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The association between fetal testosterone and violent behavior: Additional evidence using the 2D:4D digit ratio

Anthony W. Hoskin[a,*], Ryan Charles Meldrum[b]

[a] Idaho State University, Department of Sociology, Social Work, and Criminology, 921 S. 8th Avenue, Stop 8114, Pocatello, ID 83209, United States of America
[b] Florida International University, Department of Criminology and Criminal Justice, 11200 SW 8th Street, PCA-364B, Miami, FL 33199, United States of America

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ABSTRACT

Recent meta-analyses on the relationship between prenatal testosterone—measured by the 2D:4D digit ratio—and aggression and analogous traits have reported an overall weak association. Fewer studies, however, have focused specifically on violent behavior. Yet, many of these studies have relied on small samples of incarcerated men and limited their focus to intimate partner violence. Less is known about whether the link between the 2D:4D ratio and violence holds for non-incarcerated populations, for females as well as males, and for general measures of violence. To address these issues, original data were collected on a sample of young adults to estimate the association between the 2D:4D ratio and self-reported violence. The study yielded two important findings. First, the 2D:4D ratio was associated with a majority of the individual violent behaviors examined, as well as multi-item measures of violence, in both bivariate and multivariate models. Second, the 2D:4D ratio was associated with violent behavior among separate samples of men and women, though associations were frequently non-statistically significant for females.

1. Introduction

Research assessing the impact of prenatal testosterone (T) on human behavior has flourished, due largely to the development of the *2D:4D digit ratio*—an indirect measure of exposure to fetal T based on the relative length of the index and ring fingers (Manning, Scutt, Wilson, & Lewis-Jones, 1998). Making use of this measure, researchers have examined the link between prenatal T and a wide range of behavioral, personality, and health-related traits (Manning, 2008). Pertinent to our current focus, considerable energy has been devoted to examining the extent to which the 2D:4D ratio is associated with impulsivity, risk-taking, and aggression. Three meta-analyses have been conducted in recent years, and each of them report a statistically significant yet very weak association in the hypothesized direction (Hönekopp & Watson, 2011; Pratt, Turanovic, & Cullen, 2016; Turanovic, Pratt, & Piquero, 2017).

By contrast, studies focusing specifically on the link between the 2D:4D ratio and violence have provided greater empirical support (Cousins, Fugère, & Franklin, 2009; Ellis & Hoskin, 2015; Herschl, Highland, & McChargue, 2012; Hoskin & Ellis, 2015; Romero-Martinez, Lila, Sarinana-Gonzalez, Gonzalez-Bono, & Moya-Albiol, 2013). Yet, not only are such studies few in number, the majority of them have focused exclusively on intimate partner violence (IPV), with two of them consisting of very small samples of incarcerated men (Herschl et al., 2012; Romero-Martinez et al., 2013). Given this, less is known about the link between the 2D:4D ratio and general violence, if the association holds for both women and men, and if it holds for the non-incarcerated population.

In addition, most 2D:4D ratio studies have focused on predispositions toward violence (e.g., impulsivity, aggression) as opposed to actual violent offending.[1] This is unfortunate given that violence occupies a central place in various theories of testosterone and aggressive behavior (Archer, 2006; Ellis, 2005; Mazur, 2006). Two studies (Ellis & Hoskin, 2015; Hoskin & Ellis, 2015) have examined violent behavior with large, mixed-gender samples of college students. One (Ellis & Hoskin, 2015) relied on a crude, self-assessed measure of 2D:4D, and the focus in both studies was not on violent offending but general criminality that included a limited number of violent behaviors.

2. The current study

Recent meta-analytic research focusing on the association between

* Corresponding author.
E-mail addresses: hoskanth@isu.edu (A.W. Hoskin), rmeldrum@fiu.edu (R.C. Meldrum).

[1] Many 2D:4D studies examine verbal and physical aggression as outcomes using the Buss and Perry (1992) aggression questionnaire. This questionnaire, however, measures a *predisposition* toward violence rather than *overt acts of violent behavior*, as indicated by the fact that the response options to the inventory items reflect "how characteristic" each item is of the respondent. Thus, a trait, rather than overt behavior, is being assessed.

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the 2D:4D ratio and violent behavior (Turanovic et al., 2017) brings to light the paucity of studies on the topic. We add to the body of research by examining the relationship between the 2D:4D ratio and ten separate indicators, and two multi-item indicators, of violence for a mixed-sex sample of young adults. Based on theory and prior research, we hypothesize that statistically significant, negative associations will be found, such that individuals with larger 2D:4D ratios will report *less* involvement in violent behavior. As an additional feature of this study, we examine these associations separately for both males and females, which as noted earlier is something which some previous studies assessing the association between the 2D:4D ratio and violence were unable to consider.

3. Methods

3.1. Sampling

The sample for this study comprised currently enrolled undergraduate students attending a public university in a Western U.S. state who were either majoring in criminology or sociology in 2015. Students were asked if they would volunteer to complete a questionnaire and have an image of their hands recorded with a flatbed scanner; they were provided extra credit points if they participated. They were also offered additional points if they recruited other volunteers at least 18 years of age to participate (they did not have to be currently enrolled students). Subjects were told that the researchers were interested in the relationship between personal characteristics and various behaviors. A total of 287 individuals, 41% of which are male, participated in the study.

