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BIOLOGICAL CORRELATES OF SAME SEX EROTIC FANTASY AND DATE OF
BIRTH: AN EMPIRICAL STUDY OF 2D:4D RATIOS

A Thesis Submitted to the Graduate School
in Partial Fulfillment of the Requirements
for the Degree of
Master of Science

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Pittsburg, Kansas

July, 2009

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BIOLOGICAL CORRELATES OF SAME SEX EROTIC FANTASY AND DATE OF BIRTH: AN EMPIRICAL STUDY OF 2D:4D RATIOS

An Abstract of the Thesis by
Rachel Lloyd

Based on extensive psychological and embryological research, neurohormonal theory proposes that males and females develop in sexually dimorphic patterns, in large part, because of differential androgen exposure during prenatal development (Kimmel & Weiner, 1995). Likewise, the theory suggests that variations in sexual orientation are also related to differential androgen exposure in prenatal life (Robinson & Manning, 2000). This study examined the ratio of the length of the second finger (2nd digit) relative to the fourth finger (4th digit), also referred to as 2D:4D, and its relationship to same-sex erotic fantasy. These ratios are sexually dimorphic and are a presumed correlate of prenatal androgen exposure (Manning 1998a, 1998b, 1999, 2000). In addition, many sexually dimorphic disorders show seasonal birth patterns and therefore birth seasons were investigated as a potential correlate of 2D:4D ratios (Aschauer, Meszaros, Willinger, & Reiter, 1994; Badian, 1984). Results of this study indicated that women were much more likely to report fantasizing about both sexes, compared to men, and that women had significantly greater 2D:4D ratios. This difference in fantasizing may suggest that women may experience less societal restraint than men in terms of reporting sexual orientation (Kimmel & Weiner, 1995). Results also indicated that there was a trend for 2D:4D ratios to vary according to the sexual orientation of one's fantasies. Finally, results also showed that 2D:4D ratios did not vary according to birth season. The results are discussed in the context of current knowledge regarding digit ratios.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION TO THE PROBLEM.....	1
Biological Underpinnings of Sexual Orientation.....	1
Research on Neuroanatomical Differences and Genetics.....	2
Research on Neurohormonal Theory.....	4
Prenatal Androgens and Reproductive Anatomy.....	4
Prenatal Androgens and the Brain.....	5
Prenatal Androgens and Sexual Orientation.....	11
Problematic Nature of Sex- and Gender-Related Dichotomies.....	16
Male/Female Anatomical and Gender-Related Similarities.....	17
The Sexual Orientation Continuum.....	18
Theoretical Rationale and Hypothesis.....	20
II. METHOD.....	21
Participants.....	21
Procedures and Materials.....	22
III. RESULTS.....	18
IV. DISCUSSION.....	20
Directions for Further Research.....	30
REFERENCES.....	31
APPENDIX A. Questionnaire.....	39

CHAPTER I

INTRODUCTION TO THE PROBLEM

Perhaps one of the most politically charged and emotionally heated scientific debates is that of the etiology of human sexual orientation (Byne & Lasco, 1999). Attempts to explain orientation cross disciplinary boundaries and involve a wide scope of societal institutions; therefore, arguments concerning sexual orientation are intrinsically tied to politics, religion, and the family. Currently, this little understood aspect of one's sexuality has approached the forefront of biological, psychological, and sociological research. This thesis has three purposes: (a) to discuss empirical findings regarding the biological underpinnings of human sexual orientation, in particular, prenatal androgen exposure; (b) to discuss the limitations of forming discrete and mutually-exclusive categories when investigating biological correlates of sexual orientation; and (c) to examine the relationship between the ratio of the second and fourth digit (a presumed correlate of prenatal androgen exposure) and same-sex erotic fantasy, a dimension of sexual orientation (Byne & Lasco, 1999).

Biological Underpinnings of Sexual Orientation

It is generally believed that internal biological factors and external environmental factors interact in complex ways to influence behavior and mental processes (e.g., Bem,

1997). However, in the following sections, biological correlates of sexual orientation will be highlighted. First, evidence of neuroanatomical differences across groups, as well as genetic influences on self-reported behavioral orientation will be examined. The theory currently receiving the most research attention, neurohormonal theory will also be described. In particular, the effects of prenatal androgen exposure on reproductive anatomy, brain development, handedness and spatial ability, and sexual orientation will be summarized and evaluated.

Research on Neuroanatomical Differences and Genetics

Research on differences in the brains of homosexual and heterosexual individuals has revealed that several brain structures may be different in these populations. Simon LeVay (as cited in Wilson, 2000) dissected the brains of homosexual and heterosexual men and found that a certain bundle of cells in the front of the hypothalamus was less than half as large in the brains of homosexual men as in the heterosexuals. This bundle of cells, referred to as the interstitial nucleus of the anterior hypothalamus 3 (INAH 3), is responsible for emotions and sex drives. However, Levay's research has been criticized because he examined the brains of AIDS victims. It is known that this virus has a direct impact on hypothalamic function that could possibly cause the INAH-3 to shrink. Also, some drugs, such as steroids used to treat AIDS, lower testosterone that could cause a structural change in the brain (Byne & Lasco, 1999).

