

THE INFLUENCE OF PRENATAL ANDROGEN EXPOSURE ON PSYCHOPATHY

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DEDICATION

I would like to dedicate my work to my mother and father, and thank them for giving me the necessary tools to become successful and strive for the best. Without the both of them, I would not be who I am today. Everything they have taught me about life and the challenges I will have to face has made me stronger and more resilient than ever. They have taught me the value of humility, and the value of confidence; the enjoyment of humor, and the hard work that comes with independence. Thank you for giving me the strength to persevere throughout life's challenges.

ABSTRACT

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Prior research has identified significant relationships between prenatal androgen exposure and various behavioral and personality characteristics that maintain a biological component, specifically amongst males. Although evidence suggests prenatal androgens, such as prenatal testosterone, influence behavior and certain personality characteristics, its influence on psychopathy has only recently been investigated. It is suggested that psychopathy may have a biological component that may be influenced by early exposure to testosterone in fetal development, resulting in a sexually dimorphic component. Using data from an undergraduate sample at a southwestern university, the current study examines the relationship between prenatal testosterone measured by the 2D:4D ratio, and a two-factor model of primary and secondary psychopathy between sex in order to identify potential biological vulnerabilities of later adult psychopathy. Findings are consistent with theory and previous literature, where a significant correlation was identified between the 2D:4D ratio and primary psychopathy for the entire sample, and a significant relationship was identified with the 2D:4D ratio and secondary psychopathy for males while controlling for age, race/ethnicity, parental criminality, and child sexual and physical abuse. Results uniquely contribute to the biosocial literature on early prenatal testosterone influence on personality.

KEY WORDS: Prenatal Androgens, Prenatal Testosterone, 2D4D Ratio, Psychopathy

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CHAPTER I

Introduction

Although prenatal hormones such as testosterone may have an effect on characteristics found in psychopathy, research linking prenatal androgen exposure to the psychopathic personality remains limited (Blanchard, Lyons, & Centifanti, 2016). Psychopathy is typically considered a predominantly male personality disorder, and therefore sexually dimorphic in nature (Blanchard & Lyons, 2010; Kreis & Cooke, 2011; Hare, 2003; Sellbom, Donnelly, Rock, Phillips, & Ben-Porath, 2017; Strand & Belfrage, 2005). Because of the significant differences between males and females in relation to psychopathy, it may be expected that hormones that influence sexual dimorphism, such as testosterone, may play a factor in the development of psychopathy. Hormones released during utero that occur early within the gestational period can be identified through the relationship between the second and fourth finger, otherwise known as the 2D:4D ratio, which acts as a lifelong marker for prenatal testosterone exposure (Garn, Burdi, Babler, & Stinson, 1975). By identifying early biological influences on psychopathy, we may be able to understand early biological vulnerabilities in personality types that may be more inclined to engage in criminal or antisocial behaviors.

The current study investigates the relationship between the influences of prenatal androgens, specifically testosterone, on primary (i.e., selfishness and callousness) and secondary (i.e., impulsive and self-defeating behavior) psychopathic characteristics identified in the Levenson Self-Report Psychopathy scale (LSRP). Prenatal testosterone will be identified by a biomarker through the 2D:4D ratio. The current study also seeks to expand on Blanchard and colleagues (2016) work on the influence of the 2D:4D ratio on

psychopathy by using a large sample of undergraduate male and female students. The current study uses the Levenson's Self-Report Psychopathy scale to identify separate components of psychopathy known as primary and secondary psychopathy. This may help assess individual characteristics of psychopathy that may be uniquely influenced by the digit ratio that was not captured in prior research.

Research Aims

The current paper aims to bridge the gap between the psychopathic personality and early biological influences that may result in a vulnerability to certain personality characteristics. These characteristics may increase the likelihood of criminal behavior, specifically when looking at violent crime. Identifying prenatal androgen exposure as a possible influence on adult psychopathy may further account for the variance found within individuals who score high in psychopathy, and account for individual biological components that may contribute to the development of the construct itself. In addition, this paper attempts to explain why males are significantly more likely than females to have psychopathic characteristics. Specifically, prenatal androgen exposure will be used to help explain the sexual dimorphism within the personality construct using Evolutionary Neuroandrogenic (ENA) theory (Ellis, 2001, 2005).

This paper will continue with four additional chapters. Chapter II will discuss vulnerabilities to the psychopathic personality and how there may be a biological vulnerability through testosterone. Additionally, this study will use ENA theory to assess how prenatal androgens may influence a variety of psychopathic characteristics, including those identified in primary and secondary psychopathy. Chapter III will discuss the methodology of the current study, and how the participants were sampled. This

chapter will also address how the items within the study were measured, as well as the analytic strategy used. Chapter IV will present the results while chapter V will discuss the current study's findings, limitations, and suggested future research.

CHAPTER II

Literature Review

Evolutionary Neuroandrogenic Theory

Evolutionary Neuroandrogenic (ENA) theory is a biosocial perspective that combines Darwin's theory of evolution on natural selection and neurohormonal influences to explain criminal behavior (Ellis, 2001). ENA theory proposes that males are more prone toward status-striving behaviors compared to females in order to increase later mating opportunities (Ellis, 2001, 2005, 2017; Ellis & Das, 2013; Ellis et al., 2015). These preferences result in the competition for resources and victimizing behaviors (Ellis, 2005; Ellis et al., 2015). ENA theory assumes there are genetic and neurohormonal components as a result of complex brain functioning and reproductive necessity (Ellis, 2001). This suggests that males are prone to specific behaviors in order to increase their chances of reproduction. The first stage of testosterone influence occurs in the *perinatal stage* (i.e., organizational stage) during fetal development, characterized by irreversible testosterone effects that occur prior to birth (Ellis, 2001, 2005, 2017; Ellis & Das, 2013). The second stage, called the *postpubertal stage* (i.e., activational stage) occurs during puberty, and results in the male brain being exposed to greater levels of testosterone compared to the female brain (Ellis, 2001; Ellis & Das, 2013).

ENA theory focuses on two propositions: (1) evolution by natural selection maintains that males are significantly more likely to display competitive/victimizing behaviors compared to females in order increase the likelihood of reproduction and resource acquisition, and (2) genes associated with the Y-chromosome result in the male brain developing differently from the female brain, increasing competitive/victimizing

behaviors (Ellis, 2005). In addition, ENA theory does not predict all behavioral traits and criminality, but only those that show significant sex differences (Ellis & Hoskin, 2018). ENA theory focuses on explaining the transition between “crude” (i.e. unacceptable) forms of resource acquisition that may cause victimization, to “sophisticated” (i.e., acceptable) forms of resource acquisition, in addition to why criminal behavior is predominantly male (Ellis, 2005, 2017). This theory proposes a connection between neurohormonal (i.e., androgens) and evolutionary arguments (Ellis et al., 2015), in order to explain biological influences that affect male and female behavior.

ENA theory accounts for biological variables and criminal behavior, specifically amongst males between the ages of 13 through 30 (Ellis, 2005; Ellis, 2017). ENA theory is one of the only theories that specifically looks at this age range amongst males in order to identify potential causes of why this group is significantly more likely to engage in antisocial behaviors. We therefore expect ENA theory to influence a variety of characteristics and behaviors that are sexually dimorphic in nature, increase victimizing behaviors, and are significantly more likely to be seen in males between adolescence and the fourth decade of life.

Psychopathy

Psychopathy is a psychological construct that exhibits specific personality characteristics that are associated with antisocial tendencies. According to the *DSM-V* (2013), psychopathy is another term for Antisocial Personality Disorder (ASPD), characterized by a pervasive pattern and disregard for the rights of others, beginning in childhood or adolescence and continuing throughout adulthood. “This pattern has also been referred to as psychopathy, sociopathy, or dissocial personality disorder” (*DSM-V*,

2013, p. 659). Psychopathy consists of a variety of characteristics that include: (1) little sense of responsibility and a disregard for the truth; (2) stealing or cheating; (3) highly undependable with no sense of shame; (4) numerous sexual partners; (5) egocentric and unable to place themselves in someone else's shoes (i.e., lacks empathy for others); (6) may engage in risky behaviors such as overindulging in alcohol (Hare & Neumann, 2008). Individuals who meet the criteria for psychopathy, are likely to be impulsive, irresponsible parents, appear irritable or aggressive, exhibit irresponsible work behaviors and take financial risks, as well as suffer from impulse control (*DSM-V*, 2013; Hare, 2003; Hare & Neumann, 2008).

Psychopathy reflects a specific pattern of behavior that overlaps with Antisocial Personality Disorder (ASPD) within the *DSM-V* (2013). According to the *DSM-V* (2013), ASPD is characterized by a pervasive pattern and disregard for the rights of others, beginning in childhood or adolescence and continuing throughout adulthood. However, evidence suggests psychopathy engulfs specific personality traits that may differ from ASPD symptoms (Hare, 2003; Ogloff, Campbell, & Shepherd, 2016; Verona, Sprague, & Sadeh, 2012). The personality construct of psychopathy is closely tied to affective characteristics and antisocial features (Hare & Neumann, 2008). Although characteristics of psychopathy reflect a relationship with ASPD, individuals who meet the criteria for ASPD do not necessarily meet the criteria for psychopathy (Hare, 2003). Despite these discrepancies, ASPD is identified as the clinical label for individuals who exhibit psychopathic tendencies, and therefore can reflect synonymous terms at times (*DSM-V*, 2013; Walsh & Wu, 2008).

Conduct disorder also reflects early symptoms of psychopathic tendencies, and may oftentimes be a precursor for later adult psychopathy. Individuals with conduct disorder may lack remorse and guilt for others when they do something wrong, or display a callous disregard for others' feelings, lacking empathy, and appear cold and uncaring (*DSM-V*, 2013; Fanti, Kyranides, Lordos, Colins, & Andershed, 2018). As such, conduct disorder represents various dimensions of psychopathy in childhood and adolescence. Additionally, it is suspected that narcissism, impulsivity, and callous-unemotional traits are precursors to the development of psychopathy observed within youth (Hare & Neumann, 2008).

Psychopathic traits usually increase throughout adulthood and remain fairly stable over time (Hare & Neumann, 2008), declining around the fourth decade of life (*DSM-V*, 2013). Males and females who exhibited psychopathic tendencies were found to be more manipulative, report greater levels of aggression (Czar, Dahlen, Bullock, & Nicholson, 2011), and were more likely to come in contact with the criminal justice system (De Vogel & Lancel, 2016). It is suspected that individuals with psychopathic tendencies experience anxiety as a result of immediate frustrations or threats to the individual in present environmental situations rather than long-term anxiety as a result of daily stress, and therefore, their anxiety does not last (Hare & Neumann, 2008). In other words, individuals who score higher on psychopathy scales are less likely to experience reoccurring anxiety, and are more likely to have short term periods of anxiety that change as a result of their environment. This speaks to the deficiencies and affective mood experienced by individuals who score high in psychopathy. Emotional deficits (i.e., negative emotional processing) in individuals with psychopathic tendencies were found

to be less sensitive to emotional contexts, suggesting dysfunction within specific brain regions (Verona et al., 2012).

