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Environmental Sensitivity and Digit Ratio (2D:4D): Negative Results

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The current study explored the associations between different levels of developmental plasticity factors—specifically, prenatal androgen exposure and personality traits related to environmental sensitivity. We recruited participants from Japan (184 females and 90 males) and India (94 females and 86 males) and measured their personality traits of environmental sensitivity and an indirect indicator of prenatal androgen exposure, the ratio of the lengths of the index (2nd digit: 2D) and ring (4th digit: 4D) fingers (2D:4D). Overall, the analyses stratified by country and sex did not reveal a clear correlation between environmental sensitivity and 2D:4D ratios in any of the subsamples. In one subgroup, the environmental sensitivity of Japanese females showed a weak positive correlation with the left- and two-handed mean 2D:4D ratios; however, this correlation approached zero when outliers were removed and the data were reanalyzed. Finally, we considered possible explanations for the inconsistent findings regarding the associations among different levels of plasticity factors.

Keywords: environmental sensitivity; sensory processing sensitivity; digit ratio; 2D:4D; developmental plasticity; androgens

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Human psychosocial phenotypes show considerable variation across individuals. The range of phenotypes an individual can express under different environmental conditions depends on traits that contributed to plasticity, including genetic, neuroendocrine, and temperamental factors (Belsky & Pluess, 2009, 2013). Phenotypic adjustments include not only real-time changes in physiology and behavior but also adjustments of stable traits in the long term in response to early environments, such as *developmental plasticity* (Bateson et al., 2004; Del Giudice et al., 2018; Frankenhuis & Panchanathan, 2011; Gluckman et al., 2009; West-Eberhard, 2003). According to the *Differential Susceptibility Theory* (Belsky, 1997, 2005; Belsky et al., 2007; Belsky & Pluess, 2009; Ellis et al., 2011), which explains the evolution of human developmental plasticity, variation in phenotypic traits resulting from the interaction between a given environmental context and individual differences in environmental sensitivity. This theory explains that individuals with high developmental plasticity are more likely to be negatively affected in adversarial environments characterized by high stressors and maladaptive parenting styles (e.g., increased depressive symptoms and externalizing behaviors) but also benefit in supportive environments (e.g., decreased depressive symptoms and externalizing behaviors). From an evolutionary perspective, this variation in susceptibility to the early environment may have evolved as a result of "bet-hedging" genes that produce varying levels of susceptibility because phenotypic traits matching the unpredictable future environment were unknown (Belsky, 1997; Ellis et al., 2011). Several candidate factors that contribute to individual differences in developmental plasticity have been identified at the genetic, neurophysiological, and temperamental levels; however, the associations between these factors in the context of psychosocial phenotypes are often unclear. Therefore, this study aims to address this gap.

The Personality Trait of Environmental Sensitivity

A potent factor in individual differences in developmental plasticity is sensitivity to both positive and negative environmental influences. Empirical evidence obtained to date indicates that genetic (e.g., serotonergic and dopaminergic genotypes and polygenic scores derived from genome-wide analyses), neuroendocrine (e.g., neural activity in specific brain regions, such as the amygdala and insular cortex; fluctuations in cortisol levels in response to stressors), and phenotypic markers (e.g., temperament and personality) contribute to individual differences in environmental sensitivity (Assary et al., 2020; Greven et al., 2019; Hartman et al., 2023; Keers et al., 2016; Shakiba et al., 2020). Among these, phenotypic markers have become a growing focus of research in recent years due to the development of psychological scales. In addition to traditional temperament dimensions such as children's difficult temperament and negative emotionality, some developmental researchers have recently conceptualized sensory processing sensitivity as a temperament/personality trait that reflects individual differences in environmental sensitivity (Slagt et al., 2016; Slagt et al., 2018).