3.2. Measures

3.2.1. Violent behavior

Participants responded to 10 separate survey items after reading the following prompt: "As best as you can recall, how many times in your life (if any) have you done the following things." The items, based on wording used in prior research (e.g., Conger & Elder Jr, 1994), included: "Gotten into a physical fight with another person," "Threatened to physically hurt someone with a weapon, such as a knife, gun, or bat," and "Thrown objects at someone (for example, rocks or bottles) with the intent of hurting them." The items referenced lifetime violent behavior given that the 2D:4D ratio is primarily established during pregnancy (Manning, 2002: 13–14) and that prior work has employed the same reference period (e.g., Hoskin & Ellis, 2015).[2]

The number of times respondents reported they had committed each behavior was recorded unless it exceeded 10, in which case a value of 10 was recorded. Employing this technique rather than some other (e.g., log transformation) to handle extreme outliers enables us to preserve the count nature of the data (Hilbe, 2011:387–406). In addition to the 10 individual violent behaviors, two additional variables were created based on summations of the 10 items. First, a frequency count of the total number of violent behaviors each respondent reported across the 10 items was created, ranging from 0 to 100 ($\alpha = 0.89$). Second, to guard against the potential biasing influence of some forms of violence being committed with greater frequency than others, and given potential concerns over memory recall error, each of the 10 items was dichotomized to indicate whether each respondent did (= 1) or did not (= 0) report committing each of the behaviors. The dichotomized items were then summed together to create a variety index of violent behavior, with scores ranging from 0 to 10 ($\alpha = 0.84$).

3.2.2. 2D:4D digit ratio

The method for measuring each participant's 2D:4D ratio is based on the use of a flatbed scanner with a 600 × 600 dpi resolution. Each participant's *right hand* was placed palm down on the glass of the scanner and held flat to ensure that fingers were equally extended and to ensure that the scanner captured a clear picture of the entire right hand.[3] GNU Image Manipulation Program (GIMP 2.8) software was used to digitally measure the length of the second (pointing) and fourth (ring) fingers. For both fingers, mouse-controlled calipers were placed on the basal crease of the finger and extended to the tip of the finger so that the lengths were measured in number of pixels, rounded to one decimal place.

The length of the second finger divided by the length of the fourth finger was recorded as the 2D:4D ratio. Similar methodology has been used in numerous studies (e.g., Allaway, Bloski, Pierson, & Lujan, 2009). If the two fingers are approximately the same length (2D:4D ~ 1) or if the index finger is longer (2D:4D > 1), then a low fetal T level is indicated. If the ring finger is longer than the index finger (2D:4D < 1), then the T levels were high during the prenatal period. Thus, to the extent that the 2D:4D ratio is a valid proxy measure for prenatal T, and that prenatal T promotes violent behavior, we should find significant *negative* associations between the 2D:4D ratio and the measures of violence.

3.2.3. Covariates

Respondents reported their age (in whole years), sex (Male = 1, Female = 0), and race. Given the modest sample size for the study, we dichotomize race (Non-White = 1, White = 0) for the analysis. In addition, we control for honesty by asking respondents to report on a scale from 0 to 10 how honest they were (10 indicating completely honest) when answering the items on the survey to account for social desirability bias. We also included a measure tapping the extent to which participants reported they held attitudes consistent with the "code of the street" (Anderson, 2000). Specifically, we made use of the seven-item inventory (e.g., "When someone disrespects you, it is important that you use physical force or aggression to teach him or her not to disrespect you.") included in the Family and Community Health Study (see Moule Jr, Burt, Stewart, & Simons, 2015). The seven items were averaged together to create the measure *street code values* ($\alpha = 0.88$). Lastly, we included the 13-item Brief Self-Control Scale (e.g., "I often act without thinking through all the alternatives.") (Tangney, Baumeister, & Boone, 2004). After reverse-coding some items so that higher scores for each item reflect lower self-control, the 13 items were averaged together to create the measure *low self-control* ($\alpha = 0.80$).

3.3. Analytic plan

To investigate the association between the 2D:4D ratio and violent behavior, we first establish that sex differences exist in the measures of violent behavior and the 2D:4D ratio. Following this, we present bivariate correlations between the 2D:4D ratio and the measures of violent behavior for the full sample and separately for males and females. Then, we present the results of multivariate models for each measure of violent behavior, again for the full sample and separately for males and females. Given that each of the measures of violent behavior exhibited positive skew and overdispersion, we employed negative binomial regression for the multivariate models given the count nature of the data. As an additional point, the measure of the 2D:4D ratio was standardized for the negative binomial analyses to provide a more interpretable metric for the results (further discussed below).

[2] Our decision to use a non-standardized scale, versus a standardized one (e.g., Buss & Perry, 1992), was guided by the recognition that so few studies had measured a count of violent behaviors as the outcome in 2D:4D research.

[3] A meta-analysis conducted by Hönekopp and Watson (2010) reported a larger sex difference in the right hand versus the left hand, which is what led us to focus on the right hand 2D:4D ratio in this study.

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