ENA Theory, Sex, and Psychopathy

Although symptoms of psychopathy are relatively similar in males and females (Kreis & Cooke, 2011), research has consistently found that psychopathy is more prevalent amongst males compared to females, with males scoring, on average, higher in psychopathic tendencies (Blanchard & Lyons, 2010; Kreis & Cooke, 2011; Hare, 2003; Sellbom, Donnelly, Rock, Phillips, & Ben-Porath, 2017; Strand & Belfrage, 2005). Specifically, men tend to score higher in callousness, egocentricity, disruptive behavior, recklessness, aggression, physical violence, experienced reduced anxiety, and are less empathetic compared to women (De Vogel & Lancel, 2016; Kreis & Cooke, 2011; Sellbom et al., 2017); characteristics identified within both primary and secondary psychopathy. In other words, evidence suggests men may score higher in both factors of psychopathy. Research has identified men as scoring higher in both primary (Bates, Archer, & Graham, 2017; Marion & Sellbom, 2011) and secondary psychopathy compared to women, where primary and secondary psychopathy predicted one another (Blanchard et al., 2016). An association between primary psychopathy and proactive aggression (i.e., inflicting harm on others because you can, rather than reacting in self-defense) for males compared to females was found, suggesting reduced emotionality in males could increase primary psychopathy (Guerra & White, 2017). Additionally, prior research has identified a relationship between both primary and secondary psychopathy and bullying for males, where both factors predict these victimizing behaviors (Welter Wendt & Jones Bartoli, 2018).

When looking specifically at college samples, women may still reflect core personality features of [primary] psychopathy observed within the interpersonal facet of the psychopathic personality, but may differ in offending populations. For example, women with psychopathic characteristics were more likely to lie, be deceitful, lack impulse control, and commit fraud (De Vogel & Lancel, 2016; Strand & Belfrage, 2005), suggesting females in offending samples may be more inclined to reflect primary and secondary psychopathy. However, psychopathy for females may be inherently different compared to males. In college samples, males scored significantly higher than females in many of the subtypes within secondary psychopathy (Lee & Salekin, 2010). Specifically, females who scored high in secondary psychopathy reflected higher levels of agreeableness, extroversion, and guilt compared to males, whereas males reported greater criminality, risky driving, and antisocial behaviors compared to females. This may suggest primary and secondary psychopathy in females may represent the strength or severity of psychopathy rather than two distinct factors (Lee & Salekin, 2010), which may result in both factors being more pronounced in males. Because psychopathy has been recognized in greater rates amongst males compared to females, psychopathy may be a sexually dimorphic personality construct, and therefore, research on androgen receptors (AR) (e.g., testosterone) may be most promising (Gunter, Vaughn, & Philibert, 2010).

ENA theory proposes that testosterone plays an essential role in promoting competitive/victimizing behaviors (Ellis, 2005). In addition, reduced pain sensitivity and empathy in men may result in increased aggression (Ellis, 2001). This suggests there are significant sex differences in criminal behavior. For example, prior research found that as

prenatal androgen exposure increases, the likelihood of an individual committing an offense significantly increased (Hoskin & Ellis, 2014). Specifically, males may have been naturally selected to engage in victimizing behaviors due to mate selection (Ellis et al., 2015). In addition, various forms of antisocial behaviors are more prevalent amongst males compared to females (Ellis & Hoskin, 2018). As competition increases, males must learn to acquire skills and resources in a socially desirable way; males who do not learn quick enough may come in contact with the criminal justice system or face retaliation by others. A male's ability to learn is correlated with the speed in which he is able to shift from crude to sophisticated forms of behavior, or behavior that leads to an understanding of socially acceptable means of resource acquisition (Ellis, 2005). Males have evolved toward female mating preferences for resource acquisition that require competition and status, and are therefore significantly more likely to display competitive/victimizing behaviors compared to females (Ellis, 2001, 2005). Psychopathic characteristics may have therefore resulted over time from females being unable to discriminate between males who successfully obtain resources and were loyal, compared to those who were successful in learning social skills based on deception (Ellis, 2017). Either way, psychopathy has been shown to be a predominantly a male trait, suggesting that there may be sex-specific antecedents influencing this trait which then puts males at increased risk for antisocial and criminal behavior.

Measuring Psychopathy

Psychopathy is a psychological construct that incorporates different facets of personality characteristics and behaviors (i.e., callousness, egocentricity, and narcissism). Prior research has looked at psychopathy through two, three, and four-factor models to

identify specific psychopathic characteristics (Cooke and Michie, 2001, Brinkley, Diamond, Magaletta, & Heigel, 2008; Brinkley, Schmitt, Smith, & Newman, 2001; Hare, 2001; Levenson, Kiehl, & Fitzpatrick, 1995, Sellbom, 2011). Different ways of measuring psychopathy include the Psychopathy Checklist-Revised (PCL-R) or the Levenson Self-Report Psychopathy Scale (LSRP). Psychopathy through a two-factor model can be measured through primary and secondary psychopathy. This has been suggested through the LSRP (Levenson et al., 1995). Primary psychopathy identifies core personality features such as affective and interpersonal characteristics (e.g., shallowness, deceitfulness, and a lack of remorse) while secondary psychopathy addresses antisocial behavior and a self-defeating lifestyle (e.g., recklessness, impulsive, or prone to rule-breaking or violence) (Bate, Boduszek, Dhingra, & Bale, 2014; Levenson et al., 1995).

A three-factor model measuring psychopathy addresses interpersonal lifestyle including deceitfulness and selfishness at the expense of others, impulsive and irresponsible behavior, and affective characteristics that include individuals who are emotionally shallow and lack remorse or empathy (Cooke & Michie, 2001), whereas a four-factor model incorporates antisocial and criminal behavior (Hare, 2003; Sellbom, 2011). It has been suggested that the LSRP be used rather as a three-factor model of egocentricity, callousness, and antisocial tendencies in order to capture interpersonal, affective, and behavioral characteristics of psychopathy. Prior research suggests this may be better for measuring females within the sample because it may identify certain characteristics (e.g., sensation-seeking) within female samples more accurately (Brinkley et al., 2008). However, the LSRP two-factor model was created using college samples (Levenson et al., 1995), whereas a three-factor model may be best for incarcerated

populations (Brinkley et al., Cooke & Michie, 2001; 2008; Sellbom, 2011). In other words, a two-factor model has been identified as a good measure for college samples, while three or four-factor models may be better measurements for females within incarcerated samples (Brinkley et al., 2008).

Psychopathy and Crime

Individuals who exhibit psychopathic traits may lack empathy and appear callous, arrogant, affective or detached, cynical, and have a disregard for the feelings of others. Prior research has identified a positive relationship between moderate and high psychopathic individuals and criminal behavior, especially for violent crimes (Aharoni & Kiehl, 2013). The distinguishing characteristics of psychopathy appear predictive of recidivism within the criminal justice system as well (*DSM-V*, 2013). A meta-analysis conducted by Edens, Campbell, and Weir (2007) concluded that psychopathy was significantly associated with general and violent recidivism in male youths, whereas modest effects for females were found with sexual offending, suggesting psychopathy is predictive of violent recidivism. In addition, individuals with psychopathic personalities were more common in prison and drug populations (Tellegen & Waller, 2008).

In many cases, individuals who reflect psychopathic or ASPD symptoms may appear to have a history of conduct disorder in childhood or early adolescence (*DSM-V*, 2013). Individuals who score high in psychopathy disproportionately commit violent and criminal acts (Beaver, Barnes, May, & Schwartz, 2011; Dembo et al., 2007). Dembo and colleagues (2007) classified a sample of incarcerated youths into low, moderate, and high psychopathy. Results revealed that males scored significantly higher in callous-unemotional traits compared to females, while females reported greater involvement in

drug use other than alcohol and marijuana. In addition, a significant relationship was found between psychopathy and conduct disorder, suggesting adolescents who display characteristics of conduct disorder are likely to display psychopathic tendencies, acting as a precursor to adult psychopathy. Individuals with high psychopathy scores displayed higher criminal thinking scores, and reported more thefts and drug use (Dembo et al., 2007).

Prior research identified individuals who scored high in psychopathy as being more likely to recidivate sexually and violently (Aharoni & Kiehl, 2013; Urbaniok, Endrass, & Rossegger, 2007). Not only does psychopathy influence recidivism, but it also influences the crimes committed, specifically violent crimes. In a longitudinal study on adolescents, Gretton, Hare, and Catchpole (2004) identified long-term stability in aggressive behavior as one ages. Specifically, adolescents with psychopathic characteristics engaged in higher rates of nonviolent crime into adulthood, as well as maintained a propensity for violence. In addition, antisocial lifestyles and behavioral traits of psychopathy increased criminal behavior, whereas affective psychopathic traits reduced this behavior, suggesting that the emotional detachment domain of psychopathy reduces the ability to evade detection with their crimes (Aharoni & Kiehl, 2013).

Risk Factors of Psychopathy

Home Environment: Poor Parenting and Neglect

Research suggests that psychopathy is influenced by both biological and environmental factors (Beaver, Barnes, May, & Schwartz, 2011; Ehringer, Rhee, & Young, 2006; Ficks, Dong, & Waldman, 2014; Forsman, Lichtenstein, Andershed, & Larsson, 2008; Tuvblad, Wang, Bezdjian, Raine, & Baker, 2016). However, the effects of

genetic and environmental influences may vary based on the behavior or personality type (e.g., callousness, risk taking, etc.) under investigation. Research identified early-life temperament and parenting interactions in adolescents with affective traits, specifically in male infants (Beaver, Hartman, & Belsky, 2015). Parental sensitivity (i.e., the level in which a parent reflects responsive, positive, and supportive care toward the child) was found to have a significant effect on children in early life. In addition, prior research identified children who experienced greater stressful life events and family conflict as scoring significantly higher in psychopathy scores (Dembo et al., 2007). This suggests that family relationships and experiences may later impact psychopathy.

Maternal and paternal relationships have also been identified as having an impact on the development of psychopathy or psychopathic characteristics (Forouzan & Nicholls, 2015; Loney, Huntenburg, Counts-Allan, & Schmeelk, 2007). Specifically, maternal mental and personal issues that resulted in foster care increased the likelihood of psychopathy in offspring, while paternal abuse acts as a positive predictor in psychopathy as well (Forouzan & Nicholls, 2015). Preliminary examinations between maternal and child callous-unemotional traits suggest parental socialization plays a factor in child psychopathic traits, however, it is possible that children are predisposed to these traits that may also impact parental dysfunction (Loney et al., Schmeelk, 2007). Additionally, a small percentage of a sample of incarcerated youth (11%) lived with both parents prior to incarceration (Dembo et al., 2007), reducing overall parental involvement and may act as a contributing factor to antisocial and psychopathic tendencies.

