 4-2. To create a total nSex score for a given participant, first you sum the nSex images in each story. Then you sum the total nSex images for all stories that the participant wrote to yield an aggregate nSex score for that participant. Positive correlations between PSE story word count and nSex imagery can be corrected by using nSex images/1000words, z-score and square-root transformations of nSex aggregate scores. The resulting transformed scores are suitable for analysis.

Appendix 4-2

Example PSE stories selected to demonstrate the coding of nSex. Each story is presented twice, as it was coded by the two different trained coders. Examples 1-5 are exemplars of PSE stories that have low or nonexistent levels of sexual imagery, and examples 6-10 are exemplars of PSE stories that have high levels of sexual imagery. The highlighted words are the sections coded for sexual themes by each coder based on the coding categories described in Table 4-1.

Example PSE #1 (low sexual imagery) – Coder 1

the woman in the photo is having a show of her artwork in an art gallery. the man shows up to the show and they see each other from afar and become interested in eachother. the man hangs around the art show, admiring the paintings until all of the other people at the showing have left. while this is happening the woman is busy greating the people who come but keeps getting distracted by the man. after everyone is gone the man approaches the woman and they hit it off. this is a game that the woman wanted to play ==to seduce him==.

Example PSE #1 (low sexual imagery) – Coder 2

the woman in the photo is having a show of her artwork in an art gallery. the man shows up to the show and they see each other from afar and become interested in eachother. the man hangs around the art show, admiring the paintings until all of the other people at the showing have left. while this is happening the woman is busy greating the people who come but keeps getting distracted by the man. after everyone is gone the man approaches the woman and they hit it off. this is a game that the woman wanted to play ==to seduce him==.

Example PSE #2 (low sexual imagery) – Coder 1

this is a couple who have been together for a while. last week, the guy asked her parents for their daughters hand in marriage. when they said yes, he asked his girlfriend out to a special dinner. he told her it was to celebrate something he did at work. all week the woman's mother kept calling her and acting weird and she couldn't figure out why. that night the couple got dressed up and went to dinner. the woman doesn't know what is comming and she is innocently listening to the musician and relaxing with her boyfriend. the boyfriend is nervous and anticipating asking her to marry him. after the musician leaves, he gets down on one knee and asks her to marry him. she agrees

Example PSE #2 (low sexual imagery) – Coder 2

this is a couple who have been together for a while. last week, the guy asked her parents for their daughters hand in marriage. when they said yes, he asked his girlfriend out to a special dinner. he told her it was to celebrate something he did at work. all week the woman's mother kept calling her and acting weird and she couldn't figure out why. that night the couple got dressed up and went to dinner. the woman doesn't know what is comming and she is innocently listening to the musician and relaxing with her boyfriend. the boyfriend is nervous and anticipating asking her to marry him. after the musician leaves, he gets down on one knee and asks her to marry him. she agrees

Example PSE #3 (low sexual imagery) – Coder 1

Jenny and Jim had an odd marriage. Jim was away on business quite often, leaving Jenny home alone to entertain herself. One such trip happened to come up over Valentine's day, and Jenny was devastated. "One more romantic night.. spent alone," she thought. She went out and bought a half gallon of ice cream to help deal, and plopped in front of the TV in nothing but a tank top and undies. Suddenly, there was a rattling at the door. She looked, extremely frightened, as a man walked through the door. But, incredibly, it was none other than her husband Jim, with a huge boquet of flowers in his hands. He had told her he would be gone an extra day, just so that he could come home and surprise her. ==They quickly became intimate==, something they hadn't done in quite some time. They joked around and p

Example PSE #3 (low sexual imagery) – Coder 2

Jenny and Jim had an odd marriage. Jim was away on business quite often, leaving Jenny home alone to entertain herself. One such trip happened to come up over Valentine's day, and Jenny was devastated. "One more romantic night.. spent alone," she thought. She went out and bought a half gallon of ice cream to help deal, and plopped in front of the TV in nothing but a tank top and undies. Suddenly, there was a rattling at the door. She looked, extremely frightened, as a man walked through the door. But, incredibly, it was none other than her husband Jim, with a huge boquet of flowers in his hands. He had told her he would be gone an extra day, just so that he could come home and surprise her. They quickly became ==intimate==, something they hadn't done in quite some time. They joked around and p

