Original Paper

The Relationship between Prenatal Testosterone (2D:4D), Big 5 Personality Traits and GRIT in Different Cultural Contexts

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Abstract

Digit ratio (2D:4D; a putative correlate of prenatal testosterone) has been shown to be predictive of important personality factors such as mental toughness, optimism and academic achievement. However, to date no study has attempted to investigate prenatal testosterone levels as a predictor of GRIT (persistency and constancy) and the Big 5 personality traits Openness to experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism. Research has also alluded to the potential gender and cultural differences in biological underpinnings of psychological functioning. This study included a sample of Dubai and UK undergraduate students and examined associations between prenatal testosterone (2D:4D), GRIT and Big 5 personality traits (openness to experience, conscientiousness, extraversion, agreeableness and neuroticism). UK and Dubai participants followed the same testing procedure and completed a self-report measure for GRIT and Big 5 personality traits, followed by providing a right-hand scan, which was later used to measure 2D:4D using Vernier Callipers. Results showed that in Dubai participants, the measured psychological variables explained a greater amount of variance in 2D:4D than in UK participants. Openness to experience was a strong significant predictor of 2D:4D in Dubai participants whereas, GRIT, conscientiousness and openness to experience were all significant predictors of 2D:4D for UK participants.

Keywords

Prenatal testosterone, Big 5 Personality, GRIT, 2D:4D

1. Introduction

Research has sought to establish the biological underpinnings of success in different contexts including in sport, education and business (Tester & Campbell, 2007; Reed & Meggs, 2017; Branas-Garza & Rustichini, 2011). One particularly important biological factor that appears to predict success in different environments is that of prenatal testosterone (Manning, 2002). Prenatal testosterone can be determined by using a non-invasive putative marker; the relative difference between the index finger and the ring finger: 2D:4D (Manning, 2002). Several decades of research have established robust and strong correlations between prenatal testosterone exposure and 2D:4D ratio (Manning, 2002; Manning & Taylor, 2004). Moreover, there is a fair amount of indirect evidence in humans to show that prenatal testosterone is known to influence developmental disorders such as ADHD (McFadden et al, 2005; Milne et al, 2006; De Bruin et al, 2006; De Bruin et al., 2009) and autism spectrum disorder (Manning et al., 2001; De Bruin et al., 2009). Research has identified correlations between 2D:4D and these developmental conditions. Furthermore, one of the most robust findings across different cultures and contexts is the observation that 2D:4D is a sexually dimorphic trait (Honekopp & Watson, 2010) wherein males have a lower 2D:4D than females. In summary, more evidence would further validate 2D:4D as a putative marker of prenatal testosterone but a wealth of studies in the last decade support that 2D:4D is an indirect biomarker of prenatal testosterone (Voracek, 2014). Further support comes from research that has identified correlations between 2D:4D and male typical traits such as aggression (Turanovic et al., 2017), risk taking (Branas-Garza et al., n.d.), athletic achievement (Meggs & Golby, 2011; Tester & Campbell, 2007) and dominance (Manning & Fink, 2008). However, it is important to note that it seems that the evidence for direct relationships between 2D:4D and personality measures is mixed (the effects seem to be difficult to replicate). This could be due to variations in methodological procedures, using the right or left hand 2D:4D and different contexts. Some relationships between 2D:4D and behavioural measures that are related to the same personality measures seem to be more robust in particular settings. It is therefore important to examine the relationships between 2D:4D, personality variables and behaviour in different domains and cultural contexts.