Exposure to Community Violence, Home Violence, and Victimization

Violence, exposure to antisocial behaviors, and stressful or negative life events such as victimization are believed to be significant factors in the development of the psychopathic personality (Dembo et al., 2007; Forouzan & Nicholls, 2015; Schraft, Kosson, & McBride, 2013; Sharf, Kimonis, & Howard, 2014). Individuals who reported greater criminal thinking scores and reported more thefts and drug use were also exposed to a greater number of stressful events and family conflict (Dembo et al., 2007), specifically, among males who scored high in callous-unemotional traits (Sharf et al., 2014).

Greater exposure to violence within the home and community was associated with higher levels of psychopathic characteristics, suggesting abuse and neglect within the home and community on psychopathy reflect shared variance (Schraft et al., 2013). Approximately 33% of incarcerated adolescents who reported substance abuse had a family member who engaged in the behavior, while 80% of adolescents admitted to marijuana use (Dembo et al., 2007), linking shared environments or potential exposure to later delinquent behavior. Prior victimization may have a significant impact on psychopathic tendencies for women. Adult women who scored high in psychopathy were more likely to experience behavior dysfunction in childhood, impulsivity, and prior victimization (Forouzan & Nicholls, 2015).

Biological Risk Factors

Prior research suggests that some children may be genetically vulnerable to the development of callous-unemotional traits, which later may lead to the development of psychopathy (Blanchard & Centifanti, 2017). Effects of biological influences on child

psychopathy and later adult psychopathy, indicate personality characteristics remain stable over time as a result of biological and environmental influences that occur early in life. Altered brain functioning has been identified in youth with callous-unemotional traits, suggesting hormones such as the ratio between cortisol and testosterone, may play a factor in child psychopathic traits, and later adult psychopathy (Herpers, Scheepers, Bons, Buitelaar, & Rommelse, 2014). In addition, biological correlations were found between child psychopathy, impulsivity, aggression, and low resting heart rates on children and adolescents (Raine, Fung, Portnoy, Choy, & Spring, 2014; Choy et al., 2015).

A variety of biological mechanisms have influenced antisocial behavior and psychopathy. Results suggest biological risk factors predispose individuals to psychopathic characteristics and antisocial behaviors by altering autonomic functioning and causing a reduced fear response (Choy et al., 2015). For example, greater levels of testosterone were related to lower empathetic abilities, suggesting empathy is affected by neuropsychological alterations (Romero-Martínez, Lila, Sariñana-González, González-Bono, & Moya-Albiol, 2013). Additionally, low resting heart rates were associated with child psychopathy, where heart rate explained a range of 7 – 14.5% of conduct disorder, impulsivity, and callous-unemotional traits (Choy et al., 2015).

Adoption Studies and Heritability

Characteristics of psychopathy are more common among individuals with relatives who also have the disorder compared to those within the general population (*DSM-V*, 2013). This suggests there may be a genetic component that may reflect a vulnerability to the characteristics of psychopathy. Adoption studies have highlighted the

genetic risk of developing psychopathic traits, specifically between the biological fathers and male offspring (Beaver, Rowland, Schwartz, & Nedelec, 2011; *DSM-V*, 2013). Male adoptees who had a biological criminal father had a predicted probability of scoring within the top 25% of psychopathic personality traits. However, female adoptees were found to have no relationship between a criminal mother or father and psychopathy (Beaver et al., 2011).

Twin studies consisting of mid- to late-adolescence have revealed a link between psychopathy and callousness, impulsivity, and antisocial behavior, suggesting a genetic component (Forsman et al., 2008; Larsson, Andershed, & Lichtenstein, 2006; Viding & McCrory, 2012). In a sample of adolescents and young adults, twin pairs and siblings were used to identify the prevalence of various personality and anxiety disorders, concluding that a brother of someone with conduct disorder is 38% as likely to be diagnosed with the same disorder, whereas a random male is only 26% as likely within the sample (Ehringer et al., 2006). Additionally, results from twin studies also exhibited 37% of the variance in latent psychopathic personalities were due to genetics (Forsman et al., 2008; Larsson et al., 2006). Psychopathic personality dimensions consisting of manipulation and grandiosity, callous-unemotional traits, impulsivity, and irresponsibility were found to be highly heritable, with estimates ranging from 0.40-0.60 (Larsson et al., 2006). Similar results were reported by Beaver and colleagues (2011), with somewhat lower heritability estimates, explaining between 37 – 44% of the variance in psychopathy (Beaver et al., 2011).

Hormones

Hormonal influences indicate a biological vulnerability that may occur as early as the prenatal stage of development. Prior research has found evidence that supports hormonal influences in relation to psychopathy (Glenn, Raine, Yu Gao, Schug, & Granger, 2011; Loomans, Tulen, Rijke, & Marle, 2016), suggesting the endocrine system, a system within the body responsible for hormone production, may play a factor in the influence of psychopathic traits. Testosterone, for example, has been identified as influencing various characteristics of psychopathic traits (Blanchard and Lyons, 2010; Probst, Golle, Lory, & Lobmaier, 2018; Romero-Martínez et al., 2013). For example, males with greater levels of testosterone showed a greater increase in anger and aggressive response to a threatening stimulus (Romero-Martínez et al., 2013), while females with higher testosterone levels were higher in reactive aggression in response to unfair offers, demonstrating that women with greater testosterone levels react more aggressively in response to provocation (Probst, Golle, Lory, & Lobmaier, 2018).

Testosterone is associated with greater physical risk-taking, sensation seeking, and aggression (Anderson, 2012; Breedlove, 2010; Hampson, Ellis, & Tenk, 2008). Men with low levels of testosterone are more likely to report depression, which decreases as testosterone levels increase (Booth et al., 2006). In addition, a meta-analysis of prenatal testosterone exposure in 32 studies drawing from 14 countries identified testosterone as a significant, albeit weak, contributor to aggressive and violent behavior across various methodological conditions (Turanovic, Pratt, & Piquero, 2017). Understanding differences in low and high androgen exposure on sexually dimorphic components may

help explain variations in male and female behavior, physical differences, and increased susceptibility toward various diseases.

Research on the influence of testosterone on psychopathy are somewhat mixed. For example, Loomans and colleagues (2016) found that individuals in psychopathic and ASPD groups showed higher testosterone and cortisol levels compared to controls. However, according to Glenn and colleagues (2011), testosterone alone was not significantly related to psychopathy. A relationship between high cortisol reactivity and a high ratio of baseline testosterone accounted for only 5% of psychopathic traits. Although testosterone was not found to be significant, it is important to consider the way testosterone was measured. Specifically, testosterone was obtained through saliva samples, reflecting current testosterone levels, and is not indicative of lifelong, prenatal testosterone. Blanchard and Lyons (2010) were one of the first to test whether prenatal testosterone was associated with psychopathic tendencies. Their results revealed that prenatal testosterone exposure was significantly predictive of psychopathy and callousness in females and males, respectively. The current study seeks to replicate and expand upon this prior research by using the Levenson's Self-Report Psychopathy scale to address separate components of psychopathy (i.e., primary and secondary) in order to identify any possible relationships with the digit ratio unique to that subset of characteristics within the construct. Because the LSRP has been identified as an accurate measurement for psychopathy (Sellbom, 2011), the differentiation between primary and secondary psychopathy may be useful when looking at the range of the scale.

Neurobiology

Neurobiological differences within the brain between youth who experienced callous-unemotional traits compared to those who did not, suggests lifelong biological influences that support the formation of later adult psychopathy (Herpers, et al., 2014). Lifelong biological influences include reduced response of the amygdala and weaker connectivity between the ventromedial prefrontal cortex in response to an emotional stimulus. The amygdala stimulates behaviors that are instinctual such as sex and aggression (Perez, 2012). It is believed these structures of the brain influence the processing of social information such as fear and recognition of emotion, enabling the continuation of aggressive behavior (Herpers et al., 2014).

Higher levels of prenatal androgens may result in the increased masculinization of the central nervous system, and contribute to higher levels of personal distress and increased testosterone in response to stress (Romero-Martínez et al., 2013). When neurotransmitters (i.e., electrical impulses that help with the transfer of information throughout the central nervous system) become imbalanced, results may cause personality disorders such as antisocial personality disorder (Perez, 2012). In addition, evidence suggests there is a link to lead exposure in childhood antisocial behavior throughout adolescence (Sampson & Winter, 2018), and psychopathic traits in adulthood resulting from damage to the central nervous system (Wright, Boisvert, & Vaske, 2009).

Prenatal Androgen Exposure

Androgens, such as testosterone, are a group of hormones associated with the development of male traits. Males on average produce more androgens, while females produce more estrogen. These sex hormones are necessary in human development,

specifically in the development of sex organs. In addition to contributions in the development of sex organs, it is suspected that androgens influence a variety of behavioral characteristics in both human and animal populations that are sexually dimorphic, such as social dominance, antisocial behavior, victimizing behavior, and aggression (Caramaschi, Booij, Petitclerc, Boivin, & Tremblay, 2012; Booth, Granger, Mazur, & Kivlighan, 2006; Ellis, 2005; Ellis & Hoskin, 2015b).

While in utero, a fetus may become exposed to different levels of androgens that are influenced by a variety of factors such as behavior, physicality, and personality characteristics. It is suspected that maternal stress, smoking, and alcohol consumption are prenatal factors that influence changes in prenatal androgen exposure as well (Barrett & Swan, 2015). Specifically, maternal stress or smoking may increase androgen exposure in utero, which in turn may have an effect on the individual later in life. Maternal stress in combination with alcohol consumption during pregnancy in animal samples revealed altered sensitivity to testosterone in male offspring in adulthood (Ward, Bennett, Ward, Hendricks, & French, 1999). Endocrine-disrupting chemicals (EDCs) found in the wildlife of contaminated ecosystems can act as an inhibitor or antagonist to androgen production, disrupting reproductive development (Earl Gray et al., 2006). Specifically, high androgenic activity may have enough potency to affect the sex of female fish by either masculinizing or reversing their sex, while steroid usage in cattle is shown to have an androgenic effect in utero by promoting growth of the animal for later consumption.

Although environmental and prenatal influences are suspected to contribute to androgen exposure in utero, evidence also suggests that it is highly heritable. Early studies on additive genetic variance that influence finger length estimate heritability

between .40-.70 (Ramesh & Murty, 1977). A separate study conducted by Harris, Vernon, and Boomsma (1998) found testosterone levels to be as high as 66% heritable in young men and 41% in women. Overall, research has demonstrated that a strong genetic component of prenatal androgen exposure (measured through the second- and fourth-digit ratio on the hand) exists whereby genes that effect the skeletal ratio of the hand may be important for both hand growth and hormone production (Paul, Kato, Cherkas, Andrew, & Spector, 2006). Taken together, research suggests that both environmental and genetic factors influence androgen exposure in utero.