Longitudinal studies and experimental and quasi-experimental approaches have provided evidence that individuals with high environmental sensitivity as a temperament/personality trait (i.e., high plasticity) are more likely to experience developmental changes in psychosocial outcomes in response to both positive and negative early environments than those with low sensitivity (i.e., low plasticity) (Iimura & Kibe, 2020; Nocentini et al., 2018; Slagt et al., 2016; Slagt et al., 2018). A meta-analysis reported that individual differences in children's difficult temperament and negative emotionality moderate "for better *and* for worse" the effects of mothers' positive and negative parenting behaviors on children's socioemotional outcomes, such as externalizing and internalizing problems (Slagt et al., 2016). Children under 18 years with higher levels of temperament-related sensitivity were more likely to be negatively affected (i.e., higher externalizing and internalizing problems) by adversarial parenting and positively affected (i.e., lower externalizing and internalizing problems) by supportive parenting. A longitudinal study by Slagt et al. (2018) also reported that children (4–5 years old) with high sensory processing sensitivity were more developmentally susceptible to both positive and negative parenting styles "for better *and* worse" compared to those with low sensitivity. The results showed that sensitive children exhibited fewer externalizing problems under supportive parenting, whereas they exhibited a greater degree of externalizing problems under negative parenting. These results suggest that environmental sensitivity, as a temperament/personality trait, represents a psychological phenotypic marker developmental plasticity.

Perinatal Androgen Exposure and Developmental Outcomes

Del Giudice et al. (2018) hypothesized that differences in perinatal androgen (e.g., testosterone) exposure may underlie individual differences in developmental plasticity. Indeed, growing evidence suggests that individual differences in early-life androgen levels moderate the relationship between the early environmental factors and phenotypic outcomes. For example, del Puerto-Golzarri et al. (2023) reported that 8-year-old girls with high testosterone levels exhibited more aggressive behavior when exposed to an authoritarian parenting environment, whereas they showed less aggressive behavior when such parenting was low. Ouellet-Morin et al. (2011) found that 19-month-old boys with high testosterone levels showed higher cortisol reactivity to unfamiliar situations when continuously exposed to alcohol during the prenatal period. Furthermore, Portnoy et al. (2015) demonstrated that male adolescents with higher prenatal testosterone levels exhibited less externalizing behavior and aggression when cortisol reactivity was high, whereas externalizing behavior and aggression were higher when cortisol reactivity was low.

Both correlational and experimental studies have reported that prenatal testosterone exposure may be related to individual differences in the ratio of the second (index: 2D) to fourth (ring: 4D) digit lengths (2D:4D) (for review, see Manning et al., 2014). Evidence suggests that a low 2D:4D ratio, that is, a long ring finger relative to the index finger (2D:4D < 1), is associated with higher testosterone levels relative to estrogen in the fetus (Lutchmaya et al., 2004; Ventura et al., 2013; Zheng & Cohn, 2011). Although 2D:4D is considered a maker of prenatal androgen exposure, no association between these sex hormones and 2D:4D has been found in adults (Hönekopp et al., 2007). On average, males have a lower 2D:4D ratio than females (Hönekopp & Watson, 2010; Manning et al., 1998). It has been suggested that this ratio is formed very early during development (Manning et al., 1998; Ventura et al., 2013). As measuring testosterone in the perinatal period is neither ethically permissible nor methodologically convenient, 2D:4D, which is relatively easy to measure, is frequently used as an alternative. Recent studies have confirmed the association between 2D:4D and prenatal androgen exposure in non-human tetrapods (Manning & Fink, 2023); however, in humans, this relationship remains controversial. Some studies have failed to find evidence of an association between the two (see Nave et al., 2021; Richards et al., 2022).

2D:4D Ratio and Personality Traits

Although the relationship between 2D:4D and prenatal androgen exposure remains controversial, several correlational studies have reported weak associations between 2D:4D ratios and individual differences in phenotypic traits. For instance, lower 2D:4D ratios have been linked to higher levels of Extraversion in the Big Five model (Lippa, 2006), greater aggression in simulated war games among males (McIntyre et al., 2007), higher sensation seeking in both males and females (Hampson et al., 2008), more sexual partners among heterosexual males (Hönekopp et al., 2006), and better performance in long-distance running for both sexes (Manning et al., 2007).

Neuroticism, a Big Five trait strongly correlated with environmental sensitivity (Lionetti et al., 2018), has also been investigated in relation to 2D:4D in several studies. For example, Sindermann et al. (2016) found a positive correlation between Neuroticism and 2D:4D in female samples from China (N = 43) and Germany (N = 280), suggesting that prenatal exposure to sex steroids may have a specific impact on Neuroticism in females. Lautenbacher and Neyse (2020), using a representative German sample of over 3,000 individuals, also found a very weak positive association. However, the significance disappeared after controlling for covariates such as age and observer, leading the authors to conclude that the relationship may be a false positive. In contrast, South et al. (2023) reported a weak but significant positive correlation between Neuroticism and 2D:4D across their full sample (N = 268), even after controlling for age. In contrast, Rodríguez-Ramos et al. (2021) reported a negative correlation between left-hand 2D:4D and Neuroticism in a sample of Spanish female university students (N = 101). In summary, the association between Neuroticism and 2D:4D appears to vary considerably in both effect size and direction, depending on sample characteristics, measurement methods, and the scales used to assess Neuroticism.