In another study, Swaab and Hofman (1999, as cited in Wilson, 2000) found that the suprachiasmatic nucleus, a group of cells in the hypothalamus driving sleep cycles, is twice as large in homosexual men than in heterosexual men and women. Finally, one

study found that the corpus collosum, a structure that connects the two hemispheres and aids in relaying information back and forth, was 34% larger in homosexual males than in heterosexual males (Witelson & McCormick, 1990). Unfortunately, none of these studies has been replicated, even if this were true, it would remain unknown if these brain differences developed prenatally or during the individual's lifespan (Lalumier, Blanchard, & Zucker, 2000).

There is also some evidence that genetics may play a role in the development of sexual orientation. Pillard and Weinrich (1987) found that homosexual men were four times more likely to have gay brothers than their heterosexual counterparts. Further evidence stems from research performed by Heston and Shields (1968). They studied monozygotic twin rates of homosexuality and found concordance rates of 40%. Likewise, Bailey and Pillard (1991) found a 52% monozygotic rate and a dizygotic rate of 22%. Later, Bailey and Pillard (1993) published a similar study of lesbian women. Forty-eight percent of identical twin sisters were both lesbian, and as genetic relatedness decreased, so did the frequency of lesbianism in both sisters. For example, in fraternal twins, 16 percent were concordant, and for adopted sisters, concordance was only 6 percent. Finally, Hamer, Hu, Magnuson, Hu, and Parttatucci (1995) examined the long arm of the X chromosome (Xq28) and reported a correlation between Xq28 markers and male homosexuality. The studies involving structural and genetic differences provide some interesting data, but are largely inconclusive.

Research on Neurohormonal Theory

The biological theory that is currently receiving the most attention is the neurohormonal theory of sexual orientation (Bancroft, 1984; Hall 2000; Kimmel & Weiner, 1995). This theory focuses on hormonal events that occur during critical periods in embryological development, and posits that males and females develop in sexually dimorphic patterns, in large part, because of differential prenatal androgen exposure. Consistent with theoretical speculations, evidence suggests that: (a) prenatal androgen exposure alters reproductive anatomy producing sexually-dimorphic structures in males and females; (b) prenatal androgen exposure may influence the development of the fetal brain, giving rise to gender-related differences in cerebral lateralization, anatomical symmetry, handedness, and spatial ability; and (c) prenatal androgens may influence the development of human sexual orientation. In particular, the influence of prenatal androgens on sexual orientation may be connected to the sexual dimorphism seen in the relative lengths of index fingers to ring fingers in males and females. In the sections that follow, these lines of evidence are presented and evaluated.

Prenatal androgens and reproductive anatomy

As summarized by Kimmel and Weiner (1995), at the moment of conception, the organism's chromosomal sex is determined. Chromosomal males are "XY" and chromosomal females are "XX". However, males and females are anatomically identical for the first eight weeks or so of prenatal life; their reproductive structures are *undifferentiated* and have a *unisexual* appearance. Then, during the embryonic period in

males, a gene on the Y chromosome initiates the undifferentiated gonadal cells to develop into testes. The testes begin producing testosterone, a sex hormone that is one of the group of chemical agents known as androgens. Androgens “masculinize” the undifferentiated reproductive structures so that anatomical features, such as the penis, scrotum, prostate gland, epididymis, and vas deferens develop.

Also in the embryonic period, in females, genes on the X chromosomes initiate the undifferentiated gonads to develop into ovaries. The *absence* of androgens allows “feminization” to occur. That is, in the absence of testosterone, the undifferentiated reproductive structures develop into the vagina, uterus, fallopian tubes, and vulva. Clearly, sex hormones play a critical role in differentiating male and female bodies during prenatal development (Kimmel & Weiner, 1995).

Prenatal androgens and the brain

Classic neuropsychological research, as well as modern neuroimaging techniques, have provided extensive evidence for lateralization of function in the cerebral cortex. According to Saleh (2001), research has demonstrated that the left hemisphere operates in a linear, sequential fashion, and specializes in logical and analytical thought, as well as language. In contrast, the right hemisphere functions in a non-linear, simultaneous manner; dealing with nonverbal information like interpreting visuo-spatial cues. Saleh also suggests that brain hemisphericity operates on a continuum and is not dichotomous. In support of hemispheric lateralization, he found a significant difference between arts/literature majors and business/commerce majors, in that the former tended to be right brain dominant and the latter were skewed towards left-brain dominance.

Neuropsychological research also suggests the possibility of gender-related differences in lateralization of function. Humans are characteristically asymmetrical in structure and function. Like primates and other animals, *Homo sapiens* usually prefer one hand over the other and generally one side of the body over the other half (Babcock, 1993). Because the right side of the brain controls the left side of the body, if a person is left handed, his/her right brain is slightly dominant. The prevalence of left-handedness is greater in men, and therefore, men tend to utilize the right side of their brain in a more specialized manner (Marchant, 1996).

One of the most consistent gender-related differences in cognitive performance is that of mental rotation, a right brained task. In general, men outperform women on this test of cognitive ability. In one study, Roberts and Bell (2000) found that men had a faster reaction time on the mental rotation task than women, and during the test, men exhibited more activation than women in the parietal and posterior temporal regions of the brain.

Many lines of evidence suggest that there are gender-related differences in spatial ability (e.g., mental rotation ability), symmetry, and left-handedness. Consistent with neurohormonal theory, there is also evidence that mental rotation ability, symmetry, and left-handedness are related to prenatal androgen exposure (Burr, 1999).