Effects of Prenatal Androgen Exposure on Sex

Early androgen exposure poses risks and benefits to a fetus while in utero. For example, congenital adrenal hyperplasia (CAH) is a condition that occurs when an individual is exposed to an excess of prenatal androgens. Prenatal androgen excess in females with CAH may result in the masculinization of female atypical behavior and influence genital masculinization at birth, resulting in changes in behavior and physical appearance (Berenbaum, Duck, & Byrk, 2000; Brown, Hines, Fane, & Breedlove, 2002). However, when a female is exposed to significantly lower amounts of androgens in utero, she may become susceptible to Human Papilloma Virus (HPV) and increase the risk of cervical cancer as a result of hormonal factors that affect the host's immune system that protects against infection (Brabin, Roberts, Farzaneh, Fairbrother, & Kitchener, 2008).

Male and female physical differences as a result of androgen exposure are noticeable at birth, leading to an interest in the study of the brain and brain development related to prenatal androgens. Examining brain development in utero may help identify both structural and functional differences that lead to the 'masculinization' of the brain

through the exposure of prenatal androgens (Beaver & Nedelec, 2014). While no genetic sex differences were reported in heritability estimates, there remains a need to examine differences in biological influences across sexes specifically looking at psychopathic traits and androgen exposure in utero.

The 2D:4D Ratio

Testing prenatal androgen exposure while in utero is invasive and can result in risk of harm to the fetus, and therefore, is typically measured following birth. Prior research has indicated that the digit ratio between the second and fourth finger on the hand (i.e., the relationship between the ring and index finger) reflects the relationship between androgen and estrogen exposure in utero, known as the 2D:4D ratio (Anderson, 2012; Ellis & Hoskin, 2018; Beaver and Nedelec, 2014; Eichler et al., 2018; Manning, Stewart, Bundred, & Trivers, 2004; Zheng & Cohn, 2011), where a longer ring finger indicates greater testosterone exposure (Manning, 2002). Specifically, a longer ring finger (i.e., 4th digit) compared to the index finger (i.e., 2nd digit) is consider a low digit ratio and reflective of greater testosterone exposure, whereas a longer index finger in relationship to the ring finger is considered a large digit ratio and reflective of greater estrogen exposure. The relationship between the index and ring finger indicates either greater androgen or estrogen exposure, causing a masculinization or feminization of the 2D:4D ratio (Zheng & Cohn, 2011). Lower ratios have been found to be associated with criminal and antisocial behaviors (Ellis, 2015a, 2018; Hanoch, Gummerum, & Rolison, 2012; Romero-Martínez et al., 2013). *Figure 1* demonstrates what masculinized and feminized ratios on the hand look like.

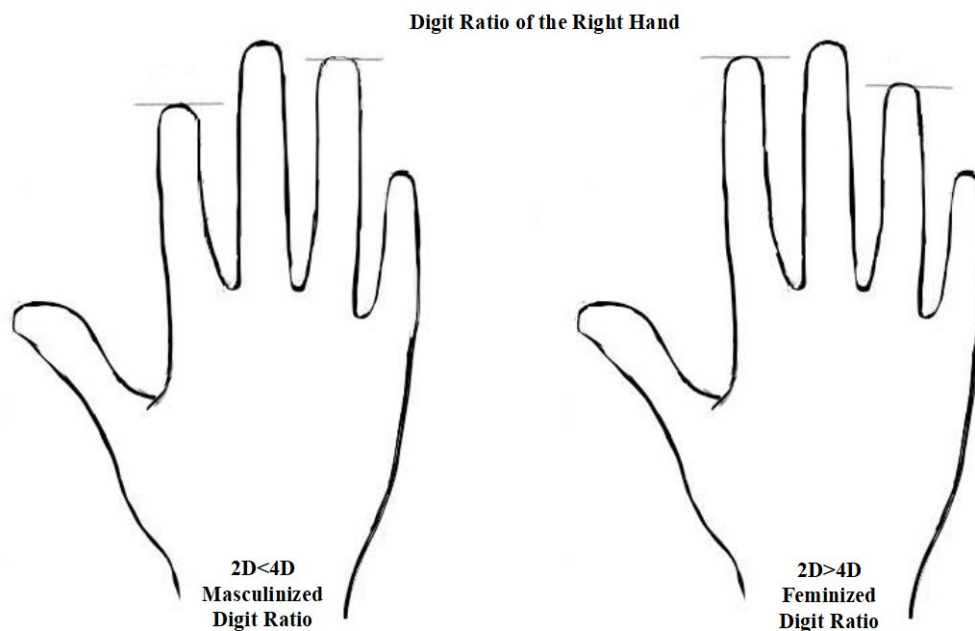


Figure 1. Masculinized and feminized digit ratios.

It is suspected that the 2D:4D ratio is established by the thirteenth week in the gestational period, and may vary within different populations (Barrett & Case, 2014; Brabin et al., 2008; Garn, Burdi, Babler, & Stinson, 1975). Digit ratios were found to be heritable (Gobrogge, Breedlove, & Klump, 2008); however, this may be attributed to the influence of prenatal androgens on genetics (Breedlove, 2010). A 2D:4D ratio that is less than 1.00 is considered masculinized, while a ratio that is greater than 1.00 is considered feminized (Schwarz, 2013). This measurement is considered an indirect biomarker, or proxy measure for prenatal testosterone (Anderson, 2012; Burton, Berenbaum, Bryk, Nowak, Quigley, & Moffat, 2009; Guterman, & Baum, 2013; Fink, Thanzami, Sewdel, & Manning, 2006; Yildirim & Derksen, 2012). However, it is important to note that although prior research has implicated larger ratios as feminized, numerous studies have found mean averages for males and females as being less than 1.00. A meta-analysis conducted by Hönekopp and Watson (2010) revealed that oftentimes both males and

females had a ratio less than 1.00, however, males had lower ratios compared to females in all studies. As a result, the 1.00 relationship between the two digits should be used as a guide to understanding the relationship between testosterone and estrogen exposure, rather than a dichotomous masculinized or feminized ratio; it should be viewed as a continuous measure with the lowest ratios representing the greatest level of prenatal androgen exposure. *Figure 2* highlights the significant differences in the 2D:4D ratio and characteristics of masculinized and feminized digit ratios.

Measuring the Digit Ratio

- ☐ The relationship between the 2nd (index finger) and 4th (ring finger) digit acts as a proxy measure for prenatal testosterone
- ☐ Research has used both the right and left hand to measure the 2D:4D
- ☐ A longer ring finger indicates greater testosterone exposure
- ☐ A longer index finger indicates greater estrogen exposure
- ☐ The second digit is divided by the fourth digit to collect the 2D:4D ratio
- ☐ Digit ratios that exceed 1 ($2D > 4D$) indicate a feminized ratio
- ☐ Digit ratios that are less than 1 ($2D < 4D$) indicate a masculinized ratio
- ☐ Low ratios ($2D < 4D$) are indicated in criminal behavior and antisocial tendencies

Figure 2. Summary of the 2D:4D Digit Ratio Measurement.

Using the 2D:4D ratio as a measurement for prenatal testosterone has been generally measured using the right hand (Butovskaya et al., 2010; Ellis & Hoskin, 2015a; Fink et al., 2006; Kiran et al., 2014; Manning, 2002). However, some studies have emphasized the effects using the left hand as well (Blanchard et al., 2016; Hönekopp, 2011; Liu, Portnoy, & Adrian, 2012; Romero-Martínez et al., 2013). Although studies

have found no significant differences between the left and right hand (Agnihotri et al., 2015; Barrett & Case, 2014; Brown et al., 2002; Burton et al., 2013; Blanchard, Lyons, & Centifanti, 2016), most research has focused on the right hand when measuring prenatal testosterone in human samples (Blanchard & Centifanti, 2017; Butovskaya et al., 2010; Fink, Manning, & Neave, 2004; Fink et al., 2006), or have suggested the right-hand is a better measurement for measuring prenatal testosterone as a result of greater variation due to a stronger testosterone effect compared to the left hand (Hönekopp & Watson, 2010).

The 2D:4D Ratio and Sexual Dimorphism in Animal and Human Studies

Prior research has indicated that the 2D:4D ratio is sexually dimorphic in both humans and animals (Agnihotri, Jowaheer, & Soodeen-Lalloo, 2015; Barrett & Case, 2014; Breedlove, 2010; Brown et al., 2002; Burton et al., 2013; Butovskaya, Burkova & Mabulla, 2010; Eichler et al., 2018; Ellis & Hoskin, 2018; Fink et al., 2006; Garbarino, Slonim, & Sydnor, 2011; Kiran, Potdar, Reddy, Shirkanthan, & Rajesh, 2014; Manning et al., 2004; Pratt, Turanovic, & Cullen, 2016; Uddin, 2013; Zheng & Cohn, 2011). Animal studies have demonstrated the effects of prenatal androgen exposure on sex-related behaviors and variations in brain development. The sexual dimorphism of mice is similar to humans, where the digit ratio of the hind limbs significantly differs based on testosterone and estrogen exposure. For example, findings on mice studies showed significant differences between the 2D:4D ratio between males and females. Zheng and Cohn (2011) further identified that when pregnant female mice were treated with estradiol (i.e., estrogen), it feminized the 2D:4D ratio in male offspring, showing how hormone production effects sexual dimorphism in utero. Specifically, the 4th digit is

decreased in males exposed to estradiol. This study was able to show how both androgen and estradiol influence the postnatal testosterone measure, suggesting the 2D:4D ratio is an effective measurement for prenatal testosterone exposure.

The relationship between androgen and estrogen exposure during embryonic development reveals the effects of sexual dimorphism found between males and females following birth (Zheng & Cohn, 2011). Specifically, men on average have lower ratios compared to females, indicating a greater increase in androgen exposure while in utero (Agnihotri et al., 2015; Blanchard & Lyons, 2010; Blanchard & Centifanti, 2017; Breedlove, 2010; Brown et al., 2002; Burton et al., 2013; Butovskaya et al., 2010; Fink et al., 2006; Garbarino et al., 2011; Hampson et al., 2008; Hönekopp, Manning, & Müller, 2006; Kiran et al., 2014; Manning et al., 2004; Zheng & Cohn, 2011). The second digit ratio is shorter in males due to the higher levels of testosterone exposure in utero, and either the same length or longer in females due to decreased testosterone exposure on average (Zheng & Cohn, 2011), where variations between males and females as well as within groups exist (Ellis & Hoskin, 2018). Additionally, sex differences in the 2D:4D ratio have also been observed between ethnic groups and countries (Blanchard et. al., 2016; Garbarino et al., 2011; Liu et al., 2012). Prior research has looked at both within and between ethnic groups when identifying sexual dimorphism of the digit ratio. Agnihotri and colleagues (2015) found significant differences between males and females, specifically looking at an Indo-Mauritian sample population. In a separate sample, white males exhibited a lower digit ratio and greater within group variability compared to other races (Barrett & Case, 2014). Adolescent women who identified as white had higher digit ratios (i.e., lower androgen exposure) compared to other ethnic

groups (Brabin et al., 2008). In addition, western male populations exhibited lower ratios compared to a Chinese sample conducted by Liu and colleagues (2012).