Current Study

As noted in the introduction, there is limited evidence examining the correlations among candidate factors underlying individual differences in human developmental plasticity. One recent study examined the hypothesis that phenotypically plastic individuals (e.g., those characterized by environmental sensitivity) and physiologically plastic individuals (e.g., those with heart rate and cortisol reactivity to stress) represents the same individuals; however, the results did not support this hypothesis (Weyn et al., 2022).

This study aimed to advance our understanding of individual differences in human developmental plasticity by exploring the association between the personality trait of environmental sensitivity and prenatal androgen exposure (as indexed by 2D:4D). Given previously reported ethnic differences in 2D:4D (Manning et al., 2003), we included participants from both Japan and India to enhance the robustness and generalizability of the findings. We examined the correlations between the personality trait of environmental sensitivity and 2D:4D —using left-hand, right-hand, and averaged (two-handed) measures—separately by country and sex.

Method

Participants and Procedure

This research project was approved by the Ethics Review Committee of Soka University (approval number: 2022030). We explained the purpose of the study and the handling of personal information to the participants prior to the study, and obtained informed consent from all participants. Prior to conducting the study, we planned to collect data from at least 82 females and 82 males in both Japan and India, in order to detect a moderate effect size $r = .30$ with 80% statistical power at a statistical significance level of $\alpha = .05$.

Japanese Sample

A total of 274 Japanese university students (184 females, 90 males, $M_{age} = 19.06$, $SD_{age} = 0.81$, age range: 18–23 years) participated in this study. Participants accessed an online survey form in their psychology class and responded to questions regarding sex, age, and psychological scales. Subsequently, participants measured the lengths of the index and ring fingers of both hands using digital calipers and reported the values on the survey form.

Indian Sample

A total of 180 Indian university students (94 females, 86 males, $M_{age} = 20.16$, $SD_{age} = 1.53$, age range 18–24 years) participated in this study. The survey was conducted in class and the participants completed a questionnaire. Following this, as in the Japanese sample survey, the participants measured the lengths of the index and ring fingers of both hands using digital calipers and reported the values in the questionnaire.

The Personality Trait of Environmental Sensitivity

Japanese Sample

The 10-item Japanese version of the Highly Sensitive Person Scale (Iimura et al., 2023) was used to measure the personality trait of environmental sensitivity. The scale included items such as "Do changes in your life shake you up?" and "Are you deeply moved by the arts or music?" measuring sensitivity to both positive and negative environmental stimuli. Each item was rated on a 7-point Likert scale ranging from 1 = *Not at all* to 7 = *Extremely*. In this study, the Cronbach's alpha, which represents the internal consistency of the scale, was .89, demonstrating sufficient reliability similar to other studies using this scale (Iimura et al., 2023; Iimura & Yano, 2024).

Indian Sample

To measure the environmental sensitivity of Indian participants, we used the 12-item Highly Sensitive Person scale (Pluess et al., 2023). We used the original English version of the scale, as English is one of the official languages of India and the participants were proficient in English. Similar to the Japanese version of the scale, this scale consists of items measuring sensitivity to both positive and negative environments, and participants rated each item on a 7-point Likert scale (1 = *Not at all* to 7 = *Extremely*). In this study, the internal consistency of the scale was α = .68, which is not moderate but within the acceptable range of reliability (Taber, 2018).

Digit Ratio (2D:4D) Measurements

Finger lengths were measured directly by the participants using digital calipers (product code 19990: Shinwa Rules Co., Ltd.), which can measure a range of 0.1 to 150 mm, for both Japanese and Indian individuals. The finger length was measured from the basal crease of the finger on the ventral side of the hand to the tip (Manning et al., 1998). This method was chosen based on the suggestion that direct measurements are more reliable than indirect measurements such as the use of scanners (e.g., Borráz-León et al., 2019). Based on the reported finger lengths, we calculated the 2D:4D ratios for the right and left hands and the mean 2D:4D ratio for both hands.