Prenatal testosterone has been shown to be related to variables that have been implicated in success in various contexts such as mental toughness and optimism (Meggs & Golby, 2011; Clough et al., n.d.), However, 2D:4D (increased prenatal testosterone exposure) also relates to developmental conditions that may prove a challenge in some contexts, i.e., Attention Deficit and Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD) and risk-taking. It appears that the relationship between 2D:4D and performance is further complicated in that personality variables moderate the relationship between prenatal testosterone and developmental disorders such as ADHD. Specifically, those exposed to high levels of prenatal testosterone and with high levels of conscientiousness report lower levels of ADHD symptoms than those with lower levels of conscientiousness and comparable prenatal testosterone exposure (Martel, 2009). To date, there is limited research that addresses the underpinning personality variables associated with 2D:4D and academic success. One study has highlighted the

84

relationship between prenatal testosterone and better performance on academic assessments of programming ability within computer science education and lower levels of computer-related anxieties; both of which relate to success in this field of study (Martel, 2009). The implications of these skills are wide-reading as IT abilities are important for students in modern education environments in many disciplines. In other research, Branas-Garza and Rustichini (2011) found that those with low 2D:4D were more successful in financial trading and had more advanced skills in abstract reasoning and risk taking. However, these relationships appear to be stronger for males than females. Another study found that male 2D:4D ratios positively predicted examination grades whilst grades were uncorrelated with 2D:4D ratio for females (Romano Leoni & Saino, 2006). Research elsewhere has highlighted gender differences in relationships between 2D:4D and academic performance, e.g., Borsnan (2008) found low 2D:4D correlated with numeracy ability in boys and high 2D:4D predicted better literacy SAT scores for girls. Whereas a study including both genders by Bull, Davidson, and Nordmann (2010) found no correlation between 2D:4D and numerical or visual-spatial ability in children.

As mentioned, personality variables have been shown to predict performance in different contexts and their importance remains when controlling for the contribution of IQ (Rosander, 2013; Noftle & Robins, 2007) and physical aptitude in sport (Golby & Meggs, 2011; Reed & Meggs, 2017). The most robust relationship between a personality variable and success in many contexts appears to be with conscientiousness (Vedel, 2014); this partially could be due to a high proportion of studies including this variable. This meta-analysis of over twenty studies found significant correlations between academic performance, openness and agreeableness. Openness, manifesting the tendency to explore, detect and enjoy abstract and sensory information (John et al., 2008) occasionally has positive relationships with academic achievement. While extraversion, being sensitive to reward and positive affect (John et al., 2008) is negatively related to the same criterion (O'Connor & Paunonen, 2007; Noftle & Robins, 2007; DeYoung, 2010; Rosander, 2013). To date, only one study has attempted to investigate prenatal testosterone levels as a predictor of academic achievement in two different cultural contexts. Nye, Androuschak, Desierto, Jones, and Yudkevich (2013) found evidence for a non-linear, quadratic, relationship between 2D:4D and academic achievement in student samples from Moscow and Manila. These effects were also found to differ according to the field of study, choice of achievement measure, and use of the right or left-hand digit ratios. The results of this study were found to be asymmetric between Moscow and Manila. Specifically, for Moscow participants, the right (left) hand generated an inverted-U (U-shaped) curve relationship with academic achievement in Moscow, while this pattern reversed in Manila. The current study therefore sought to build on this research and examined the relationships between prenatal testosterone exposure (2D:4D), the big 5 personality traits and GRIT in UK and Dubai students. Dubai presents a unique cultural context, i.e., the challenges faced by the Eastern world are distinct from those experienced in the Western world. It would therefore provide a useful insight to understand these potential cultural differences and their impact on the relationships between

biological factors (2D:4D) and personality. As an initial exploratory study, it was deemed important to first identify any differences in linear correlations between prenatal testosterone and personality.

2. Method

2.1 Participants

222 Undergraduate Sport and Exercise Science students (male n = 116) with M_{age} = 19.2, SD = 1.87 from the UK and 94 Undergraduate Psychology students from Dubai (male n = 38) with Mage = 18.9, SD = 1.61 volunteered to take part in the current study. The UG students were currently in their 1st year of their taught University programmes.