Example PSE #4 (low sexual imagery) – Coder 1

John and Rebecca have worked together for a few months at a bank in Chicago. They were always friendly to one another, but neither ever seemed to be interested in more than that. One day, Rebecca was headed home from work on the L-train when it suddenly broke down. Stranded in a place where she knew no one, she nervously searched for a place to go. She entered a restaurant and was told that there were no tables left and even fewer seats. When she asked what it mattered about seats, they responded to her that they had been seating people at the same tables because so many people were stranded in the area from the subway. She was hungry, and therefore agreed to be seated with another person. Nervously, she approached the table, and realized that it was a man sitting there. Awkwardly realizing

Example PSE #4 (low sexual imagery) – Coder 2

John and Rebecca have worked together for a few months at a bank in Chicago. They were always friendly to one another, but neither ever seemed to be interested in more than that. One day, Rebecca was headed home from work on the L-train when it suddenly broke down. Stranded in a place where she knew no one, she nervously searched for a place to go. She entered a restaurant and was told that there were no tables left and even fewer seats. When she asked what it mattered about seats, they responded to her that they had been seating people at the same tables because so many people were stranded in the area from the subway. She was hungry, and therefore agreed to be seated with another person. Nervously, she approached the table, and realized that it was a man sitting there. Awkwardly realizing

Example PSE #5 (low sexual imagery) – Coder 1

Today was probably the luckiest day of Ted's life. Everything was going absolutely flawlessly. He was performing exceptionally well at work and at the end of the day he found out that he was promoted to division leader. Acting as though everything went horribly wrong he surprised his wife with the good news. They immediately felt it necessary to celebrate by ==taking off their clothes and having a sort of celabratory sex==

Example PSE #5 (low sexual imagery) – Coder 2

Today was probably the luckiest day of Ted's life. Everything was going absolutely flawlessly. He was performing exceptionally well at work and at the end of the day he found out that he was promoted to division leader. Acting as though everything went horribly wrong he surprised his wife with the good news. They immediately felt it necessary to celebrate by taking off their clothes and having a sort of ==celabratory sex==

Example PSE #6 (high sexual imagery) – Coder 1

A man is sitting in a chair holding his hands behind his head, while a woman in a dark dress is standing in front of him. The man has a blank look on his face, but it is evident that ==sexual thoughts and emoitions are running through his mind.== the woman is standing in such a way, as to ==pose sexually, or tease the man==. Next, they will probably ==exgage in sexual manor==

Example PSE #6 (high sexual imagery) – Coder 2

A man is sitting in a chair holding his hands behind his head, while a woman in a dark dress is standing in front of him. The man has a blank look on his face, but it is evident that ==sexual thoughts and emoitions are running== through his mind. ==the woman is standing in such a way, as to pose sexually, or tease the man==. Next, they will probably exgage in ==sexual manor==

Example PSE #7 (high sexual imagery) – Coder 1

A man and woman are hugging each other in what seems to be either snow or water. The woman looks very ==seductive==. The man ==looks to be eroused and is giving the expression that he wants things to escalate to something higher==. There is no doubt both our feeling a sense of intimacy. The man and woman will ==most likely continue on with the foreplay== and then began to romanticly start to kiss.

Example PSE #7 (high sexual imagery) – Coder 2

A man and woman are hugging each other in what seems to be either snow or water. The woman looks very ==seductive.== The man looks ==to be eroused and== is giving the expression that he wants things to escalate to something higher. There is no doubt both our feeling a sense of intimacy. The man and woman will most likely continue on with ==the foreplay and== then began to romanticly start to kiss.

Example PSE #8 (high sexual imagery) – Coder 1

The man is sitting on a dome shaped chair with the ==woman trying to seduce him==. It is not shown in the picture fully but it looks like the woman is ==stripping and trying to seduce the guy.== I came to this conclusion by the way the man is sitting and his posture. The glass floor reflects his shoes and it looks to be very shinny. Outside it seems the view of the sky. The male actor in this scene seems to be having a good time, looking at his female counterpart. His expression says that ==he might want some sexual activity== from the woman. While there is not much evidence to show about the female. Next they might ==engage in sexual activity==.

