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Masculinity/Femininity predicts brain volumes in normal healthy children

Amy M. Belfi^{a,e}, Amy L. Conrad, Ph.D.^b, Jeffrey Dawson, Sc.D.^c, and Peg Nopoulos, M.D.^{a,b,d,e}

^aInterdisciplinary Graduate Program in Neuroscience, University of Iowa, 200 Hawkins Drive, 2115 RCP, Iowa City, Iowa, USA

^bDepartment of Psychiatry, University of Iowa Carver College of Medicine, 200 Hawkins Drive, W278 GH, Iowa City, Iowa, USA

^cDepartment of Biostatistics, University of Iowa, S145 CPHB, Iowa City, Iowa, USA

^dDepartment of Pediatrics, University of Iowa Carver College of Medicine, 200 Hawkins Drive, W278 GH, Iowa City, Iowa, USA

^eDepartment of Neurology, University of Iowa Carver College of Medicine, 200 Hawkins Drive, 2115 RCP, Iowa City, Iowa, USA

Abstract

Previous research has shown sex differences in brain morphology (De Bellis et al., 2001). However, these studies have not taken gender into account. Gender is a phenotype that describes behavior. In this study, we examined the relationship between gender, sex, and brain volumes in children. One hundred and eight children ages 7 to 17 were administered the Children's Sex Role Inventory (Boldizar, 1991) and obtained volumetric brain data via MRI. We found that in the frontal lobe, higher masculinity predicted greater volumes of white matter. Also, in the temporal lobe, higher femininity predicted greater volumes of gray matter.

Keywords

development; gender; MRI; sex differences

1. Introduction

Differences in brain structure and function between the sexes has been a topic of scientific inquiry for over 100 years. In particular, this topic has had significant interest in the past 20 years given the tools of brain imaging which allows the in vivo study of brain structure and function. In regard to brain structure, one of the most consistent findings from the neuroimaging literature is that males, on average, have greater overall cerebral volume than females by approximately 10% (Caviness, Kennedy, Richelme, Rademacher, & Filipek, 1996; De Bellis et al., 2001; Giedd, 2004; Nopoulos, Flaum, O'Leary, & Andreasen, 2000;

Reiss, Abrams, Singer, Ross, & Denckla, 1996; Sowell et al., 2007). Moreover, after accounting for the increased volume of the cerebrum, males have been reported to have a higher proportion of white matter, while women have a higher proportion of gray matter (Filipek et al., 1994; Gur et al., 1999). The basic sexual dimorphism in brain structure of larger brain volume in males is well documented in adults, but has also been reported as early as newborns (intracranial volume) (Gilmore et al., 2007), 1-2 year old infants (total brain volume) (Knickmeyer et al., 2008), throughout childhood (Giedd, Castellanos, Rajapakse, Vaituzis, & Rapoport, 1997) and even in monkeys (Knickmeyer et al., 2010).

However, all of these studies have evaluated differences in sex, regardless of gender role behavior. Gender role behavior is defined as the phenotypic aspect of sex, i.e. how a person exhibits masculine and feminine traits. Males and females can identify with traits that are typical of both masculine and feminine gender roles. That is, while males, in general, are overall more masculine than females, male gender roles and male sex are not exactly the same. Males can be feminine and females can be masculine. It is important to note the difference between “gender role behavior” and core gender identity, that is, the sense of being male or female. In the present study, we use the term “gender role behavior.” We define gender role behavior using a measure of identification with masculine and feminine traits. Thus, in measuring “masculinity” and “femininity”, we are measuring gender role behaviors. Being more masculine means that one identifies with more masculine gender role behaviors.