2.1.1 Measures

The GRIT-S scale

The Grit Scale, which measures trait-level perseverance and passion for long-term goals. The Short Grit Scale (Grit-S) retains the 2-factor structure of the original Grit Scale (Duckworth, Peterson, Matthews, & Kelly, 2007) with 4 fewer items and improved psychometric properties. Duckworth and Quinn (2007) have provided evidence to support the internal consistency, test/re-test reliability, consensual validity and predictive validity of the GRIT-S.

The Big 5 Inventory

44-item inventory that measures an individual on the big five factors (dimensions) of personality (Goldberg, 1993). Each of the factors is then further divided into personality facets. The big 5 factors are: *Extraversion vs. Introversion* (extraversion is characteristic of a tendency to prefer high stimulation, social engagement and risk-taking activities*); Agreeableness vs. Antagonism* (the tendency to seek co-operation and pro-social behaviours), *Conscientiousness vs. Lack of direction* (being committed and applied to related tasks and activities)*; Neuroticism vs. Emotional Stability* (the tendency to be emotionally stable and have relatively stable mood/effective emotional regulation)*; Openness vs. Closedness to experience* (the tendency to prefer novelty and new experiences); Srivastava (1999). In addition, BFI has demonstrated high convergent validity with self-report scales and peer ratings of the Big Five (Gosling, Rentfrow, & Swann, 2003). Previous tested reliability of the BFI has typically ranged from 0.79 to 0.88 (Benet-Martinez & John, 1998).

Prenatal testosterone measure (2D:4D). Digital hand scans were taken using a flatbed scanner Digit ratio was measured using Vernier Callipers (Fink et al., 2006) accurate to 0.01 mm.

3. Results

Table 1. Correlation Matrix (UK Sample)

	Age	L2D4D	R2D4D	E	A	C	N	O	GRIT
Age		-.039	.049	.017	-.098	.281**	-.143*	.097	.229**
L2D4D			.308**	.034	-.082	.006	.14*	-.097	.002
R2D4D				.091	.085	-.018	.164*	-.025	-.041
Extraversion					.028	.102	-.29**	-.015	.097
Agreeableness						.071	-.111	.129	.156*
Conscientiousness							-.234**	.096	.543**
Neuroticism								-.069	--.267**
Openness									.022
GRIT									

$* = p <0.05$, $** = p <0.01$.

Table 2. Correlation Matrix (Dubai Sample)

	GRIT	O	N	C	A	E	L2D4D	R2D4D
GRIT		.422**	-.262*	.514**	.345**	.686**	-.67**	-.37*
Openness							.112	-.116
Neuroticism							.412*	.312*
Conscientiousness							-.609**	-.212*
Agreeableness							-.312*	.214*
Extraversion							-.507**	.231*
L2D4D								.721**
R2D4D								

$* = p <0.05$, $** = p <0.01$.

Independent samples t-test

There was no significant difference in left or right 2D4D between males and females, $t (221) = 1.02$, $p > 0.05$. There were significant differences in agreeableness t $(221) = 3.18$, $p < 0.01$) and neuroticism $t (221) = 3.89$, $p < 0.01$) between males and females with males scoring significantly lower. There were significant differences in extraversion and conscientiousness between the UK and Dubai sample population means. Specifically, UK participants scored significantly lower in extraversion and higher in conscientiousness than Dubai participants.

Hierarchical Linear regression

6 predictor variables; GRIT, Openness to experience, Extraversion, Neuroticism and Conscientiousness

and a criterion of right-hand 2D:4D were included in the analysis. The UK sample revealed that a significant portion (p <0.05), r^2 = .25 and therefore 25% of the variance in 2D:4D was explained by the predictor variables (r^2 = .245, p < 0.05) and there were two significant individual variable predictors; Extraversion: β = .15, $p < 0.05$ and Neuroticism: β = .22, $p < 0.01$. For the Dubai sample, the co-efficient of determination revealed that a larger proportion of the variance in digit ratio, 57%, p <0.001 could be explained by the predictor variables. There were two significant predictors; Grit: β = -.36, p < 0.05 and Conscientiousness: β = -.35.