One piece of evidence that mental processing is related to prenatal androgens stems from research performed on women with the intersex condition of congenital adrenal hyperplasia (CAH), a congenital condition caused by exposure to high levels of prenatal androgens (Burr, 1999). Normally activity of the adrenal gland influences cortisol, which in turn circulates to the hypothalamus and pituitary. In this classic

negative feedback system, cortisol, released by the adrenal glands, inhibits hormonal release by the hypothalamus and pituitary so that relatively constant cortisol levels are maintained. In CAH fetuses, the adrenal gland cannot manufacture enough cortisol and therefore the brain never receives the negative feedback signal. The brain, in essence, sends messages to the adrenal to produce more cortisol, and in response, the adrenal dispatches the precursors of cortisol. These precursors are converted into testosterone instead of cortisol. Prenatally, the adrenal pumps a large amount of testosterone into the female fetus's blood (Burr, 1999). The newborn will have ambiguous genitalia and internal female reproductive structures. Normally, a plastic surgeon can alter the external genitals to appear more feminine.

CAH girls display masculinized female genitals along with enhanced spatial ability and lower verbal IQ scores (Finegan, Niccols, & Sitarenios, 1992). Other studies show that CAH is associated with elevated rates of "tomboyism," aggression, and typical masculine preferences.

Likewise, prenatal exposure to diethylstilbestrol (DES), a synthetic hormone that masculinizes behavior in rats, is correlated with a masculine pattern of cerebral lateralization in human females (Finegan et al., 1992). Jacklin, Wilcox, and Maccoby (1989, as cited in Finegan et al., 1992) examined hormone levels in umbilical cord blood samples and performed a test on the children at the age of 6 years. They found statistically significant inverse relationships between testosterone levels and spatial abilities for girls, and no relationships for the boys. Finally, Finegan et al. (1992) measured prenatal androgen levels in second trimester amniotic fluid samples and found an inverse relationship between four year old girls' counting and sorting abilities and

prenatal testosterone exposure. Counting and sorting most likely involve the left hemisphere of the brain.

Some researchers propose that symmetry in the brain, or any other part of the body, reflects developmental stability, which is correlated with overall fitness for reproduction. Asymmetry may serve as a marker for the viability of an organism (Kowner, 2001). Kowner measured asymmetry in a student population and found a positive correlation between high levels of asymmetry and extreme right or left-handedness. In general, prenatal estrogen exposure tends to lead to greater symmetry, whereas exposure to testosterone appears to have the opposite effect. Testosterone, in its most extreme forms appears to create a brain that is specialized for utilizing the right and left hemispheres more independently from one another than the more “feminized” brain that better incorporates both hemispheres concurrently (Kowner, 2001).

Because many mental and developmental disabilities seem to show sexually dichotomous patterns, such as autism, reading disabilities, and schizophrenia, early androgen exposure may be one factor involved in their etiology as well (Aschauer, Meszaros, Willinger, & Reiter, 1994; Badian 1985; Castrogiovanni, Iapishino, Pacchierotti, & Peiraccini, 1998; Shelton et al., 2000; Torrey, Miller, Rawlings, & Yolken, 1997; Wilson, 2000). It is well established that most animals experience a “mating season,” and as a result, their testosterone levels show seasonal variability. This calls into question whether humans undergo similar seasonal fluctuations. If testosterone levels change annually, then it can be hypothesized that those individuals prenatally exposed to higher levels of androgen may develop more asymmetrically and thus have a greater propensity to develop certain disorders. It is no wonder, that some of the same

disabilities that show a sexually dimorphic pattern also demonstrate seasonal birth patterns. Sexual orientation in fantasies could also demonstrate a seasonal pattern that theoretically could be related to seasonal fluctuations in plasma androgen levels in the mother's body.

As the examples above illustrate, certain aspects of symmetry and handedness have been linked to prenatal androgen exposure. Now, specific characteristics of the "hand" have, as well (e.g., Manning, Scutt, & Lewis-Jones, 1998a, Manning, Scutt, Wilson, & Lewis-Jones, 1998b, Manning, Triviers, Singh, & Thornhill, 1999, Martin & Manning, 1999, Sluming & Manning, 2000, and Robinson & Manning, 2000). Researchers now know that sexual dimorphism is seen in the relative lengths of the index fingers to the ring fingers in males and females. Typically, women's index fingers are about the same length as their ring fingers (or a little shorter), but men's ring fingers are often considerably longer than their index fingers. The ratio of the length of the second finger (2nd Digit) relative to the fourth finger (4th Digit), also referred to as 2D:4D, is related to prenatal androgen exposure.

This ratio (2D:4D) may correlate with prenatal testosterone levels for many reasons. First of all, the differentiation of the digits is under the control of Homeobox (i.e., *Hox*) genes which also control the differentiation of the testes and ovaries. Because this gene organizes the digit lengths and the genital bud, researchers believe that the differentiation of the gonads likely determines finger lengths (Kondo, et al., 1997; Mortlock & Innis, 1997; Peichel et al., 1997). In addition, the finger length ratio is generally a sexually dimorphic trait (Manning et al., 1998) with males displaying longer fourth digits relative to their second digits on average than females. It is thought that the

relative digit lengths are probably set in utero around week 14 of gestation (Manning et al., 1998), and 2D:4D ratios have been found to be positively correlated with estrogen and negatively correlated with testosterone in adults.

