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The effect of prenatal androgen exposure on the development of neural reactivity systems: A study of the HEXACO Personality Inventory

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ABSTRACT

The ratio of the lengths of the second and fourth digits of hands (2D:4D) seems to vary as a function of systematic differences in prenatal androgen exposure (Hönekopp & Watson, 2010). The 2D:4D ratio has been shown to be related to a variety of personality attributes. This study predicted that 2D:4D would covary with scores on the emotionality dimension of the six-facet HEXACO personality assessment, due to emotionality's relationship with neural reactivity systems controlled by the amygdala (Hines, Allen, & Gorski, 1992), but that 2D:4D would relate to no other facet. Consistent with hypotheses, data showed that men had smaller ratios than women on both the right, $t(405) = 2.84$, $p < .05$, $d = .28$, and left hands, $t(405) = 4.51$, $p < .05$, $d = .45$, and the relationship between 2D:4D and emotionality was outside of sampling error of zero, $r = .18$, $p < .001$. Additionally, 2D:4D was unrelated to the remaining HEXACO facets. Findings suggest that prenatal testosterone exposure has an organizing effect on personality traits.

1. Introduction

Previous research has demonstrated that personality traits are heritable (e.g., Plomin, Corely, Caspi, Fulker, & DeFries, 1998), however, few studies have examined the relationship between prenatal hormone exposure and broad models of personality dimensions (e.g., Big Five, HEXACO). Fink, Manning, Neave, and Grammer (2004) found that on the right hand 2D:4D, an indicator of prenatal testosterone exposure (see Manning, 2000 for a review), correlated only with neuroticism scores ($r = .25$). Luxen and Buunk (2005), however, reported that the partial correlations (when controlling for handedness) between 2D:4D and the dimensions of the Big Five Inventory (Costa & McCrae, 1992) were statistically significant for agreeableness ($r_{part} = .36$) and conscientiousness ($r_{part} = .28$), but correlations between 2D:4D and the other Big Five dimensions were within sampling error of zero. Finally, Lippa's (2006) findings departed from both Luxen and Buunk's findings and Fink et al.'s findings. Lippa (2006) found a statistically significant relationship between 2D:4D and extraversion ($\beta = -.08$) and openness to experience ($\beta = .12$).

These three studies lack a clear mechanism for how prenatal androgen exposure would result in differences in personality. Although researchers have begun to elucidate the mechanisms by which 2D:4D sexually differentiates (see Breedlove, 2010 for a review), exactly how personality traits sexually differentiate is still unclear and the aforementioned studies have not shed any more light on that process. Additionally, their arguments for why one might expect a relationship between 2D:4D and "X" personality traits consist of expected sex differences in both 2D:4D and "X" personality trait. In other words, they hypothesize that given both outcomes display a sex difference, then it is expected that both outcomes should correlate with one another. However, the mere existence of two sex differences does not provide a compelling argument for why one might expect two sex differences to also correlate with one another. Moreover, although sex differences were hypothesized in Fink et al.'s (2004) study, no sex difference was found in neuroticism, however, there still existed a significant correlation between neuroticism and 2D:4D; it is unclear why. Furthermore, Lippa (2006) found a relationship between 2D:4D and openness to experience, a personality trait that does not typically display a sex difference; however, this relationship was also not clearly explicated. Given the lack of a clearly specified mechanism, a weak argument explaining why one should expect 2D:4D–Big Five relationships, and inconsistent findings regarding with what personality trait 2D:4D correlates, the veracity of these findings is questionable.

The current paper explains how to assess prenatal androgen exposure through the use of the 2D:4D ratio. Additionally, the current paper argues for the use of the HEXACO Personality Inventory to examine the relationship between prenatal androgen exposure and personality traits, because HEXACO allows one to derive a mechanism for which prenatal androgen exposure may affect the development of various personality traits. Finally, the paper will present a study that examines the relationship between prenatal androgen exposure, as indicated by 2D:4D, and the emotionality dimension of HEXACO.

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1.1. 2D:4D

Hönekopp and Watson (2010) meta-analyzed the endocrine literature and found that the 2D:4D ratio is consistently smaller for men than for women. It has been known for some time that the sexual differentiation of the 2D:4D is the result of prenatal androgen exposure (Gobrogge, Breedlove, & Klump, 2008; Manning, Scutt, Wilson, & Lewis-Jones, 1998), establishes as early as the age of two, and does not change through puberty (see Manning, 2000 for a review). Further evidence of prenatal androgen exposure's influence on the 2D:4D can be found in women with congenital adrenal hyperplasia (CAH); Brown, Hines, Fane, and Breedlove (2002) found that women with CAH had masculinized 2D:4D due to elevated prenatal androgen exposure.

What makes 2D:4D a useful indicator of prenatal androgen exposure is that 2D:4D is a proxy for sex hormones, specifically androgens, at the time of brain organization (Manning et al., 1998). Phoenix, Goy, Gerall, and Young (1959) demonstrated long ago the importance of prenatal hormones on the organization of the neural systems of the brain. The same hormones responsible for organizing the morphology, such as 2D:4D, are also responsible for organizing the neural systems that result in behaviors.