Example PSE #8 (high sexual imagery) – Coder 2

The man is sitting on a dome shaped chair with the woman trying to ==seduce him==. It is not shown in the picture fully but it looks like the woman is stripping and trying to ==seduce the guy.== I came to this conclusion by the way the man is sitting and his posture. The glass floor reflects his shoes and it looks to be very shinny. Outside it seems the view of the sky. The male actor in this scene seems to be having a good time, looking at his female counterpart. His expression says that he might want ==some sexual activity== from the woman. While there is not much evidence to show about the female. Next they might engage in ==sexual activity==.

Example PSE #9 (high sexual imagery) – Coder 1

==The young lovers fought playfully on their hotel bed==. They'd just come into Paris the night before, and they weren't ready to go out and start sightseeing yet for their honeymoon. All they wanted right then was to spend time together with each other. After a few more whacks of the pillow, she lay down next to him, laughing. He looked over to her and smiled, then rolled over on top of her. She grinned up at him as he leaned down to kiss her. She embraced him passionately and pulled him close. ==He tore off her clothes and she pull his boxers off. He thrust his penis into her and she moaned with joy. His hands moved up her body, grabbing her breasts.==

Example PSE #9 (high sexual imagery) – Coder 2

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Example PSE #10 (high sexual imagery) – Coder 1

This is a first date and ==the girl want to seduce the man== so she can ruin his career. The guy is the major of his town and "happily" married. This women's friend was ==used by tthe major for sex and== her life ruined. This girl wants the major to understand what it feels like to be used. They had a good night out at a bar where the major try to get the women drunk but she only pretend to drink the drinks. she acted drunk and invite him back to her place.   The major is ==feeling pretty lucky cause he's going to get laid== and the women is statisfied becuase everything is going according to the plan. The women will take the pictures and ruin his career and his wife will leave him.

Example PSE #10 (high sexual imagery) – Coder 2

This is a first date and the girl want ==to seduce the== man so she can ruin his career. The guy is the major of his town and "happily" married. This women's friend was used by tthe ==major for sex== and her life ruined. This girl wants the major to understand what it feels like to be used. They had a good night out at a bar where the major try to get the women drunk but she only pretend to drink the drinks. she acted drunk and invite him back to her place.   The major is feeling pretty lucky cause he's going to ==get laid and== the women is statisfied becuase everything is going according to the plan. The women will take the pictures and ruin his career and his wife will leave him.

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Chapter 5

Conclusion

This thesis has offered insights into relationships between motivation, biology, and behavior that expand upon past research in a variety of ways. In this concluding chapter, I would like to review the core findings of the studies, describe limitations of the present research and future directions that could address those limitations, and also comment on the individual differences approach that ties the three studies together.

The first study extended past work on testosterone and dominance, by examining the moderating effects of testosterone at the level of the brain in response to dominance stimuli. While there had been considerable evidence positively linking testosterone and dominance pursuit, there was little evidence addressing how testosterone moderates responses to dominance challenges from others (Mazur & Booth, 1998). Moreover, there was essentially no evidence looking at how testosterone acts at the level of the brain to drive differential neural responses to dominance challenges. The first study provided evidence suggesting that differing levels of testosterone moderate brain activation in the amygdala, a substrate linked to the perception of threats in one's environment.

The second study proposed a new model for the biology of dominance in women, by showing that estradiol and not testosterone is linked to dominance motivation and responses to dominance contests in women. The studies of the endocrinology of human dominance have historically used male subjects and the hormone testosterone, but the male model positively linking testosterone and dominance failed to apply to women despite several attempts (Mazur & Booth, 1998). Based on past research in animals, I hypothesized that estradiol, which has a role in dominance behavior in female mammals, would have a role in dominance motivation in women. I found two relationships that conceptually parallel work using males and testosterone. Namely, estradiol and dominance motivation are positively linked, and estradiol levels change in response to winning and losing dominance contests as a function of individuals' dominance motivation.