So far, Manning and his team of researchers have discovered indications of several correlates of 2D:4D, including depression, musical ability, reproductive success, and left-handedness. Manning and Dowrick (1999, as cited in Martin & Manning, 1999) detected that the Beck Depression Index (BDI) was positively related to digit length, particularly digit four in men but not women. They controlled for the overall body size of the participant by dividing the digit length by height. Sluming and Manning (2000) tested the relationship between 2D:4D and musical ability, using 70 musicians (16 women and 54 men). They discovered that the men had significantly lower 2D:4D ratios than non-musicians. This means that they may have been exposed to greater degrees of testosterone prenatally. This finding makes sense in light of the association between musical ability and right brain dominance.

Manning et al. (1998a, 1998b) found that digit symmetry and having a low 2D:4D ratio were positively correlated with large ejaculations, increased sperm motility, more testosterone, and less estrogen in men. Significant negative relationships were discovered between 2D:4D ratios in men and reproductive success (as measured by the number of children produced) in English and Spanish samples, and significant positive associations were indicated between 2D:4D ratios in women and reproductive success in the English, German, and Hungarian samples (Manning et al., 2000). These researchers also found that a high 2D:4D ratio in a female coupled with a low 2D:4D ratio in a man met with the highest reproductive success rate. They also compared father-child pairs and discovered

a significant positive correlation of 2D:4D ratios. This finding suggests that genetic material from the father may have some influence on the development of the 2D:4D ratio (Manning et al., 2000).

Further evidence comes from the finding that the waist: hip ratio (which is thought to be a positive correlate of testosterone) of Jamaican women is negatively correlated with the 2D:4D ratio of their children. Therefore, women with high testosterone generally produce children who have theoretically experienced high testosterone prenatally (Manning et al., 1999). Not surprisingly, left-handedness has also been associated with low 2D:4D ratios (Manning et al., 2000).

Prenatal androgens and sexual orientation

Based on extensive psychological and embryological research, neurohormonal theory proposes that males and females develop in sexually dimorphic patterns, in large part, because of differential androgen exposure during prenatal development. Likewise, the theory suggests that variations in sexual orientation are also related to differential androgen exposure in prenatal life (Byne & Lasco, 1999).

Many animal studies have explored the relationships between prenatal hormone exposure and sexual behavior. One of the earliest studies was performed on monkeys by Goy, Resko, and Gera (1972), who showed clearly that in primates, male juveniles typically show higher levels of rough and tumble play than females. Goy et al. (1972) then administered androgens to the pregnant mother to see what the resulting behavior would be in her offspring. They noted that there was almost no difference in the males; however, the females were born with significantly masculinized female genitalia and they

played almost as aggressively as the males. In another study on rats, Gorski et al. (1978) found that injections of hormones reversed the sexual positions rats normally assumed. When the female rats were given testosterone, they displayed less lordosis, which is the receptive female mating posture; however, they displayed typical male sex behavior and began mounting other females. In fact, the more testosterone they receive, the more female rats display typical male-rat sex behavior (Gorski et al., 1978). In contrast, when they deprived the male rats of testosterone by castrating them before birth, their sex behavior was more feminine and they develop allowed themselves be mounted by other males (Gorski et al., 1978).

Scientists have also been able to make male rats go through the biochemical motions of ovulation by injecting them with female hormones. When castrated and exposed to estrogen, they displayed same-sex sexual behavior, and a nucleus in their brain, termed the sexually dimorphic nucleus (SDN) was larger than normal male rats and resembled the size of the female SDN.

Based on extensive animal research, researchers initially hypothesized that *either* sex would form a “male typical” or “masculinized” brain if exposed to an *excess* of androgens. Likewise, *either* sex would develop a “female typical” or “feminized” brain if *not* exposed to these hormones at the right time (Byne & Lasco, 1999). Because they had found sexual behavior at least partially dependent on hormone exposure in animal studies, researchers began to question if the same principle would apply with humans. Initially, researchers presumed that homosexual men would be “more feminine” in brain and behavior, and lesbians would be likewise “more masculine.” Because of this, their research tended to focus on providing confirmation that this was the case (Gallo, 2000).

In one such study, Sanders and Ross-Field (1986) found that male homosexuals performed more like females on tests of cognitive ability. In addition, during the 1980's many studies were done in an effort to correlate sexual orientation with resting hormone levels. It was presumed that gay men would have higher levels of estrogen and lesbian women would have higher testosterone levels. A review of the literature revealed that twenty of these studies found no difference between testosterone or estrogen levels in gay and straight men. Three studies demonstrated that homosexuals had lower levels of testosterone; however, two of these were methodologically unsound because of psychotic drug use of participants, which is known to lower testosterone levels. Two studies reported *higher* levels of testosterone in gay men than in straight men, and one found them to be *higher* in bisexuals than either gays or straights (Burr, 1999). At the time, it was thought that these findings must have resulted from errors on the part of the researchers.

Unlike the pioneering work in this area, newer research suggests that homosexuals of *both* sexes seem to have been exposed to *higher* than average degrees of androgens prenatally. Ellis and Ebertz (1997) contended that homosexuals do not perform worse on measures on tests that typically favor male typical brain cognition. Rather, homosexuals respond in a typical male pattern, only much more extreme. Witelson and McCormick (1990) reported that compared to the general population, homosexual men showed an increased rate of left-handedness, which suggests a greater degree of testosterone exposure in utero. Similarly, in a meta-analysis of studies with almost 25,000 participants, gay men had 34% greater odds of being left handed than

heterosexual men and lesbian women had 91% greater odds of being left handed than heterosexual women (Lalumiere et al., 2000).