1.2. Big Five versus HEXACO

The Big Five was proposed by Costa and McCrae (1992) as a framework to categorize people's behavior as personality dimensions: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. Each dimension is characterized by a set of behaviors displayed by individuals that report high on said dimension. For example, those said to be highly agreeable tend to cooperate with, to get along with, and to be helpful toward others.

Although the Big Five has dominated the field of personality psychology and is often used as researchers' organizing framework for understanding personality differences, there have been a number of criticisms of this framework (e.g., Block, 1995). In response to the criticism lodged against Big Five, Lee and Ashton (2004) offered an alternative framework, HEXACO, for understanding personality. More specifically, the HEXACO framework asserts that human personality can be described by six facets, one facet more than the standard Big Five: honesty–humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience (Lee & Ashton, 2004). The honesty–humility dimension derives from the fairness tenet of reciprocal altruism. Sincerity and low entitlement are behavioral indicators of fairness. Emotionality derives from biology's idea of kin altruism, or helping out members of your family or group. Behavioral indicators expressed by those high on emotionality are empathetic concern, developing emotional attachments to close others, and avoiding harm to oneself and the group. Additionally, extraversion is interpreted as one's desire to engage in social activities, therefore, indicators of this personality dimension are outgoingness, liveliness, and sociability. Agreeableness is similar to honesty–humility, but derives instead from the tolerance tenet of reciprocal altruism. Behavioral indicators expressed by those who adhere more strongly to this principle are forgiveness and low argumentativeness. Conscientiousness is thought of as engagement toward task-related pursuits; behavioral indicators of this dimension are organization skills, diligence, and thoroughness. Finally, those open to experience engage in idea-related pursuits. Behavioral indicators displayed by those high on this dimension are curiosity, innovation, and intellect (Ashton & Lee, 2007).

One strength of HEXACO, relevant to the understanding of how prenatal androgen exposure may influence the development of personality traits, is that one dimension of the HEXACO (i.e., emotionality) is derived from biological conceptualizations of kin altruism. Understanding people's motivation to protect their group and avoid harm allows for a greater understanding of the cognitive and affective mechanisms involved in behavioral displays consistent with this dimension.

1.3. 2D:4D and HEXACO

Recently, Shaw, Kotowski, Boster, and Levine (2012) found that prenatal androgen exposure, as indicated by the 2D:4D ratio, is related to verbal aggressiveness. They suggest that, consistent with previous research (Hines et al., 1992; Johnson, Breedlove, & Jordan, 2008), prenatal androgen exposure affects the development of verbal aggressiveness by affecting the development of the amygdala. Part of the limbic system, the amygdala is involved in social information monitoring and emotional response mediation (e.g., Williams et al., 2006). Additionally, the limbic system has often been associated with the neural reactivity systems of the Flight-and-Flight System (FFS), animals' reaction to threatening stimuli is to either fight or flee (Cannon, 1929), and the Behavioral Inhibition System (BIS), which causes people to vary in the extent to which they inhibit themselves from engaging in behaviors that could lead to negative consequences (Gray, 1981).

Given that emotionality, as described by Ashton and Lee (2007), motivates people to engage in behaviors that are kin altruistic such as avoiding harm, it is possible that the emotionality facet of the HEXACO model is related to the same neural reactivity systems (i.e., FFS, BIS) via a similar route as verbal aggressiveness that was described by Shaw et al. (2012). For instance, those who report to be high on HEXACO's emotionality dimension are likely to be low in verbal aggression, because those who would try to avoid harm are unlikely to also be verbally aggressive. It is possible that verbal aggression, as defined by Infante and Wigley (1986), is a behavioral manifestation of those low on emotionality. If emotionality and verbal aggression are related to each other, it is possible that the same neural reactivity systems (e.g., FFS, BIS) are responsible for both personality traits. Therefore, if Shaw et al.'s (2012) conjecture is correct and prenatal androgen exposure organizes the neural reactivity systems that result in verbal aggression, it is possible that prenatal androgen exposure additionally organizes the neural reactivity systems that are responsible for emotionality. Therefore, prenatal androgen exposure, as indicated by 2D:4D, should be related to scores on the emotionality facet. More specifically, because greater prenatal androgen exposure would result in smaller 2D:4D and organize neural reactivity systems in such a way that individuals would be more likely to fight and less likely to inhibit themselves from engaging in harm (i.e., low emotionality), 2D:4D will be positively correlated with emotionality scores on the HEXACO inventory.

It is unclear how the other dimensions of the HEXACO would be related to one of the neural reactivity systems discussed above. Furthermore, it is difficult to conjecture as to what neural system that would also be organized by prenatal androgen exposure might be responsible for the other five dimensions. Therefore, it is unlikely that any of the other dimensions of HEXACO (i.e., humility–honesty, extraversion, agreeableness, conscientiousness, openness to experience) are related to prenatal androgen exposure, as indicated by 2D:4D.

In order to examine the relationship between prenatal androgen exposure, emotionality, and the other HEXACO dimensions, a study was conducted measuring 2D:4D and personality via the HEXACO inventory.

2. Method

2.1. Participants

Four-hundred five undergraduates at a large Midwestern university in the United States were participants (*P*s) in this study.