4. Discussion

The present study was designed to build on existing research on the putative marker of prenatal testosterone and important psychological factors that are typically associated with success and the ability to manage adverse events. A secondary aim was to provide suggestions for future research on cultural differences and provide some exploratory insights into the possible explanations for cultural influences on personality development. In the overall sample analysis, it was found that an increased level of GRIT was associated with openness to new experiences, conscientiousness and agreeableness. This suggests that the ability to be open to new perspectives, experiences and strategies to approach challenges appears to be important for persisting with long-term goals. Moreover, being committed to one's tasks (r = .54) and also being marginally more agreeable (r = .16) is associated with passion and determination to achieve long-term goals (GRIT). Duckworth & Quinn (2007) have highlighted that passion for long-term goals and perseverance in the face of challenges are primary predictors of success and longevity in different contexts. The authors first identified the relevance of this construct in education through initial observations that some young people achieve success, irrespective of IQ and educational prowess and therefore the ability to persist in the pursuit of goals despite set-backs and failures is important. Our findings provide further support for the importance of GRIT in conscientiousness (a tendency to be dedicated to achieving one's goals). Moreover, perhaps the strong relationship between commitment and GRIT further supports the importance of identifying and maintain passion for one's goals and associated tasks in determining conscientiousness. Other findings revealed that the older participants reported higher levels of GRIT and a reduction in neuroticism. This is consistent with literature on personality development throughout late adolescence and early adulthood in that persistence and determination for longer-term goals that could be related to the increased role clarity and importance of work and personal goals and commitments are typical of these periods of development and aging (Rhodes, Devlin, Steinberg, & Giovannetti, 2017). Moreover, with an increased ability to overcome challenges and adversity; owing to an ability and tendency to develop novel methods of coping and problem-solving strategies it would appear intuitive that young adults to report a reduction in emotional instability as they age. Moreover, it is likely that the transition from further to higher education may bring about an increase in neuroticism initially, until they identify new strategies and ways of coping within their new environment.

To examine cultural differences, we provide insights based on the different predictors associated with a putative biological marker of prenatal testosterone (2D:4D). In the UK student sample, prenatal testosterone was significantly predicted by traits associated with emotional and social temperament (extraversion and neuroticism) and the Reticular Activating system (RAS). Whereas in the Dubai sample, those traits most strongly explained by biological predictors were traits associated with delayed gratification and goal achievement. This could suggest that Western values, socio-economic and cultural factors play a more significant role in delayed gratification and goal achievement rather than predetermined biological factors. Whereas, in Middle-Eastern populations, emotional temperament appears to be explained by socio-cultural factors. Those in Dubai reported significantly higher levels of extraversion than Western individuals and this difference could be explained by factors such as economic affluence and cultural values that promote extravert temperaments (Dubai has an emphasis on high-sensation seeking and the value of social capital). The differences in socio-economic status of the samples may explain differences in neuroticism as research consistently finds that those with higher socio-economic status report lower levels of neuroticism (Elliott, Turiano, & Chapman, 2017). These insights would require further research that include measures of social, economic and cultural values as well as biological predictors such as prenatal testosterone to confirm the nature of the impact of biological and socio-cultural factors on personality development.

The study has several limitations that need to be considered when evaluating the findings and associated conclusions. The data was taken at a cross-sectional time point and therefore the stability and consistency of these relationships is unknown. Further longitudinal research is necessary to identify the nature of these relationships across time and their stability. Moreover, the cultural differences lend themselves to anthropological theory; in that personality and behaviour should be understood in the cultural context in which they arise. Whilst prenatal biological factors are useful putative markers of personality development, the findings of this study suggest that cultural context and environmental interaction is important in the manifestation of personality and expression of personality traits.

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90

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