In light of these new findings, along with the 2D:4D studies, there are several reasons why homosexual men and women may have been exposed to greater degrees of androgens than heterosexuals. First of all, the role of estrogen in masculine sexual differentiation is connected to testosterone because testosterone is converted to estrogen by the enzyme, aromatase, which is present in some brain cells (McGivern, 1991). It is one of the greatest inconsistencies in biology, according to Burr (1999), that estrogens or “female hormones” make the brains of rats male. While the male rat brain needs testosterone, when this “male hormone” arrives in the brain, it is converted into estradiol, a “female hormone” which actually masculinizes the male rat brain. Female rats are not masculinized because they contain a sort of hormonal armor called alpha-fetoprotein that seizes the estradiol before it reaches brain cells. Therefore it seems that having an excess of testosterone for men may actually precipitate a larger amount of estrogen to be synthesized, thus feminizing the brain to some degree.

Large amounts of estrogen may also “feminize” the male body. One example of this occurrence is gynecomastia, which happens when males develop breasts structurally similar to female breasts. Men routinely produce large amounts of testosterone, but fat tissue in human beings converts this male hormone into estradiol, a female hormone; in fact, the principle source of estrogen in male primates is fat, which converts male to female hormones. Sufficiently fat men, male apes, and male gorillas, manufacture enough estrogen to cause them to develop breasts, and thus they become pseudo-hermaphrodites (Burr, 1999).

In female humans, greater amounts of testosterone may work to masculinize the brain because estrogen is already produced and females may not be as sensitive to its behavioral effects. It could also be that males are less sensitive to larger amounts of prenatal testosterone so exposure to very large degrees may further desensitize their brains to its results. On the other hand, females are more receptive to smaller grades of androgens so the increase in prenatal exposure may be very potent to their system. In essence, hormonal mechanisms are probably acting in paradoxical ways, some inconceivable at present, on human sexual orientation.

Supporting the hypothesis that homosexuality is influenced by increased testosterone exposure in utero, research has also found that 2D:4D ratios are related to sexual orientation. Robinson and Manning (2000) compared a sample of homosexual men to controls recruited without regard to sexual orientation. They, unlike previous researchers, included a scale designed to measure sexual orientation based on sexual fantasy and overt sexual behavior. In this way, they were able to obtain a rating from 1-6, in which 1 signifies exclusive heterosexuality, and 6 signifies exclusive homosexuality and everything in between is considered at some level of bisexuality. The survey contained items relating to the participants' past sexual partners as well as fantasies. Along with this measure, called the Sexual Orientation Score (SOS), the researchers included a question about ethnicity because they wanted to rule out the possibility of racial differences in 2D:4D affecting the results. Therefore, they used an exclusively Caucasian male sample. They discovered a significant increase in 2D:4D from bisexual men to homosexual men to controls. This seems to provide some evidence that the heterosexual men, in theory, were exposed to the least amount of androgens, bisexual

men experienced the highest quantities, and homosexual individuals fell in between the two extremes.

Finally, Williams et al. (2000) examined the 2D:4D ratios of 720 men and women attending a public street fair in San Francisco. They were given an anonymous survey that included items such as sex, age, sexual orientation, handedness, and the number and gender of children their mother carried before them. Photocopies of their right hands were then taken and 2D:4D was measured and analyzed. They found that 2D:4D was not significantly correlated with sexual orientation in men unless the number of older brothers was taken into account. However, in lesbian women, 2D:4D of the right hand was significantly “more masculine” than that of heterosexual women and it did not differ significantly from heterosexual men. Robinson and Manning (2000) posited that a potential reason that no significant relationship between sexual orientation in men and 2D:4D ratios was indicated in the Williams et al. (2000) study was because the researchers failed to control for ethnicity. Williams et al. (2000) also did not examine the 2D:4D of bisexuality in any way.

Problematic Nature of Sex- and Gender-Related Dichotomies

The present research stemmed from the growing body of literature, which suggests that the 2D:4D ratio, a presumed correlate of prenatal androgen exposure, is a sexually dimorphic characteristic that varies according to sexual orientation. However, my study extended this line of research by investigating the relationship between 2D:4D ratios and incidence of same-sex erotic fantasy. According to Martin and Lyon (1972), a homosexual person is an individual whose primary *erotic*, psychological, emotional, and

social interest is in a member of the same sex, even though those interests *may not be overtly expressed* (emphasis added [p. 1]). Therefore, a measure of same-sex erotic fantasy provided a vehicle to explore biological correlates of a more “covert” aspect of one’s sexuality, and will test the generalizability of 2D:4D relationships.

Orientation expressed in sexual fantasy was measured subjectively and objectively, with response choices that included heterosexual, homosexual, and bisexual partners, along with the activity or passivity of the participant. This was important for many reasons. First of all, one difficulty in studying human sexual orientation stems from scientific researchers who perceive a need to form two discrete and mutually exclusive categories for human traits and behaviors. A person is either a man or a woman, feminine or masculine, and gay or straight. In reality, seldom does an individual possess such extreme traits on one end of the spectrum. Rather, these individual characteristics tend to manifest themselves in varying degrees based on a person’s individual experiences, physiological makeup, and the interplay between the two (Marchant, 1996; Walen, 1996). As such, it can be argued that many of the sex differences might be caused by levels of hormones or other continuous variables that may not lead to extreme differences in phenotype.