The endocrine system produces hundreds of hormones that interact with the nervous system that may influence later behaviors (Booth et al., 2006). The androgen receptor (AR) is more active, or higher in the digit 4 than in the digit 2, while less activation of the AR results in decreased growth of the 4th digit and causes a feminized digit ratio (Zheng & Cohn, 2011). This provides evidence that the 2D:4D ratio is a lifelong result of prenatal androgen exposure, and an indicator of changes that occurred within the endocrine system during early development that may moderate testosterone sensitivity and certain behaviors later in life (Breedlove, 2010; Wacker, Mueller, & Stemmler, 2013; Zheng and Cohn, 2011).

The 2D:4D Ratio and Behavior

It is suspected that androgens masculinize various behaviors early in development. A significant amount of literature indicates there is a relationship between the digit ratio and sexual dimorphism in humans, which may be explained by masculinizing the effects of prenatal androgens on behavior (Breedlove, 2010). If prenatal androgens are responsible for certain sex differences and behavior, then prenatal androgens accounting for individual variation should be affected by sex as well (Breedlove, 2010). Pratt and colleagues (2016) suggested that prenatal testosterone may be more important for males and not as important for females when it comes to behavior. Prior research suggests a low digit ratio may affect various human behaviors including: sexual orientation in females, Attention Deficit Disorder (ADD), aggression, risk taking (i.e., financial risks), impulsivity, and antisocial behaviors (Booth et al., 2006; Breedlove,

2010; Garbarino et al., 2011; Hampson et al., 2008; Hanoch, Gummerum, & Rolison, 2012; Hönekopp, 2011; Turanovic et al., 2017). Women who were diagnosed with Congenital adrenal hyperplasia (CAH) not only had a masculinized digit ratio, but displayed behaviors characteristic of males, such as boy-typical play¹ (Berenbaum et al., 2000). In addition, women with lower 2D:4D ratios were more likely to engage in physical risk taking, such as sky diving (Hampson et al., 2008).

It is hypothesized that testosterone plays an essential role in both competitive and victimizing behavior (Ellis, 2005). Testosterone levels in men increase before competition, continue to rise during the event, and remain high following the event after a win. Prior research has identified intimate partner violence (IPV) perpetrators as having higher basal testosterone rates in relation to greater levels of anger, anxiety, and a worsened mood (Romero-Martínez et al., 2013). Low ratios in the right hand were also related to increased anger expression and risk of IPV recidivism as well (Romero-Martínez, Lila, & Moya-Albiol, 2017).

Testosterone was linked to behavioral problems in boys that resulted in externalized risky behavior and an increased likelihood of symptoms of conduct disorder. (Booth et al., 2006; Eichler et al., 2018). In addition, the 2D:4D ratio was significantly lower for boys than for girls (Blanchard et al., 2017; Manning et al., 2004). Children who had higher ratios and who were exposed to greater levels of estrogen were more likely to show fewer externalizing behaviors, while children who were exposed to higher levels of prenatal testosterone were more likely to show greater externalizing behaviors (Blanchard

¹ Boy-typical play was measured by how long the child played with the toy, their choice of a “boy” or “girl” toy, and the activity type.

et al., 2017). The relationship between a low ratio and gender found that boys exhibited greater externalizing behaviors and problems compared to girls (Liu, et al., 2012).

Although various human behaviors were found to be significantly related to the 2D:4D ratio, results varied based on sex. For example, prenatal testosterone was found to effect aggression levels for males while influencing risk-taking behaviors for females (Hönekopp, 2011). Males were more likely to report verbal aggression with a low left-hand digit ratio, where no relationship was found with women. Conversely, a low right digit ratio for women corresponded to greater risk-taking behavior and greater crime association (Hönekopp, 2011; Hoskin & Ellis, 2014). Although aggression was found to be correlated with a low digit ratio in males, research has also found significant differences between females with a low digit ratio compared to control samples. A negative correlation between the digit ratio on aggression and sensation seeking for males and females was identified, suggesting personality may be influenced by the endocrine system (Hampson et al., 2008).

Ellis and Hoskin (2015b) hypothesized that the brain's exposure to androgens increases the involvement of criminal behavior for both sexes due to the pain reducing and anxiety reducing effects of testosterone on the brain, suggesting androgen exposure in utero contributes to offending behavior through risk taking. Due to the effect androgens have on the brain, this in turn allows individuals to accept adverse effects their decisions may have regarding the consequences that are associated with risky behaviors (Ellis, 2015). Males are significantly more likely to commit crimes of all types, regardless of geographic location, culture, or age, compared to females, suggesting that males pose a vulnerability to aggression and rule-breaking as a result of their sex, and have evolved in

ways that suggest males engage in behaviors that may increase their reproductive opportunities (Ellis, 2005, 2017). If prenatal androgen exposure influences offending behavior, then I would expect there to be greater rates of offending amongst males compared to females, due to increased levels of testosterone found in males.

The influence of prenatal testosterone may help identify a cause for significant differences between males and females as it relates to antisocial behaviors. Wilson and Daly (1985) identified homicide rates as being overwhelmingly committed by males, where they also committed 93% of robberies, 94% burglaries, and 91% of motor vehicle thefts in 1980. When looking at crime categories, males and females reported significantly higher crime rates on all types of crime, where crime was negatively associated with a low right hand 2D:4D ratio (Hoskin & Ellis, 2014). These results indicate that exposure to prenatal testosterone may increase an individual's likelihood of participating in a variety of offenses, where lower ratios increase the likelihood of behavior deemed antisocial and/or criminal (Hanoch et al., 2012). In a separate study, Wacker and colleagues (2013) sampled 203 young males between the ages of 20 – 35 years, and found that prenatal testosterone may predict various personality traits in men due to their lower digit ratios in comparison to women. Offenses associated with a lower ratio on the right hand include reckless driving, illegal drug use, gambling, vandalism, finance-related offenses, minor vandalism, assault, and illegal drug distribution for the entire sample (Ellis & Hoskin, 2014). It is expected that individuals who have lower ratios are more likely to engage in antisocial behaviors. Furthermore, lower 2D:4D ratios have found to be significantly correlated with self-reported offending, suggesting that the

2D:4D ratio may hold as a biomarker for criminality and other various types of behavior (Booth et al., 2006; Ellis & Hoskin, 2018).

2D:4D Ratio and Psychopathy

Prior research has indicated testosterone may impair certain socio-cognitive abilities in men, and influence variations between individuals who show psychopathic traits compared to those who do not (Carré et al., 2015). Identifying mechanisms within the neuroendocrine system may help us understand individual differences in human behavior and the influence of testosterone on personality. The digit ratio and psychopathy should be further investigated in order to better understand the influence of hormones on specific personality characteristics that have been identified as risk factors to criminal behavior. A link between the digit ratio with impulsivity and antisocial behaviors suggests there may be an association between the 2D:4D ratio and psychopathy (Hanoch et al., 2012). The digit ratio may be indirectly associated with antisocial behaviors resulting from a lack of empathy and the facilitation of violence, and lead to a higher risk in the development of psychopathic traits (Yildirim & Derksen, 2012).

Two studies have looked at the effects of the digit ratio on psychopathic characteristics. Blanchard and Lyons (2010) sampled 54 participants (30 males and 24 females) and found that larger 2D:4D ratios (indicating high levels of prenatal estrogen) were positively correlated with psychopathy for females. These findings were contrary to their prediction since greater levels of testosterone (i.e., lower ratios) have been linked to characteristics identified within psychopathy and criminality, as well as antisocial behaviors in previous studies (Blanchard et al., 2016; Ellis, 2015a, 2018; Hanoch et al., 2012; Romero-Martínez et al., 2013; Yildirim & Derksen, 2012). Blanchard and Lyons

(2010) conclude that estrogen may play a factor in the development of psychopathy for females where prenatal estrogen has an organizational effect on the brain early in development. Additionally, a significant relationship for a callous effect for males with lower right-hand digit ratio identifies a component of psychopathy that may be affected by prenatal androgen exposure.

A separate study has since identified low ratios on the left hand as being predictive of primary and secondary psychopathy for women in a sample of 67 males and 81 females (Blanchard et al., 2016). Specifically, a low left and right-hand digit ratio predicted both primary and secondary psychopathy in females, while no relationship was found for males. The authors suggest hormone levels either play a greater role in the female fetus compared to males, or reflect a measurement of psychopathy that is not an accurate measurement for females (Blanchard et al., 2016).

Although the previous study found a relationship between the 2D:4D ratio and psychopathy for females and callousness for males, results may be due to a number of factors. The sample size in the Blanchard and Lyons (2010) study only contained 54 participants while Blanchard and colleagues (2016) contained 148 total participants. Blanchard and Lyons (2016) measures psychopathy through the Self-Report Psychopathy Scale III (SRP-III) through a two-factor model of primary and secondary psychopathy. However, it has been suggested that the SRP-III may be best suited as a four-factor model (i.e., interpersonal, affective, lifestyle, and antisocial tendencies) compared to a two-factor as a result of the scale being structured as a four-factor model (Gordts, Uzieblo, Neumann, Van den Bussche, & Rossi, 2017; Neal & Sellbom, 2012; Williams, Paulhus, & Hare, 2007). In addition, snowball sampling was used (Blanchard & Lyons, 2016). The

current study uses the LSRP, which has been identified as a good measure for primary and secondary psychopathy (Yildirim & Derksen, 2015).

The Current Study

By investigating the relationship between the 2D:4D ratio and psychopathy, as well as the differences between males and females, we may be able understand the biological vulnerabilities that contribute to characteristics that are associated with crime and delinquency. Due to the relationship of prenatal androgens on personality characteristics vulnerable to biological influences, we expect the 2D:4D ratio to have an effect on adult psychopathy. Because the 2D:4D ratio is a proxy measure for early testosterone exposure, we would expect to see a positive correlation between prenatal testosterone and psychopathy. This study will also seek to identify the differences between masculinized and feminized ratios with primary and secondary psychopathy, while controlling for age, race, parental criminality, and child sexual and physical abuse. This would account for possible early environmental factors that may result in greater psychopathy scores (Dembo et al., 2007; Schraft et al., 2013), and possible biological factors as a result of heredity (Beaver et al., 2011; *DSM-V*, 2013). In addition, we would expect to see sex differences on the influence of prenatal testosterone and its effects on psychopathy, where males who are on average exposed to greater testosterone will have significantly lower right-hand digit ratios compared to females. This study would be the largest study to analyze the relationship between the 2D:4D ratio and psychopathy by sex.

Hypothesis 1: There will be a negative correlation between the 2D:4D digit ratio and psychopathy, where masculinized ratios are associated with greater psychopathy.

Hypothesis 1. A.: The relationship between the 2D:4D ratio and psychopathy will remain significant after controlling for race, age, sex, parental criminality, and child sexual and physical abuse.

Hypothesis 2: There will be a stronger negative relationship between the 2D:4D digit ratio and psychopathy for males compared to females.

Hypothesis 2. A.: The relationship between the 2D:4D ratio and psychopathy by sex will remain significant after controlling for race, age, parental criminality, and child sexual and physical abuse.