Few studies have used gender role behavior to investigate differences in brain structure. One previous study (Bourne & Maxwell, 2010) indicated that psychological gender is related to lateralization in processing emotional facial expressions, although this study did not directly investigate brain structure. In a previous study from our lab, Wood et al. (2008a) found that in adults, female sex was associated with proportionally larger volumes of the straight gyrus in the ventral frontal cortex, an area of the brain thought to govern social function. We also reported that the larger the straight gyrus, the better the performance on a social function test. Moreover in males, higher femininity scores on a gender assessment were associated with larger volumes of this region. This may provide evidence that gender can be predictive of brain volumes along with or over and above biological sex.

While the Wood study evaluated a small cortical region of the brain, no study has yet to evaluate the effects of masculinity and femininity on the sexual dimorphism of the brain in a more global fashion, evaluating both cerebrum size and proportionate tissue distribution. If masculinity/femininity can predict brain volumes over and above the effect of sex, this may explain some variation among the sexes in terms of behavioral differences. The current study is aimed at investigating the relationship between both gender role behavior and sex and global brain volumes in a large sample of healthy children. Three research questions were addressed. First, how closely related are gender role behaviors and sex? Secondly, does our sample replicate the previous findings on sex differences in brain morphology? Finally, the third and most important question, can gender role behaviors predict brain volumes over and above the effect of sex?

2. Materials and Methods

2.1 Participants

The sample in this study consisted of 108 (male = 56, female = 52) normal healthy children (ages 7 – 17). Participants were recruited via newspaper advertising as a normal comparison group for a study of children with oral clefts.

Medical and psychiatric illness was assessed by parental report in an interview with an experienced research assistant. Children were excluded if parents reported significant (requiring medical intervention) medical, neurological, or psychiatric illness, including alcohol and other substance abuse; a diagnosis of gender identity disorder would have also resulted in exclusion from this study. Select subtests (Vocabulary, Block Design, and Picture Completion) from the Wechsler Intelligence Scale for Children III (WISC-III) was used to measure the IQ for children ages 7-16 (Wechsler, 1991). The Wechsler Adult Intelligence Scale III (WAIS-III) was used to obtain the IQ measures for 17 year-olds (Wechsler, 1997). Socioeconomic status was collected by self-report from parents on a 1-5 scale, with 1 representing the highest social class. All subjects were of Caucasian ethnicity. Written informed consent was obtained from at least one parent and assent was obtained from the child, if age 12 or greater, for all participants prior to participation. The study was approved by the Human Subjects Institutional Review Board.

To evaluate demographic measures between groups, independent sample t-tests were performed for age, IQ, and parental socioeconomic status (SES). There were no statistically significant differences between sex groups (males and females). Table 1 demonstrates demographic measures for each group.

2.2 Assessing gender role behavior

The questionnaire used to determine participants' gender score was the Children's Sex Role Inventory (CSRI; Boldizar, 1991). The CSRI is well-validated for use in determining identification with masculine and feminine characteristics in children. A previous longitudinal study using the CSRI has found that these levels of masculinity/femininity are stable by childhood and do not significantly change over adolescence (Priess, Lindberg, & Hyde, 2009). A "sex role" is defined as a person's level of identification with masculine and feminine characteristics. That is, a person who identifies more with feminine characteristics is said to have a more feminine "sex role." While the terms "sex" and "gender" are often used interchangeably, it is necessary for the present study to differentiate between the two. While the CSRI is said to measure "sex roles," the current paper will refer to these as psychological "gender" roles. The term "sex" is reserved for use in referring to biological sex.

The CSRI consists of 20 items (10 masculine & 10 feminine). For each item (e.g. "I am sure of my abilities"), children are asked to rate on a 1-4 scale how true it is of them. Masculinity and femininity are assessed on separate dimensions. The items on the CSRI were directly adapted from the Bem Sex Role Inventory (BSRI; Bem, 1974), which assesses gender in adults. The items on the scale were selected from a preliminary list of 200 positive personality characteristics. For each item on this list, participants were asked to rate how

desirable the trait is in American society for either a man or for a woman. For example, a participant was asked, “In American society, how desirable is it for a man to be truthful?” Participants rated every item either for a man or for a woman. For an item to be included in the final list of characteristics, it must have been rated by both males and females to be significantly more desirable for a man than for a woman, and vice versa. That is, if a characteristic was found to be significantly more desirable for a man, it was included as a masculine item.