Data Analysis

As a preliminary analysis, we calculated descriptive statistics for each variable, such as the mean, standard deviation, and minimum and maximum values. We also tested for sex differences in the main variables (i.e., 2D:4D ratio and sensitivity). Next, as the main analysis to examine the research question, we calculated the correlation coefficients between the personality traits of environmental sensitivity and left/right and mean 2D:4D by sex and country. We performed a series of analyses using R version 4.2.2 (R Core Team, 2022) and its interface, R Studio version 2023.06.1+524 (RStudio Team, 2023). The data and R scripts used in this study are uploaded to the Open Science Framework (https://osf.io/8kc5v/?view_only=5dbafed0c203496a8ac27de7faf3b9cc).

Results

Preliminary Analyses

Tables 1 and 2 present the descriptive statistics for each variable for the Japanese and Indian participants, respectively. In the Japanese participants, there were sex differences in the mean values of the main variables (i.e., 2D:4D and sensitivity). Japanese females had higher right 2D:4D ($t(271) = 2.26$, Cohen's $d = 0.29$, $p = .024$), left 2D:4D ($t(271) = 2.03$, $d = 0.26$, $p = .043$) and mean

Table 1. Descriptive statistics for Japanese participants

	Female (N = 184)				Male (N = 90)			
	M	*SD*	*MIN*	*MAX*	*M*	*SD*	*MIN*	*MAX*
Age	19.05	0.83	18.00	23.00	19.08	0.75	18.00	21.00
Right 2D length	64.56	5.24	47.10	87.60	69.73	4.82	59.90	86.90
Right 4D length	65.67	5.55	47.30	87.60	71.80	5.15	60.20	88.10
Left 2D length	64.60	4.89	47.20	83.40	69.50	4.79	58.80	84.40
Left 4D length	65.42	5.20	47.80	81.20	71.32	5.23	59.20	86.40
Right 2D:4D	0.985	0.05	0.84	1.19	0.972	0.04	0.87	1.11
Left 2D:4D	0.989	0.05	0.73	1.28	0.976	0.05	0.79	1.24
Mean 2D:4D	0.987	0.04	0.79	1.23	0.974	0.04	0.83	1.17
Sensitivity	4.80	1.10	1.00	7.00	4.29	1.29	1.00	6.90

Note. 2D = 2 digit. 4D = 4 digit. Sensitivity = personality trait of environmental sensitivity. For males, the sample size for left 2D, left 4D, left 2D:4D, and mean 2D:4D was N = 89.

Table 2. Descriptive statistics for Indian participants

	Female (N = 94)				Male (N = 86)			
	M	*SD*	*MIN*	*MAX*	*M*	*SD*	*MIN*	*MAX*
Age	20.16	1.60	18.00	24.00	20.16	1.47	18.00	24.00
Right 2D length	61.94	4.04	49.80	71.10	67.14	4.72	54.50	77.20
Right 4D length	62.56	4.08	54.10	74.50	67.94	4.32	56.40	79.00
Left 2D length	61.89	4.22	48.30	70.20	67.49	4.72	55.60	78.30
Left 4D length	62.72	4.25	54.10	75.70	68.65	4.64	55.90	79.10
Right 2D:4D	0.988	0.04	0.89	1.09	0.983	0.03	0.86	1.05
Left 2D:4D	0.991	0.05	0.84	1.10	0.989	0.04	0.83	1.10
Mean 2D:4D	0.989	0.04	0.87	1.08	0.986	0.03	0.86	1.07
Sensitivity	4.81	0.97	2.33	6.75	4.89	0.85	2.75	6.42

Note. 2D = 2 digit. 4D = 4 digit. Sensitivity = personality trait of environmental sensitivity.