The third and final study successfully measured implicit sexual motivation indirectly through coding sexual themes in participants' creative stories. I found that this new measure demonstrated criterion validity by predicting a measure of operant learning that used visual sexual rewards. In the tradition of implicit motive research, the measure also showed sensitivity to priming via sexual pictures.

Limitations, innovations, and future directions

A limitation that is shared to some extent by all three studies is the inability to confirm causal links between independent and dependent variables. The second and third studies had aspects of experimental manipulation but principally relied upon correlational analysis. Future work could overcome this limitation through complementary work using experimental manipulations of steroid hormone levels or motivational states. In

motivation research, the preferred use of correlational versus experimental manipulation approaches is a central issue of debate, and experimental manipulations are not without their limitations too. By using experimental manipulations, one can try to isolate the effects of a biological factor, like a steroid hormone, or a psychological factor, like power motivation. Yet, motivational and biological states vary between individuals independently of any manipulations, and these variations can moderate the effect of a manipulation on an individual, as was seen in study two of this thesis. Experimental manipulation studies rarely consider how their manipulations affect individuals based on their baseline biological and psychological factors, but would benefit from such consideration moving forward. Despite the limitations of each approach, when used in conjunction, they can provide the clearest understanding of the relationships between motivational processes, their causal components, and related behaviors.

While the first study in this thesis, which linked brain activation and testosterone levels, offered a significant piece of new evidence, this line of research could still be expanded in several ways. The study was limited to correlational analysis, where experimental manipulation of testosterone levels while perceiving dominance signals would allow for greater assertions of causality. Moreover, one could also combine the merits of individual differences and experimental manipulation approaches by first looking at main effects of testosterone administration on brain responses to dominance signals, and then one could examine the extent to which endogenous testosterone levels affect the changes driven by testosterone administration. In other words, what is the direct effect of testosterone, and does testosterone administration effect people differently depending on their baseline levels of testosterone? Despite its limitations, the first study

in this thesis is unique and innovative, because studies in humans that attempt to tie together behavioral endocrinology and neuroendocrinology are the rarity. Future research in humans that attempts to combine these bodies of knowledge could provide new insights into the interactive effect of steroid hormones and social signals on the psychoneuroendocrine processes of dominance behavior.

Future extensions of the first study could also include varying the nature of the dominance stimuli as well as examining the roles of other steroid hormones. The first study was also limited by using only a single type of dominance stimulus, facial expressions of anger. Future work could use different stimuli in an effort to pinpoint exactly what aspects of dominance stimuli drive brain activation differences as a function of testosterone levels. It also would be intriguing to examine, based on the findings of the second study, if the effects of endogenous estradiol in women parallel the effects of endogenous testosterone in men. If so, we would then have evidence linking estradiol to patterns of neural activation in response to dominance challenges in women, in addition to dominance motivation and responses to dominance contests.

The second study of this thesis was unique and innovative in several ways. This study was methodologically innovative, because it demonstrated that when using salivary estradiol as an independent variable, measurement error should be considered as a moderator. With regard to experimental approaches, future studies could employ experimental manipulations of estradiol levels in laboratory settings to more directly test questions regarding the causal link between estradiol and dominance in women. The second study was also the first study of its kind to show that estradiol levels change in response to dominance contests, by using a method that employed both experimental

104

manipulation and individual difference approaches. Stemming from the unique estradiol changes finding, this work also raised questions about exactly how estradiol concentrations can change rapidly in response to social interactions. Once, again there is excellent animal research that has mapped out the biology of testosterone change in social interactions (Sapolsky, 1987), but there is essentially no research looking at mechanisms of rapid estradiol change in females. Determining the mechanisms of estradiol change would be an excellent area of research to pursue in the future, in addition to the need for replication of the presently reported results. Beyond replication of both the basal and dynamic relationships between estradiol and implicit power motivation, future research could also work toward predicting aspects of dominance behavior using estradiol levels.