CHAPTER III

Methods

Data

The data for the current study included undergraduate students from a Southwestern university during the fall of 2016. Participants were selected based off enrollment in introductory criminal justice courses. Because characteristics of psychopathy tend to decline around the fourth decade (*DSM-V*, 2013), studying young adults may provide useful information for this personality construct (see Blanchard & Lyons, 2010; Blanchard et al., 2016). In addition, prior research has identified greater rates of psychopathic tendencies in males compared to females in college samples (Blanchard & Lyons, 2010; Lee & Salekin, 2010), therefore disaggregating by sex was an essential component to the current study. Lastly, identifying a masculinized or feminized digit ratio in relation to sex was essential due to males on average having lower digit ratios compared to females (Agnihotri et al., 2015; Blanchard & Lyons, 2010; Blanchard & Centifanti, 2017; Breedlove, 2010; Brown et al., 2002; Burton et al., 2013; Butovskaya et al., 2010; Fink et al., 2006; Garbarino et al., 2011; Hampson et al., 2008; Hönekopp, Manning, & Müller, 2006; Kiran et al., 2014; Manning et al., 2004; Zheng & Cohn, 2011).

The data were collected through two separate steps that included a paper and pencil in-class survey, followed by an individual, laboratory setting to collect biological data from each participant. A total of 862 participants completed the in-class self-report survey. Students were then verbally notified, followed by an email from their course

instructor, regarding a follow-up lab portion of the survey². Approximately 66% of students who completed the in-class survey scheduled a time to come to the lab ($N = 567$). The laboratory measurements included data on heart rate, skin conductance, saliva samples to capture cortisol and testosterone, DNA, facial symmetry, and information on various types of dietary, exercise, and sleep habits. Additionally, researchers included a measure of the digit ratio on both the right and left hand. Because prior research has focused on the right hand when measuring prenatal testosterone (Butovskaya et al., 2010; Fink, Manning, & Neave, 2004; Fink et al., 2006), the current study has chosen to address the potential relationship between the right hand 2D:4D ratio and psychopathy. Students who participated in the right 2D:4D measurement consisted of a total of 533 participants. This discrepancy from the total lab portion of the data and the recorded right-hand digit ratio was a result of some students declining to give their digit ratio measurement³.

This final analytical sample ($n = 533$) comprised approximately 67% female and 33% male who identified as either white (62%) or nonwhite (38%). The age of the participants ranged from 18 to 49 years, with a mean of 20 years of age ($S.D. = 3.08$). After accounting for the participants that participated in the survey and bio portion of the data specific to the 2D:4D ratio ($N = 533$), list-wise deletion was used to remove all missing data from the control variables in addition to the 2D:4D ratio, reducing the analytical sample to $N = 430$. Grand mean substitution⁴ was then used for both primary

² Students were offered extra credit for their participation. Extra credit ranged from 2 – 5 points based on their participation in the study or an alternative assignment was provided by the instructor.

³ Some students refused to give their digit measurements due to a fear that the lab was collecting their fingerprints.

⁴ Grand mean substitution was used for the dependent variable of both primary and secondary psychopathy in order to increase the sample size. This resulted in an additional 51 participants. However,

and secondary psychopathy. In addition, multicollinearity did not appear to be a problem within the sample. All variance inflation factors were under 2. Table 1 provides the demographic variables for all measures of interest.

Table 1

Descriptive statistics of the analytic sample (N = 430)

Variables	Mean (%)	S.D.	Range
Dependent Variable			
Primary Psychopathy	13.29	5.95	1 – 34
Males	15.40	5.96	1 – 34
Females	12.27	5.68	1 – 32
Secondary Psychopathy	9.90	4.11	0 – 21
Males	10.59	3.76	1 – 19
Females	9.56	4.23	0 – 21
Independent Variables			
Right 2D:4D Ratio	0.97	0.03	0.88 – 1.09
Males	.97	.02	.91 – 1.05
Females	.98	.03	.88 – 1.09
Female	67.44%		0 – 1
Age	20.28	3.08	18 – 49
Nonwhite	61.86%		0 – 1
Child Sexual Abuse	7.91%		0 – 1
Child Physical Abuse	7.67%		0 – 1
Parental Criminality	27.44%		0 – 2

list-wise deletion was used for the independent variable of the right 2D:4D ratio, gender, age, and race/ethnicity.

Measures

Psychopathy

The Levenson self-report psychopathy (LSRP) scale is often used to measure different factors that encompass psychopathy (i.e., callousness, egocentricity, and narcissism). The LSRP has been found to be an accurate measure of psychopathy (Sellbom, 2011). The LSRP consists of 16 items measuring primary psychopathy that identify core personality features such as selfishness and manipulation, and 10 items that assess secondary psychopathy in the form of antisocial behavior, such as impulsivity or a self-defeating lifestyle (Bate et al., 2014; Levenson et al., 1995). Because the LSRP differentiates between primary and secondary psychopathy within the scale, it has become more popular when measuring the full range of the psychopathy construct (Yildirim & Derksen, 2015).

As such, the current study used the Levenson's Self-Report Psychopathy scale (LSRP), where higher scores correspond with greater levels of psychopathy. Specifically, participant self-reported psychopathy was captured by 26 items from the LSRP, where 16 of the items captured primary psychopathy ($\alpha = 0.82$, $M = 9.90$, $S.D. = 5.95$, $Range = 1 - 34$) and 10 items captured secondary psychopathy ($\alpha = 0.71$, $M = 9.82$, $S.D. = 4.11$, $Range = 0 - 21$). All items can be viewed in Appendix A. Responses were based off a 4 – point Likert scale (0 = Strongly Disagree, 1 = Disagree Somewhat, 2 = Agree Somewhat, 3 = Strongly Agree). The total psychopathy measure reflects qualities of callous unemotional traits, deceitfulness, impulsivity, a self-defeating lifestyle, victim-blaming, and antisocial behavior ($\alpha = 0.85$, $M = 25.30$, $S.D. = 9.23$, $Range = 1 - 53$) (Bate et al., 2014; Sellbom, 2011; Levenson et al., 1995). In order to address primary and secondary

psychopathy within the LSRP, factor analyses were used using a .30 factor loading as the threshold (Levenson et al., 1995). Factor analyses revealed that, with the exception of 2 items, primary psychopathy loaded onto one factor⁵. All of the items for secondary psychopathy loaded onto one factor as well.

Independent Variables

2D:4D Ratio

The 2D:4D ratio ($M = 0.97$, $S.D. = 0.03$, $Range = 0.88 - 1.09$) is a continuous measure obtained by scanning the participants hand and measuring the difference between the 2nd digit with the 4th digit. The 2D:4D ratio was obtained and measured through ImageJ, a computer assisted-software, after the participant's hand was scanned. Digit ratios can be obtained by hand scans or by photocopying an individual's hand in order obtain precise measurements that identify prenatal testosterone exposure (Anderson, 2012; Blanchard & Lyons, 2016; Blanchard & Lyons, 2010; Carré et al., 2015; Fink et al., 2006; Hampson et al., 2008; Romero-Martínez et al., 2013). Individuals with a 2nd and 4th digit that are equal to each other represent a ratio of 1.00. Ratios less than 1.00 are considered masculinized, while ratios greater than 1.00 are considered feminized.

Control Variables

Sex was dichotomized (0 = *male*, 1 = *female*) in order to identify whether the 2D:4D ratio has varying effects between males and females on psychopathy. Individuals who did not identify their sex or identified as transgender ($n = 2$) were removed from the

⁵ The two items that did not load onto one factor were dropped from the measure. These items consisted of "I would be upset if my success came at someone else's expense" and "I make it a point of trying not to hurt others in pursuit of my goals".

data prior to the analyses. Parental criminality identified any prior arrest by the participant's mother or father (0 = no arrest history, 1 = one parent with an arrest history, 2 = both parents with an arrest history). Child sexual abuse and physical abuse were dichotomized as two separate control variables to identify sexual and physical abuse experienced prior to 18 years of age (0 = no, 1 = yes). Additional control variables include age ($M = 20.28$, $S.D. = 3.08$, $Range = 18 - 49$) and race/ethnicity (0 = White, 1 = Nonwhite).

Analytic Strategy

In order to address the proposed research questions, the analyses will be performed in three steps. First, an examination of sex differences on key variables, such as the 2D:4D ratio and psychopathy will be examined via t-tests. Next, Pearson's correlations between the 2D:4D ratio and the two psychopathy factors will be conducted for the full sample to address hypothesis one, then disaggregated by sex to address hypothesis two. If results reveal a significant relationship between 2D:4D and psychopathy for both males and females, a comparison of coefficients test using the Fisher r-to-z transformation will then be conducted to determine whether the magnitude of the relationship significantly differs across sex for hypothesis two. Following this, regression analyses will be performed to further examine the relationship between prenatal testosterone levels (e.g., 2D:4D ratio) and levels of psychopathy while controlling for age, sex, parental criminality, child physical and sexual abuse, and race/ethnicity to address the second part of hypothesis one and hypothesis two⁶.

⁶ The left-hand digit ratio and average digit ratio between the left and right hand were observed within the sample. A Pearson's correlation revealed that they were highly correlated ($p < .001$), and therefore, used only the right-hand digit ratio for the study.

CHAPTER IV

Results

Difference of means tests on the measures of psychopathy by sex reveal that men, on average, report greater primary ($t = 5.27; p < .001$) and secondary ($t = 2.46; p < 0.05$) psychopathy in comparison to women. In addition, males had on average significantly lower 2D:4D ratios ($t = -3.44; p < .001$) relative to females. Pearson's correlation coefficients among the full sample revealed a significantly negative relationship between the 2D:4D ratio and primary psychopathy ($r = -0.10, p < .05$), whereby individuals with lower ratios were significantly more likely to report primary psychopathy. There was, however, no significant bivariate relationship between secondary psychopathy and the 2D:4D ratio for the full sample when addressing hypothesis one ($r = -0.01, p > .05$).

When examining these bivariate relationships by sex, the results reveal that within the male subsample, secondary psychopathy was significantly and negatively correlated with the 2D:4D ratio for hypothesis two ($r = -0.19, p < .05$). This indicates that males with more masculinized digit ratios may report greater levels of secondary psychopathy. For the female sample, the 2D:4D ratio was not significantly correlated with either primary ($r = -0.03, p > .05$) or secondary ($r = 0.07, p > .05$) psychopathy.

Table 2 presents the results from the multivariate linear regression analyses using the full sample to address the second part of hypothesis one. As seen in Table 2, the 2D:4D ratio was no longer significantly associated with primary psychopathy once controlling for sex, race, age, child sex abuse, child physical abuse, and parental criminality. Sex, ($b = -3.13, t = -5.17, p < .001$), race ($b = 1.72, t = 2.97, p < .01$), and age ($b = -0.25, t = -2.84, p < .01$) were, however, significant predictors of primary

psychopathy. In addition, the 2D:4D ratio was not significantly associated with secondary psychopathy, but sex ($b = -0.97$, $t = -2.23$, $p < .05$) and age ($b = -0.14$, $t = -2.20$, $p < .05$) were significant predictors.