Male/Female Anatomical and Gender-Related Similarities

Although males and females are sexually dimorphic anatomically, in actuality, men and women share many physical similarities. For example, male and female genitalia develop from the same fetal tissue. The embryo has a “bisexual” phallus, and in males it differentiates into a penis and in females it becomes a clitoris. According to

Reuben (1999), at least two percent of the sexual organs of the male and female really belong in the other sex- in some cases this percentage may be quite a bit higher. For example, the testicles can be thought of as female ovaries, and there is actually a tiny amount of tissue on the edge of the male bladder that would have been a vagina, had he been a female. Men even have a hymen called the seminal colliculus that takes the form of a hill of tissue next to the prostate gland. Likewise, there is a prostate gland in women known as the Skene's glands, two tiny holes on either side of the urethra.

In addition, according to Burr (1999), there are many graduations from female to male. Because intersexuality occurs in as many as four percent of births, many more individuals may lie somewhere along a continuum of biological sex characteristics.

There is also a great deal of variability in studies examining gender-related differences in cognitive ability, masculinity, and femininity. First of all, in nearly all of the findings supposedly supporting differences, there is a tremendous degree of variability in the outcomes. Usually a good portion of the men look more like women psychologically and vice versa. Conceptions of femininity and masculinity vary greatly by social and cultural context, and therefore the sexes should not be reduced to a bipolar dichotomy as society often tries to accomplish (Parker, 1998).

The Sexual Orientation Continuum

Sexual orientation research tends to follow the same patterns as the anatomical and gender-role literature. Homosexual acts and feelings have been recorded in almost every society studied, however, only recently has society begun to dichotomize people and classify them as either homosexual or heterosexual. Greenburg and Bystry (1984)

propose that one reason for the development of categories of sexual orientation was the new capitalism of the nineteenth century America that increased the competition among men because it strengthened the sexual division of labor, and added more weight to the ideology of the family. Likewise, the medical community further defined homosexuality by claiming it as a medical abnormality. Since the emergence of these limiting identifiers, many people still hold the assumption that bisexuality is not a legitimate orientation, and there is little empirical information about bisexuality or covert sexual behavior to date (Brookey, 2001).

Sigmund Freud thought there was a universal biological propensity to bisexuality (1920, as cited in Conrad & Schneider, 1996). Kinsey, Pomeroy, and Martin (1948), who performed perhaps the most exhaustive sex survey to date, argued that the categories of homosexuality, heterosexuality, and bisexuality were artificial mental constructs that included a variety of actual behavior. In response to his astonishing finding that 37 percent of the adult, white male population had experienced an orgasm during a homosexual encounter, Kinsey reported that humans possess the biological capacity for sexual stimulation, but the source of that arousal in no way precludes that it is independent of the capacity. He also came to the conclusion that homosexuality as a category did not exist, but only homosexual acts and thoughts.

Among those who have studied bisexuality, many researchers believe that several of the animal studies have provided more evidence for bisexuality and transexuality than homosexuality. For example, Gorski et al. (1978) argue that rats provide a model for transexuality because the hormones given to the male rat will most likely give him the sense that he is a female trapped inside a male rat's body.

Kinsey et al. (1948) and Rokach (1990) have also suggested that bisexuality may be more likely in women than men. On Kinsey's seven-point scale of sexual orientation, men, both homosexual and heterosexual, are typically on the far ends of the scale. On the other hand, women are also at the ends of the continuum but are more likely than men to be found on the scale between 2 and 5 (Bailey et al., 2000). Because of these many complexities, it is important to refrain from imposing what may be artificially constructed restraints on the study of sexual orientation. I intended to push these boundaries by measuring the sexual fantasy preferences of respondents utilizing subjective and objective questions.

Theoretical Rationale and Hypotheses

Based on the previous digit ratio research, as well as the arguments for a continuous pattern of sexual orientation, in the present study, I tested four hypotheses: (a) given the correlation between 2D:4D's and prenatal hormone exposure, women will have larger ratios than men; (b) women will be more likely to report fantasizing about both sexes than men; (c) those with lower ratios will have an increased tendency to fantasize about members of the same sex, and (d) that ratios will vary significantly as a function of the day of the year on which a participant was born.

CHAPTER II

METHOD

Participants

Following approval of the Pittsburg State University Human Subjects Committee, undergraduate students in general psychology, educational psychology, social psychology, and developmental psychology were asked to participate. Those in general psychology received course credit and signed up to participate at various timeslots. The researcher actively recruited those in the other classes through a small presentation and the opportunity for extra credit points. Students were told their participation was voluntary, that they could withdraw at any time without penalty, and that they were free to leave answers blank.

In total, 108 students (45 females, 63 males) at Pittsburg State University agreed to participate. They provided requested demographic and sexual fantasy information, and allowed the lengths of their 2nd and 4th fingers to be measured. Ages of participants ranged from eighteen to sixty-nine ($M = 21.8$, $SD = 6.7$).

Procedure and Materials

Upon arrival, students completed departmental forms and then were asked to review a cover letter, informed consent form, and the questionnaire. They were told about the nature of the study and any questions they had were answered in full. They were also told that they could choose not to participate at any time without penalty. They were reminded that they should only answer the questions with which they felt comfortable. If they chose to participate, individuals signed the informed consent form that was collected and filed by the researcher.