Table 3. Correlation coefficients between 2D:4D and environmental sensitivity for Japanese participants

	1	2	3	4	5	6	7	8
Female (N = 184)								
1. Age	—							
2. Right 2D length	.03	—						
3. Right 4D length	−.06	.85**	—					
4. Left 2D length	.06	.79**	.65**	—				
5. Left 4D length	−.04	.66**	.78**	.78**	—			
6. Right 2D:4D	.18*	.18*	−.36**	.20**	−.28**	—		
7. Left 2D:4D	.17*	.14	−.27**	.25**	−.40**	.74**	—	
8. Mean 2D:4D	.19*	.17*	−.33**	.24**	−.37**	.92**	.94**	—
9. Sensitivity	.00	−.02	−.08	.04	−.08	*.12*	***.21***	***.18**
Male (N = 89~90)								
1. Age	—							
2. Right 2D length	−.15	—						
3. Right 4D length	−.11	.86**	—					
4. Left 2D length	−.09	.91**	.82**	—				
5. Left 4D length	−.17	.80**	.93**	.77**	—			
6. Right 2D:4D	−.07	.19*	−.33**	.10	−.31**	—		
7. Left 2D:4D	.13	.09**	−.24*	.25*	−.41**	.63**	—	
8. Mean 2D:4D	.05	.15	−.31**	.21	−.41**	.87**	.93**	—
9. Sensitivity	−.08	.01	.00	−.01	−.02	*.01*	*.01*	*.01*

Note. 2D = 2 digit. 4D = 4 digit. Sensitivity = personality trait of environmental sensitivity.
** $p < .01$, * $p < .05$.

Table 4. Correlation coefficients between 2D:4D and environmental sensitivity for Indian participants

	1	2	3	4	5	6	7	8
Female (N =94)								
1. Age	—							
2. Right 2D length	.03	—						
3. Right 4D length	.08	.74**	—					
4. Left 2D length	.07	.80**	.81**	—				
5. Left 4D length	−.06	.72**	.88**	.81**	—			
6. Right 2D:4D	.21*	.15	−.08	.34**	−.28**	—		
7. Left 2D:4D	−.07	.36**	−.35**	−.01	−.21*	.33**	—	
8. Mean 2D:4D	.07	.32**	−.28**	.19	−.30**	.79**	.84**	—
9. Sensitivity	.08	−.14	−.07	−.16	−.17	*.00*	*−.11*	*−.07*
Male (N = 86)								
1. Age	—							
2. Right 2D length	−.05	—						
3. Right 4D length	−.07	.78**	—					
4. Left 2D length	−.04	.82**	.84**	—				
5. Left 4D length	−.13	.75**	.88**	.89**	—			
6. Right 2D:4D	.20	.19	−.02	.31**	−.17	—		
7. Left 2D:4D	.02	.47**	−.19	.09	−.06	.31**	—	
8. Mean 2D:4D	.12	.44**	−.14	.22*	−.13	.73**	.88**	—
9. Sensitivity	−.03	.14	.11	.11	.10	*.03*	*.05*	*.06*

Note. 2D = 2 digit. 4D = 4 digit. Sensitivity = personality trait of environmental sensitivity.
** $p < .01$, * $p < .05$.

2D:4D ($t(271) = 2.28$, $d = 0.30$, $p = .023$) ratios than those of males. The mean values for the personality trait of environmental sensitivity were also higher for females than the values for males ($t(272) = 3.35$, $d = 0.43$, $p = .001$). In contrast to the results of Japanese participants, no sex differences were found in the mean values of the main variables (i.e., 2D:4D and sensitivity) for Indian participants.

Correlations between 2D:4D and the Personality Trait of Environmental Sensitivity

Tables 3 and 4 show the correlation coefficients between 2D:4D and sensitivity for Japanese and Indian participants by sex, respectively. A scatter plot is shown in Figure 1 to provide a visual understanding of the relationship and distribution of the 2D:4D ratios and sensitivity.

In Japanese participants, females with greater left 2D:4D and mean 2D:4D ratios also tended to have greater sensitivity ($r = .21$ and .18, respectively); however, the effect sizes were small. In Japanese males, the correlation between the 2D:4D ratio and sensitivity was not greater than zero ($rs = .01$). Indian participants showed no association between the 2D:4D ratios and sensitivity in either females or males.

Analysis of Outliers for Japanese Females

As noted above, higher left 2D:4D and mean 2D:4D in Japanese females were shown to correlate with high sensitivity. However, in Figure 1 (A, B, and C), we can see that some individuals showed extreme values in the upper right. With the intention of increasing the robustness of the findings, we again calculated correlation coefficients between 2D:4D and sensitivity, excluding data from Japanese female participants ($N = 3$) whose right or left or mean 2D:4D were outside the $M \pm 3SD$ range. The correlation coefficients between the sensitivity and left 2D:4D ($r = .15$, $p = .047$) and mean 2D:4D ($r = .11$, $p = .130$) were even smaller.