Table 2

Multivariate regression measuring primary and secondary psychopathy for the full sample ($N = 430$)

Variable	Primary Psychopathy		Secondary Psychopathy	
	<i>b</i>	SE	<i>b</i>	SE
R2D:4D	-8.03	10.65	1.61	1.68
Sex	-3.13***	0.01	-0.97*	0.44
Nonwhite	1.72**	0.58	-0.07	0.42
Age	-0.25**	0.09	-0.14*	0.06
Child Sex Abuse	-0.64	1.11	-0.77	0.78
Child Physical Abuse	0.027	1.11	-0.02	0.80
Parental Criminality	0.12	0.49	-0.05	0.35

* $p < .05$, ** $p < .01$, *** $p < .001$

Results for the multivariate regression analyses by sex are presented in Table 3, addressing the second part of hypothesis two. Results reveal that the 2D:4D ratio ($b = -27.23$, $t = -2.04$, $p < .05$) remained significantly associated with secondary psychopathy for males while controlling for race, age, child sex abuse, child physical abuse, and parental criminality. When assessing primary psychopathy by sex, the analyses revealed that only race ($b = 2.11$, $t = 2.00$, $p < .05$) was a significant predictor in males with nonwhites reporting significantly more symptoms of primary psychopathy. For females,

on the other hand, both age ($b = -0.27, t = -2.78, p < .01$) and race ($b = 1.59, t = 2.28, p < .05$) were significant predictors, with younger nonwhite respondents reporting higher levels of primary psychopathy.

Table 3

Multivariate regression analyses between 2D:4D and primary and secondary psychopathy by sex

Variable	Primary Psychopathy				Secondary Psychopathy			
	Males (N=140)		Females (N=290)		Males (N=140)		Females (N=290)	
	<i>b</i>	SE	<i>b</i>	SE	<i>b</i>	SE	<i>b</i>	SE
R2D:4D	-27.02	21.07	0.20	12.37	-27.23*	13.35	13.22	9.39
Nonwhite	2.11*	1.08	1.59*	0.70	-0.25	0.67	0.19	0.53
Age	-0.18	0.22	-0.27**	0.10	-0.23	0.14	-0.12	0.07
Child Sex Abuse	-4.55	4.20	-0.40	1.16	-1.69	2.66	-0.90	0.88
Child Physical Abuse	0.75	2.49	-0.05	1.25	-1.05	1.58	0.30	0.95
Parental Criminality	-1.31	1.03	0.58	0.55	-0.33	0.65	0.10	0.42

* $p < .05$

CHAPTER V

Discussion

This study investigated the relationship between prenatal testosterone and primary and secondary psychopathy by sex. Results remain consistent with prior literature, suggesting that males are more likely to exhibit primary (Bates et al., 2017) and secondary psychopathy compared to females (Blanchard et al., 2016; Lee & Salekin, 2010; Marion & Sellbom, 2011). For instance, Marion and Sellbom (2011) sampled approximately 400 undergraduate students between the ages of 18 and 56 years, and found that males not only scored higher in primary psychopathy identified by the LSRP, but scored higher in aggressiveness, antisocial behavioral features, narcissism, sensation seeking, and disinhibition in comparison to females, while females scored higher in emotional empathy. In a separate undergraduate sample, males were identified as scoring significantly higher within subtypes of secondary psychopathy, with men scoring higher on dimensions of egocentricity, cold-heartedness, fearlessness, blame externalization, reduced stress, and impulsivity (Lee & Salekin, 2010). These results suggest males are more likely to reflect characteristics of both primary and secondary psychopathy in comparison to females.

The current study provided additional evidence that identifies males as having significantly lower digit ratios compared to females, as indicated by prior literature (Agnihotri et al., 2015; Blanchard & Lyons, 2010; Blanchard et al., 2016; Breedlove, 2010; Brown et al., 2002; Fink et al., 2004; Garbarino et al., 2011; Hönekopp et al., 2006; Hönekopp & Watson, 2010; Manning et al., 2004; Zheng & Cohn, 2011). It is important to reiterate that it has been suggested that digit ratios should be treated as a continuum

with the lowest digit ratios representing greater testosterone exposure rather than dichotomous categories of “masculinized” and “feminized” (Hönekopp & Watson, 2010). Almost 82% of females within the current sample had 2D:4D ratios less than 1 (which would be considered “masculinized”) compared to 90% of males. The t-test results did reveal, however, a significant difference between the two where males had significantly lower digit ratios compared to females. Hönekopp and Watson (2010) identified numerous studies where females exhibited ratios less than 1.00. Specifically, across 116 studies from numerous countries, less than 10 identified a mean average digit ratio in women that was equal to or greater than one. This suggests that the digit ratio should be looked at more so as a continuum with the lowest ratios indicating greater prenatal testosterone.

Our results also align with ENA theory, which states that males should have the lowest 2D:4D measurements due to increased exposure to androgens in utero, which may then in turn affect various personality characteristics and behaviors that are reliant on neurohormonal influences and neuroandrogenic effects (Ellis, 2001; Ellis & Hoskin, 2015b; Ellis et al., 2015). In fact, our results reveal a significant correlation between males and the 2D:4D ratio, where lower digit ratios are correlated with secondary psychopathy. The multivariate regression analysis further revealed the importance of the 2D:4D ratio as a significant predictor of secondary psychopathy in males, while controlling for sex, race, age, child sex abuse, child physical abuse, and parental criminality. This suggests that because males are generally exposed to greater levels of prenatal androgens, specifically testosterone, they may be more susceptible to its effects and therefore, holds more influence over behavioral and antisocial features. More

specifically, males may be vulnerable to early biological influences that could affect characteristics that influence competitive and victimizing behaviors or qualities and account for greater criminal and antisocial behavior (Ellis, 2001, 2005, 2017; Ellis & Das, 2013; Ellis et al., 2015). In other words, males may be more susceptible to early influences of testosterone as a result of increased exposure in a way that promotes competitive and victimizing behaviors and traits that seemingly overlap with characteristics of secondary psychopathy.

From an ENA perspective, these findings may further explain why males are more likely to engage in crime (Ellis, 2005; Ellis, 2017). That is, males may be at an increased likelihood of engaging in victimizing behaviors as a consequence of increased prenatal testosterone exposure (Ellis, 2001, 2005, 2017; Ellis & Das, 2013; Ellis et al., 2015), identified within the psychopathic personality that is specific to antisocial tendencies. ENA theory contains two components: an evolutionary component on how behaviors associated with criminality have come to exist, and a neurohormonal component of why these behaviors exist (Ellis & Hoskin, 2015b). In other words, prenatal androgens provide the neurohormonal component of why behaviors may exist while unacceptable forms of resource acquisition to improve reproductive success in combination with a female mating bias (i.e., female mating choices made toward mate selection in response to male behaviors) provide the evolutionary process (Ellis, 2001; Ellis & Hoskin, 2014; 2015b). As a result of neuroandrogenic influences, the brains exposure to androgens influence how the brain functions through cognition, learning, and emotionality that later effect behavior through antisocial tendencies and criminality (Hoskin & Ellis, 2015b); characteristics observed within secondary psychopathy.

Although the current study did not find a significant relationship between the 2D:4D ratio and psychopathy for females, prior research has shown that the digit ratio may have an effect on various personality characteristics in women (Fink et al., 2004). For example, variations between males and females have been observed in prior studies that identify the influence of prenatal testosterone on personality (Burton et al., 2013; Fink et al., 2004), including the 'Big Five' personality types (i.e., neuroticism, conscientiousness, agreeableness, openness, and extroversion). For instance, neuroticism (e.g., experience greater negative thoughts and feelings) has been positively related to a feminized digit ratio (Burton et al., 2013; Fink et al., 2004), and openness has been found to be associated with a higher 2D:4D ratio as well (Burton et al., 2013). Scoring high in these personality characteristics would potentially be characterized by decreased testosterone exposure. More specifically, testosterone may produce both pain- and anxiety- reducing effects through early exposure within the brain (Ellis & Hoskin, 2015b; Ellis et al., 2015), leading these personality characteristics to be associated with greater estrogen exposure. Additionally, Fink and colleagues (2004) found that women showed a significant negative association between the digit ratio and agreeableness, where masculinized ratios reported higher agreeableness. Although agreeableness was not as predicted, this may be a result of unclear contributions of hormones and sex differences in behavior that are not clearly expressed in personality models (Fink et al., 2004). It is also important to note that not all personality characteristics or behaviors may be accurately measured by the digit ratio, but by only those that may be influenced by early testosterone influence. Although agreeableness may have produced inconsistent results, characteristics such as competitiveness, sensation-seeking, and risk taking may be

influenced by the brain's exposure to androgens that promote these behaviors (Ellis & Hoskin, 2015b).

Identifying associations between personality traits and behavioral patterns may help distinguish traits that are affected by endocrine influences during development. Increased androgen exposure may affect the brain circuitry involved in specific personality traits, suggesting personality may be attributed to androgen exposure. However, this may only hold true for personality types with a biological significance that are subject to the effects of the endocrine system (Hampson et al., 2008), such as aggression, impulsivity, sensation-seeking, and assertiveness that includes dominance behaviors that are related to gaining and maintaining social status (Booth et al., 2006; Wacker et al., 2013). These behaviors could in turn result in competitive and victimizing behaviors in order for males to maintain dominance and social status, where competition exists as a continuum marked by acceptable or unacceptable actions to attract mates (Ellis, 2005; Ellis & Hoskin, 2014; 2015b). This may then result in males being more inclined to engage in risky behaviors or antisocial lifestyles identified within secondary psychopathy as a result of evolutionary processes to increase reproductive opportunities.

Limitations and Future Research

The current study is not without its limitations. First, the study used an undergraduate student sample, specifically students who were enrolled in criminal justice courses. While other studies have also relied on college samples when studying psychopathy (Blanchard and Lyons, 2010; Bate et al., 2014; Blanchard et al., 2016; Lee & Selekin, 2010; Levenson et al., 1995; Williams et al., 2007), the results presented within should be interpreted with caution as they are not generalizable to other

populations. As such, future studies should evaluate different populations other than college samples, including incarcerated samples through adolescent and adult populations, vary on geographical location and country to control for culture and differences between race and ethnicity, conduct twin samples or relationships between parent and offspring to look at heritability influences, and look at the general population, such as adults who were not sampled from one college or university.