The third study of this thesis innovatively addressed the problem of how to measure sexual motivation in humans. The existing problem was twofold: first, the early attempts to create an indirect, personality measure of sexual motivation were failures, and second, the existing self-report measures of sexual motivation were typically focused on specific portions of sexual physiology and did not encompass broader psychological aspects of motivation. Measuring sexual themes through participants' creative writing proved possible, making this study unique from the others in this thesis, because it offers a new method to psychology researchers. Without question, this method will need further replication and validation, but has offered promise in this initial study. While the study did use experimental manipulation of sexual motivation for PSE stories to demonstrate that visual priming arouses sexual motivation, the prediction of the criterion behavior, implicit learning, was still bound to correlational analysis. Future work could

look to arouse sexual motivation in the context of a behavioral paradigm in an effort to show that implicit sexual motivation can be aroused and that the state of arousal also drives differences in behavior.

Evolutionary perspective

To theoretically merge the studies of this thesis, I would like to put the findings of each study within an evolutionary framework. In the context of the first study, several theorists have argued that males high in testosterone have greater reproductive success which is fostered by higher dominance status and resulting access to mates (Mazur, 1985). The majority of this work focused on the pursuit and attainment of dominance, but it also showed that high testosterone individuals are more likely to maintain their dominance and are less stressed by dominance challenges (Sapolsky, 1987). On the basis of increased dominance pursuit and decreased stress responses to dominance challenges, both of which lead to greater access to mates, high levels of testosterone in males has been argued to have adaptive reproductive advantages (Mazur, 1985). From an evolutionary perspective, the benefit of being less stressed by and fearful of dominance challenges has the adaptive advantage of allowing one to maintain their dominance status, because they are less likely to flee a challenge if it is not perceptibly stressful. That perception happens in the brain, and if testosterone plays a role in that perception and behavioral response, then it should manifest itself in a perceptible difference in neural responses to dominance challenges. The first study of this thesis addressed this by providing confirmation that high-testosterone men show less amygdala activation to dominance threats. This makes it one of the first studies in humans to tie the putative male dominance hormone, testosterone, to the area of the brain where it has been shown

106

to mediate dominance behavior, in a manner that corroborates the adaptive behavioral benefits of high levels of testosterone.

The second study of this thesis also can be tied to an evolutionary perspective. Estradiol is positively associated with female sexual motivation across mammalian species (Carter, 2002). Human research has shown that women behaviorally pursue sex more in peri-ovulatory periods, which are marked by high and rising levels of estradiol (Grammer et al., 2004). Our second study showed that women high in estradiol are also more dominance motivated. It is plausible that high-estradiol women are more behaviorally dominant and that their behavioral dominance offers them greater access to mates. The combination of greater access to mates and greater sexual motivation is ideal for increased reproductive success. In that sense, high levels of estradiol can potentially be considered critical in promoting mating success through increases in dominance and sexual motivation that would coincide with times of ovulation.

The last study was very closely tied to the concept of reproductive success, in that it measured participants' sexual motivation as well as the degree to which they will learn to gain visual sexual reward. From an evolutionary perspective, the more sensitive one is to a cue that signals a mating opportunity, the greater the likelihood that said individual will have access to mating opportunities, because they are attuned to the possibility to mate by such cues. Thus, it would be of adaptive benefit for sexual cues to be salient and powerful rewards that shape individuals' behavior in a manner that would lead to greater access to mating opportunities. It follows that those who are the most sexually motivated would find sexual cues to be the most salient, a concept that holds across motives (Schultheiss & Wirth, in press). Study three showed that sexual cues are powerful

reinforcers of behavior, and that their strength is dependent on individuals' levels of sexual motivation.

The common theme: individual differences

The studies in this thesis offer fresh perspectives and measures in the biological and behavioral study of human motivation. The chapters of this thesis are linked by the common theme of individual differences. Using individual differences in motivation as predictor variables can be illuminating and more specific than only examining main effects. In the introduction of this thesis, I explained that such individual differences can manifest themselves in different ways. One manifestation is through biology, like individual differences in testosterone levels. This was the perspective of the first study on testosterone, the brain, and dominance. Another manifestation of individual differences is through personality, like implicit motives. The last two studies successfully employed this perspective in predicting both behavior and biology. Both types of individual difference moderators offer a more fine-grained analysis that looks beyond the main effect of a situation, stimulus, or chemical, by asking what factors intrinsic to an individual also play a role in the psychological process in question.

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