Additional Analysis on Indian Participants

To increase the robustness of the findings, given that 2D:4D among Indian participants varied more between individuals than between sexes (i.e., no clear sexual dimorphism in 2D:4D; Table 2), we combined the female and male sub-datasets into a single dataset and recalculated the correlation coefficients with sensitivity. As a result, no association was found between 2D:4D and sensitivity ($rs = -.04$ to .01, $p > .05$).

Discussion

Various organisms, including humans, can adaptively adjust their phenotypes, that is, developmental plasticity, in response to their environment early in life (Bateson et al., 2004; Del Giudice et al., 2018; Frankenhuis & Panchanathan, 2011; Gluckman et al., 2009; West-Eberhard, 2003). However, current knowledge of correlations among candidate factors that may cause individual differences in human developmental plasticity is limited. Therefore, the present study attempted to add new knowledge by exploratively examining the correlations between the personality trait of environmental sensitivity and an indirect measure of prenatal androgen exposure, 2D:4D. Analysis of data obtained from Japanese and Indian participants revealed no clear correlation between the personality trait of environmental sensitivity and 2D:4D overall. Among Japanese females, the personality trait of environmental sensitivity was weakly positively correlated with the left- and two-handed mean 2D:4D ratios, but the correlation approached zero when outliers were excluded. Based on findings that prenatal testosterone exposure affects the development of the limbic system and emotional behavior (Hu et al., 2015), prenatal androgen exposure may also be involved in the development of environmental sensitivity; however, this assumption was not supported by our study, which used the 2D:4D ratio as an alternative marker.

A central question in understanding individual differences in human developmental plasticity is whether individuals with high levels of *one* plasticity-related factor (e.g., environmental sensitivity) are the same as those with high levels of *another* factor (e.g., prenatal androgen exposure). However, our findings did not support the idea that those factors co-occur in the same individuals. Moreover, it is difficult to provide a plausible explanation for the current situation regarding the relationships between factors at different levels (e.g., physiological and personality factors) that are involved in individual differences in developmental plasticity (e.g., Weyn et al., 2022). However, we propose two hypotheses based on existing evidence regarding how different plasticity factors influence individual differences in developmental plasticity.

The first hypothesis is that multiple factors, independently or in interaction, cumulatively contribute to the degree of developmental plasticity. The evidence underpinning this hypothesis is that individual differences in susceptibility to both positive and negative environments during childhood result from the cumulative effects of multiple genotypes (Belsky & Beaver, 2011; Keers et al., 2016). The second hypothesis is the domain-specific hypothesis of a plasticity factor, which states that in a given environment (e.g., quality of nurture), factor "*A*" become a plasticity factor, but factor "*B*" does not. This hypothesis is supported by recent findings suggesting susceptibility to positive and negative environmental influences may be domain-specific rather than domain-general (Belsky et al., 2022; Hentges et al., 2023; Markovitch et al., 2023; Markovitch et al., 2021; Markovitch & Knafo-Noam, 2021). The findings and theories that explain these hypotheses may be useful for further understanding individual differences in human developmental plasticity.