Next, they were instructed to wait for the researcher to measure their fingers before completing the questionnaire so that answers would remain anonymous. Likewise, the researcher asked participants to leave an empty seat between themselves. The researcher proceeded to measure the lengths of the participants' 2nd and 4th fingers with digital vernier calipers that measured to the nearest .01 millimeter. Fingers on the participant's dominant hand were measured on the ventral surface of the hand, from the basal crease to the tip. Fingers were measured in a double blind fashion because a flap was attached to the display window of the calipers and the participant lifted the flap and recorded the value in spaces on his/her questionnaire. These values likely had no meaning for the participant. In addition, the measuring device was returned to the zero point for each successive measurement.

Next, participants completed questionnaires with a pencil that was provided. The questionnaire included a demographic section and three questions concerning the nature of their sexual fantasies (see Appendix A). It contained two objective questions that

asked the participant to report the number of sexual fantasies of the opposite sex and same sex they had in the previous six month time period. The third question asked the participant to mark all options that applied to his/her fantasies, and responses included the sex of the object of fantasies and whether the participant was active or passive in sexual fantasies.

After completion of the questionnaire, students were asked to place theirs in the middle of a blank envelope that was full of other completed questionnaires. Participants did not place identifying information on questionnaires. Finally, they were thanked for their participation and excused. The amount of time to complete the study averaged ten minutes.

CHAPTER III

RESULTS

All analyses were conducted using the SAS program for demographic variables, lengths of the second and fourth fingers, and sexual fantasy content. It was the original intention to exclude non-white participants from the data analysis because finger length ratios have demonstrated considerable variation amongst different ethnicities. However, a t-test showed that there was not a significant difference in 2D:4D ratios between white and non-white participants so all ethnicities were included in the final analyses, $t(106) = 1.55, p = .12$).

First, a series of Pearson Product-Moment correlational analyses were conducted. Those that displayed significant correlations were then utilized for further analysis with other statistical tests. Next, response items on the third question regarding sexual orientation and activity/passivity in fantasies were grouped in several ways: according to the sex of the participant's fantasized partner (opposite, same, or bisexual), according to whether the participant reported active, passive, or both roles in fantasies, and according to the variety of items marked in terms of frequency of responses. Additionally, birthdates were coded as the number of the day in the year ranging from 1-365. All hypotheses were tested utilizing an alpha level of $p < .05$. First, I hypothesized

that women would have larger 2D:4D ratios than men. Therefore, female and male finger length ratios were compared using a t-test. Consistent with a priori hypotheses, females ($M = .99$) had greater ratios than males ($M = .97$). The difference was statistically significant, $t(106) = -3.26, p = .0015$.

Second, I hypothesized that women would be more likely than men to fantasize about both sexes. It was found that women were much more likely to fantasize about both sexes. A 2 x 3 two-way chi square demonstrated that those who reported fantasies of the same sex were significantly more likely to be women than men, $\chi^2(1, 2) = 7.39, p = .025$. Eleven percent of women chose a bisexual/homosexual response compared to 5% of men. When response items on the third question regarding sexual orientation in fantasy were categorized according to the activity or passivity of the participant in his/her fantasies, no significant differences were found between the sexes, $\chi^2(1, 2) = .79, p = .67$.

Third, to test whether 2D:4D ratios differed by fantasy content, data were analyzed in several manners. Results were unclear due to contradictions in the various tests. Those who reported bisexual or homosexual fantasies did not differ by finger length ratios from those who reported only heterosexual fantasies, $F(2, 96) = .63, p = .53$. In addition, responses on the third question regarding fantasy content were categorized into one of two groups, based on the number of items marked into two. If the participant marked one or two responses, s/he was placed in one group (low variety), and if three or more responses were checked, s/he was placed in the other group (high variety) for the purpose of this analysis. In the latter case, the participant would have checked at least one item that corresponded to having partners of both sexes or a partner of the same

sex in his/her fantasies (see Appendix A). A one way analysis of variance revealed a significant difference in the 2D:4D ratios of both groups, $F(1,106) = 9.01, p = .0034$. Those in the high variety group ($M = .98$) had lower ratios than those placed in the lower variety group ($M = 1.0$).

Moreover, a 3 x 3 two way chi square found significant differences in handedness, a presumed correlate of prenatal androgen exposure for those who reported a homosexual, heterosexual, or bisexual identity in the demographics section of the questionnaire, $\chi^2(2, 2) = 13.4, p = .009$.

Finally, I hypothesized that finger length ratios would vary by season of birth. There was no correlation between birth date and finger length ratios ($-.08$).

CHAPTER IV

DISCUSSION

The present data are somewhat compatible with the neurohormonal theories of sex development and sexual orientation. The first two null hypotheses regarding 2D:4D's and sex along with sex and sexual orientation in fantasies can be rejected as the results clearly indicate a relationship in the direction of the original hypotheses. Though the hypothesis that there would be a difference in finger length ratios of those who reported varying sexual orientations in fantasies could not be supported, some evidence to support the neurohormonal theory was demonstrated by the relationship between handedness and the sexual orientation in fantasies. In addition, the significant relationship between variety of responses marked and 2D:4D ratios supports the neurohormonal theory of sexual orientation because those in the high variety group would have marked at least one bisexual/homosexual response and also had significantly lower 2D:4D ratios. The neurohormonal theory posits that those with preferences toward the same sex will have lower finger length ratios due to higher prenatal androgen exposure. Finally, there was no relationship between birth season and 2D:4D's as originally predicted by the researcher.