Next, the current study measures psychopathy through a two-factor model of primary and secondary psychopathy as done by prior literature who have used undergraduate samples (Blanchard et al., 2016; Lee & Salekin, 2010; Levenson et al., 1995); however, research suggests using a three- or four-factor model may be preferred when measuring female psychopathy, specifically when it comes to incarcerated women (Brinkley et al., 2008; Sellbom, 2011). Three- or four- factor models have been used in incarcerated samples as a way of incorporating antisocial and criminal behavior seen within incarcerated samples as compared to undergraduate populations (Hare, 2003; Sellbom, 2011). When using a two-factor model, the first factor identifies interpersonal and affective facets that reflect core personality features such as a lack of guilt or remorse, selfishness, manipulation, and deceitfulness (Hare, 2003; Levenson et al., 1995); all of which could be captured with undergraduate samples as they do not reflect criminal behavior typically seen within these samples. Factor two identifies an antisocial facet (i.e., rule-breaking, violent, drug use, or other forms of criminal behavior) and lifestyle facet (i.e., recklessness, sensation-seeking, and impulsivity) (Bate et al., 2014; Hare, 2003; Levenson et al., 1995). By using a two-factor model, research can still capture characteristics found within these two factors, however, there is less emphasis placed on

criminal behavior and rule-breaking (i.e., antisocial facet), as it may not be as pertinent to an undergraduate sample as compared to incarcerated samples. This may be why a two-factor model is well suited for undergraduate populations. Despite this, factor 1 still contains an interpersonal facet and affective facet that are relevant to different populations as they are both marked by core personality features. As a result, the LSRP should be investigated using a three-factor model to incorporate facets of personality (e.g., egocentricity, callousness) and behavior (e.g., antisocial features) when looking at the digit ratio in relation to psychopathy for undergraduate samples to identify differences in primary psychopathy. In addition, a four-factor model should be investigated to identify differences within secondary psychopathy as well. By using a four-factor model as a measurement of psychopathy, this would further break down individual characteristics such as the lifestyle or antisocial facet within the psychopathic personality identified within secondary psychopathy that may be susceptible to prenatal testosterone and endocrine influence.

Lastly, it is also important to note that the digit ratio is only a proxy measure for prenatal testosterone (Anderson, 2012; Burton et al., 2013; Fink et al., 2006; Yildirim & Derksen, 2012). As such, using the 2D:4D ratio as a biomarker for prenatal testosterone and its influence on behavior and personality should be taken with caution (Turanovic et al., 2017; Uddin, 2013). One criticism to using the digit ratio as a proxy measure for prenatal testosterone is that digit ratios may not only be affected by prenatal androgens, but rather genetics, suggesting heritability rather than androgenic effect in fetal development (Breedlove, 2010; Gobrogge et al., 2008). However, this is not surprising being that androgens may regulate gene expression, therefore influencing the digit ratio

(Breedlove, 2010). In addition, research has justified the use of the digit ratio as a good measurement for prenatal testosterone as a result of prior analyses being unable to accurately classify an individual by sex based off the digit ratio alone, but rather to compare differences between groups, through correlations (Breedlove, 2010; Berenbaum et al., 2009). Individuals were observed between groups using the left and right 2D:4D ratio for control men and women, and individuals with androgen insensitivity syndrome (CAIS) (i.e., individuals who have no exposure to prenatal androgens in utero and would therefore reflect feminized digit ratios) to identify differences between the digit ratio as a measurement compared to individuals who have had no androgen exposure, rather than sex differences (Berenbaum et al., 2009). Results revealed men had lower digit ratios than women, while within the female sample, women with CAIS had the most feminized digit ratios, although not significant suggesting prenatal androgen exposure may be measured by the digit ratio as a result of variability between groups (Berenbaum et al., 2009).

Conclusion

This study is the largest study to analyze the relationship between the 2D:4D ratio and psychopathy by sex. The results provide evidence in support of ENA theory and prenatal testosterone influence to explain the sexual dimorphism found within the psychopathy construct. Specifically, the current research identified a significant relationship between the 2D:4D ratio and secondary psychopathy for males indicating that greater exposure to prenatal testosterone in males may lead to the increased likelihood in engaging in antisocial tendencies or a self-defeating lifestyle, including impulsive behavior, drug abuse, preference for rule-breaking, sensation-seeking, and

overall irresponsibility. This study provides evidence that males who tend to have greater amounts of prenatal testosterone are more susceptible to competitive and victimizing behaviors found within the secondary psychopathic characteristics. This may help explain the evolution of psychopathic tendencies as it pertains to antisocial behaviors in males through neurohormonal and prenatal androgenic influences observed within a construct that is sexually dimorphic, and emphasizes male competition and victimizing behaviors in order to gain resources and improve mating opportunities. In addition, different components within the psychopathy construct may be more affected by prenatal testosterone as a result of sex, further supporting possible endocrine influence of prenatal androgens on personality.

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APPENDIX

Psychopathy LSRP Scale

Primary Psychopathy

1. In today's world, I feel justified in doing anything I can get away with to succeed.
2. My main purpose in life is getting as many goodies as I can.
3. Even if I were trying very hard to sell something, I wouldn't lie about it.
4. I enjoy manipulating other people's feelings.
5. Looking out for myself is my top priority.
6. I tell other people what they want to hear so that they will do what I want them to do.
7. Cheating is not justifiable because it is unfair to others.
8. I would be upset if my success came at someone else's expense.
9. For me, what's right is whatever I can get away with.
10. Success is based on survival of the fittest; I am not concerned about the losers.
11. I feel bad if my words or actions cause someone else to feel emotional pain.
12. Making a lot of money is my most important goal.
13. I let others worry about higher values; my main concern is with the bottom line.
14. I often admire a really clever scam.
15. People who are stupid enough to get ripped off usually deserve it.
16. I make of point of trying not to hurt others in pursuit of my goals.

Secondary Psychopathy

- 17. I am often bored.
- 18. Before I do anything, I carefully consider the possible consequences.
- 19. I quickly lose interest in tasks I start.
- 20. I have been in a lot of shouting matches with other people.
- 21. I find myself in the same kinds of trouble, time after time.
- 22. I find that I am able to pursue one goal for a long time.
- 23. Love is overrated.
- 24. When I get frustrated, I often "let off steam" by blowing my top.
- 25. Most of my problems are due to the fact that other people just don't understand me.
- 26. I don't plan anything very far in advance.

Response Categories: 4-Point Likert scale (0 = *Strongly Disagree*, 1 = *Disagree Somewhat*, 2 = *Agree Somewhat*, 3 = *Strongly Agree*)

VITA

Education

M.A. in Criminal Justice and Criminology 2017 – 2019
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Academic Positions

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Presentations

2019

Perez, K., Meeker, K., Hayes, B., O’Neal, E. (2019, March). *Bystander Intervention: An Examination of Likelihood and Risk of Intervention*. Annual meeting of the Academy of Criminal Justice Sciences, Baltimore, MA.

Bashaw, D.R., Castro, A., Gunderson, C.A., Pedersen, W.C., Abbate, E., Alba, S., Avila, T., Carpentier, S.T., Kotico, V., Lozano, J.P., Madsen, E., Mendoza, J., **Perez, K.**, Rivers, M., Solis, N., Taylor, A., Toyohara, S., Valle, S. (2019, April). *Triggers mean more from the out-group: Type of target moderates the effect of a triggering event on state hostility*. Poster to be presented at the annual meeting of the Western Psychological Association, Pasadena, CA.

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Gunderson, C. A., Flores, R. F., Pedersen, W. C., Abbate, E., Avila, T., Chester, C., Contreras, M. Geraci, G. Jeynes, L., Kotico, V., Madsen, E., Mendoza, J., Musto, K., Nahigan, V., **Perez, K.**, Rivers, M., Ruiz, G., Taylor, A., Zamorano, C. (2018,

March). *Blinded by anger: Collective rumination increases displaced aggression toward in-group but not out-group targets*. Poster to be presented at the annual meeting of the Society for Personality and Social Psychology, Atlanta, GA.

Bashaw, D., Gunderson, C.A., Pedersen, W.C., Flores, R.F., Abbate, E., Avila, T., Chester, C., Contreras, M., Ellison, J.M., Geraci, G., Jeynes, L., Kotico, V., Madsen, E., Mendoza, J., Musto, K., Nahigan, V., **Perez, K.**, Rivers, M., Ruiz, G., Taylor, A., Zamorano, C., & Lozano, J. (2018, March). *Aggressing against our own: Rumination type moderates the effect of collective narcissism on displaced aggression towards in-group targets*. Poster presented at the meeting of the Society for Personality and Social Psychology, Atlanta, GA.

Avila, T., Gunderson, C., Pedersen, W.C., Abbate, E., Bashaw, D., Kotico, V., Madsen, E., Mendoza, J., **Perez, K.**, Rivers, M., Taylor, A., & Toyohara, S. (2018, March). *In-Group Status Won't Protect You: The Moderating Effect of a Trivial Triggering Event On Ruminative Displaced Aggression*. Poster presented at the meeting of the Society for Personality and Social Psychology, Atlanta, GA.

2017

Gunderson, C. A., Flores, R. F., Ellison, J. M., Pedersen, W. C., Abbate, E., Avila, T., Chester, C., Contreras, M. Geraci, G. Jeynes, L., Kotico, V., Madsen, E., Mendoza, J., Musto, K., Nahigan, V., **Perez, K.**, Rivers, M., Ruiz, G., Taylor, A., Zamorano, C. (2017, April). *The more I think about it, they deserve it too: Degree of rumination moderates the effect of target type on group-based retribution*. Poster presented at the annual meeting of the Western Psychological Association, Sacramento, CA.

Gunderson, C. A., Flores, R. F., Pedersen, W. C., Abbate, E., Avila, T., Chester, C., Contreras, M. Geraci, G. Jeynes, L., Kotico, V., Madsen, E., Mendoza, J., Musto, K., Nahigan, V., **Perez, K.**, Rivers, M., Ruiz, G., Taylor, A., Zamorano, C. (2017, April). *Collective rumination increases displaced aggression toward in-group but not out-group targets*. Poster presented at the annual CSULB PSYCH day research symposium, Long Beach, CA.

Gunderson, C. A., Ellison, J. M., Flores, R. F., Pedersen, W. C., Abbate, E., Chester, C., Contreras, M. Geraci, G. Jeynes, L., Kotico, V., Madsen, E., Mendoza, J., Musto, K., Nahigan, V., **Perez, K.**, Rivers, M., Ruiz, G., Taylor, A., Zamorano, C. (2017, January). *Stewing about a provocation: The moderating effect of rumination type on the relationship between collective narcissism and displaced aggression*. Poster presented at the annual meeting of the Society for Personality and Social Psychology, San Antonio, TX.

Flores, R. F., Ellison, J. M., Gunderson, C. A., Pedersen, W. C., Abbate, E., Avila, T., Chester, C., Contreras, M. Geraci, G. Jeynes, L., Kotico, V., Madsen, E., Mendoza, J., Musto, K., Nahigan, V., **Perez, K.**, Rivers, M., Ruiz, G., Taylor, A.,

Zamorano, C. (2017, January). *The Impact of Outgroup Entitativity and Group Membership on Ruminative Displaced Aggression*. Poster presented at the annual meeting of the Society for Personality and Social Psychology, San Antonio, TX.

Honors, Awards and Activities

Member of Phi Kappa Phi Honor Society	2016 – present
Member of Psi Chi	2015 – present
Dean’s Honor List	2015 – 2016
Member of Alpha Omicron Pi	2015 – 2016
Dean’s List (Citrus College)	2011 – 2014

Professional Affiliations

Academy of Criminal Justice Sciences	2018 – present
American Society of Criminology	
Division of BioPsychoSocial Criminology	2019 – present