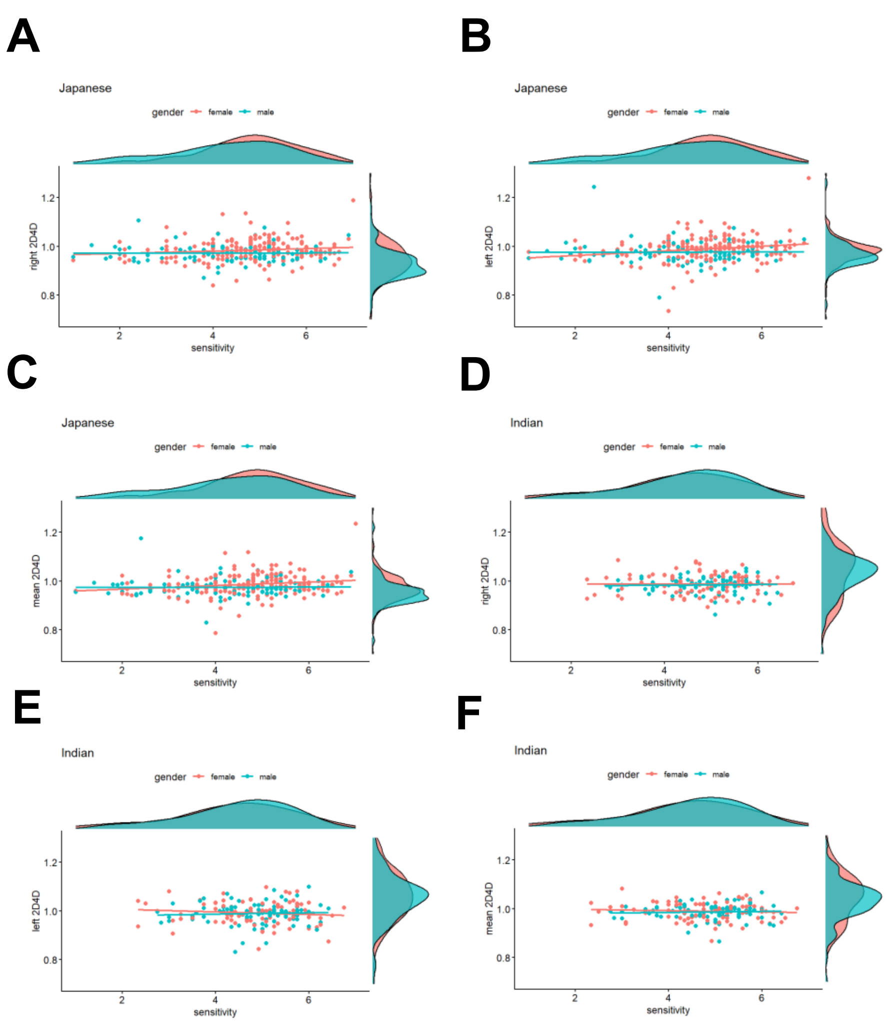

Figure 1. Scatterplots of 2D:4D ratios and the personality trait of environmental sensitivity among Japanese and Indian participants.

Note. Scatterplots labeled A, B, and C show the association between sensitivity and right, left, and mean 2D:4D ratios, respectively, for Japanese participants; scatterplots labeled D, E, and F show the same associations for Indian participants.

Limitations

The present study provides new insights into candidate factors contributing to individual differences in human developmental plasticity by examining, for the first time, the association between 2D:4D and the personality trait of environmental sensitivity. The robustness of the findings was enhanced by collecting data from participants in two demographically distinct countries, Japan and India. Although these are the strengths of this study, there are also some limitations worth noting. First, since this study aimed to examine the bivariate correlation between the digit ratio and sensitivity, if future studies may benefit from statistically controlling for variables commonly associated with both digit ratio and sensitivity (e.g., the Big Five personality traits), a better understanding of their relationship could be gained. Second, finger length was measured by the participants using digital calipers under the guidance of the authors, which are likely less reliable than expert-conducted measurements (Hönekopp & Watson, 2010). Third, given that no clear mean differences in 2D:4D were found between females and males, especially in the Indian data, it is likely that the findings of this study may not generalize this sample. Fourth, the association between 2D:4D and prenatal androgen exposure in humans remains controversial compared to evidence obtained in other species of tetrapods (Manning & Fink, 2023). To address our research question, i.e., the association between individual differences in environmental sensitivity and prenatal androgen exposure, it seems ideal, albeit practically challenging, to measure prenatal androgens directly or to employ alternative markers that are more valid or direct than 2D:4D. Finally, we were unable to directly compare the data from the Japanese and Indian samples because different language versions of the HSP scale were used (i.e., 10 items in Japanese and 12 items in English). If ethnic differences are assumed to relate to environmental sensitivity and the 2D:4D ratio, future studies using samples from other cultural backgrounds (e.g., Western countries) may yield more informative and generalizable findings.

Conclusion

This is the first study to examine the association between the personality trait of environmental sensitivity and 2D:4D ratios, which are candidate markers of individual differences in human developmental plasticity. We did not find a clear association between these variables, at least in our data on the Japanese and Indian students. In recent years, several studies have examined the associations between the candidate factors involved in individual differences in human developmental plasticity (Weyn et al., 2022). However, given the currently inconsistent associations among these candidate factors, it may be necessary to construct a strong theory that includes and links genotypic, neuroendocrine, and phenotypic candidate factors to explain individual differences in developmental plasticity.

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