The finding that 2D:4D's differed by sex of the participant is not surprising considering the previous literature. Likewise, there are several reasons that the sexual

orientation of one's fantasy may differ by gender. Because sexual fantasies are private and do not depend on the participation of the partner, they may be more revealing of gender differences in sexuality than actual sexual behavior (Ellis & Symons, 1990). Also, in a fantasy, one can imagine whatever one desires unconstrained by social convention, practical and legal barriers, or by fears of rejection or embarrassment (Wilson, 1997). However, because the only method of obtaining information about sexual fantasies is through self-report data, the possibility that the participant could lie or give an answer that s/he thinks the researcher is interested in remains a possibility that is difficult to control.

There are several reasons women may more readily admit to fantasies involving both sexes. Previous studies have found sex differences in sexual fantasies and it seems that women may be more likely to resist violating a cultural taboo. Women may feel safer indicating that both sexes are present in their fantasies. Wallen contends that nature needs nurture, so that a hormonally induced behavioral predisposition can only be expressed in a supportive social environment (1996). There is less societal stigmatization of homosexual and bisexual women than men. In addition, the media continually displays same sex female interactions.

On one hand, women's fantasies have been shown to demonstrate themes of narcissism, passivity, and sadomasochism. On the other hand, men's fantasies have been described as active, aggressive, power oriented, masochistic, and impersonal (Wilson & Lang, 1981). However, Rokach found that students revealed no sex differences in the content of male and female fantasies. Both men and women preferred traditional and facilitative fantasies, along with those displaying intimacy over exploratory, impersonal,

or sadomasochistic fantasies. The researcher also found that men very clearly stayed away from fantasies that had any connection to homosexuality, but women were somewhat more likely to indicate these themes in their fantasies (1990). This was congruent with the present research because women were much more likely than men to report bisexuality in fantasies. It could also be that, in men, a stronger biological propensity to think of members of the same sex may be needed for them to experience these fantasies or report them. One reason that has been suggested by previous literature is that women have been shown to be more likely to fantasize about being the recipient of sexual activity (Barclay, 1997; Wilson & Lang, 1981). There has long been a question as to whether the recipient of homosexual behavior is actually homosexual. This was not supported in the present research because results indicated no significant differences in passivity between the sexes.

Another possible interaction could occur because testosterone levels have been shown to increase the frequency of sexual fantasies (Bancroft, 1984). This suggests that it is possible that those who fantasize more often may also be willing to include both sexes in their fantasies. Evidence was contrary regarding this statement.

Lastly, results did not support the hypothesis that 2D:4D's would vary by birth season. This finding could be a true reflection of nature or the analysis may have been limited by a small sample size.

Finally, sexual fantasies were chosen for many reasons. A measure of covert and autoerotic behavior such as sexual fantasies would likely show greater variability and thus generalizability to the population. Subjective and objective items were included to acknowledge the non-mutually exclusive nature of sexual orientation.

Directions for Further Research

It is clear that the burgeoning evidence for the neurohormonal theories of human sexual orientation are a starting point for future research in this area. The finger length ratios have finally provided a possible window into the events of prenatal life. However, it is still unclear if and when there are specific critical periods for hormone exposure. Also, scientists still do not have enough knowledge of the sometimes unpredictable nature of hormones and their interactions. Hopefully, in future studies, technology will allow researchers to investigate these issues.

In light of society's attempt to polarize the sexes and sexual orientation, more research is necessary that will examine the complex patterns of bisexuality and the different components to the expression of sexual orientation such as fantasies, identity, relationships, and overt behavior. So far, much of the literature attempting to find differences between homosexuals and heterosexuals has lacked replication or has contained methodological flaws and weaknesses. The research regarding these topics is important for social, scientific, political, and psychological reasons and the issue of human sexual orientation has a profound effect on the way in which science is able to examine the sexes and varying levels of sexual orientation.

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APPENDIX

Appendix A

Questionnaire**Demographic Information**

1. Age I am ____ years old.
2. Birthday (00/00/00) _____
3. Biological Sex M F
4. Ethnicity White Black Asian Hispanic Other
5. Number of brothers your biological mother carried before yourself until at least the second trimester ____ Brothers ____ Unsure
6. Which hand do you use primarily? Right Left Both
7. I consider myself to be: Gay Straight Bisexual

Sexual Fantasies

1. In the previous six months, how many times have you fantasized about performing sexual acts or being the recipient of sexual acts with a member of the opposite sex? ____.
2. In the previous six months, how many times have you fantasized about performing sexual acts or being the recipient of sexual acts with a member of the same sex? ____.
3. Mark all that apply to your fantasies:
 - ____ I sometimes fantasize about performing sexual acts upon both sexes in the same fantasy.
 - ____ I sometimes fantasize about performing sexual acts upon only the opposite sex.
 - ____ I sometimes fantasize about performing sexual acts upon only the same sex.
 - ____ I sometimes fantasize about being the recipient of sexual acts with both sexes.
 - ____ I sometimes fantasize about being the recipient of sexual acts with only the opposite sex.
 - ____ I sometimes fantasize about being the recipient of sexual acts with only the same sex.

Finger Lengths

Length of second finger _____ Length of fourth finger _____