On the BSRI, participants are asked to rate on a 7-point scale how well each of the characteristics describes themselves. For the CSRI, these characteristics were changed into a statement about the child himself. For example, the masculine BSRI attribute “assertive” was changed to “It's easy for me to tell people what I think, even when I know they will probably disagree with me.” The children then rate this statement on a 4-point scale, ranging from “not at all true of me” to “very true of me.” See Appendix A for the full list of items on the CSRI.

The scores for each of the 10 items per category are added and the average is taken to determine each participant's masculine score and feminine score; the highest score in each category is therefore 4. For the present analysis, we also created a masculine/feminine continuum score by subtracting the feminine score from the masculine score. Therefore, the higher the continuum score, the more masculine a person is, and the lower the score the more feminine. While this variable is not continuous, the terminology continuum is used to describe gender spanning the continuum from fully masculine to fully feminine. Table 2 shows performance on the CSRI, and Figure 1 displays the full distribution of scores on the masculine/feminine continuum.

2.3 MRI acquisition

Images were obtained on a 1.5 Tesla GE Signa MR scanner. Three different sequences were acquired for each participant (T1, T2, and proton density or PD). T1 weighted images, using a spoiled grass sequence, were acquired with the following parameters: 1.5 mm coronal slices, 40° flip angle, TR = 24ms, TE = 5ms, NEX = 2, FOV = 26cm and a 256 × 192 matrix. The PD and T2 weighted images were acquired with the following parameters: 3.0 mm coronal slices, TE = 36ms (for PD) or TE = 96ms (for T2), TR = 3000ms, NEX = 1, FOV = 26cm, 256×192 matrix and an echo train length = 8. Automatic processing of the images after acquisition was done using *Brain Research: Analysis of Images, Networks, and Systems* (BRAINS2), a locally developed family of software programs. Details of the image analysis are published elsewhere (Magnotta et al. 2002). Briefly, a three-dimensional data set is created, and the images are realigned, resampled, and the Talairach Atlas is warped onto the brain (Talairach and Tournoux, 1988). Within the stereotactic space, boxes (voxels) were assigned to specific brain regions. Intracranial volume was subdivided into brain tissue and cerebral spinal fluid. The cerebrum was divided into its four lobes. Automated measures obtained using a stereotactically-based method have been reported by our lab and others to be efficient and accurate for cerebral lobe measures (Andreasen et al. 1996; Collins et al. 1994). This use of automated measurement using the Talairach atlas has been validated in pediatric populations within the age range of the current study (Kates et al. 1999).

2.4 Statistical analyses

All analyses were completed using SPSS 19.0 for Windows. Mean values were calculated for both males and females for brain morphology measures, including intracranial volume (ICV), total tissue, total CSF, total white and gray matter, as well as white and gray matter for each of the cerebral lobes. To control for sex differences in body and brain size, ratios were created. Total intracranial volume (ICV) was divided by height; total tissue and total CSF were each divided by ICV; total cerebrum volume and total cerebellum volume were each divided by total tissue; total cortex and total white matter were divided by total cerebrum tissue; and total temporal, occipital, parietal, and frontal lobes were divided by total cerebrum tissue. Sex effects were assessed using univariate ANCOVA (covariates= age and SES). Bonferroni Correction was applied for each set of comparisons and p-values are adjusted for multiple comparisons. Sets included: Cerebrum and Cerebellum (2); Regional Gray Matter (7); and Regional White Matter (7). Laterality of sex effect was evaluated by including a sex by side interaction in the model, but this factor was removed if not significant. The relationship between brain structure and masculinity/femininity after controlling for age, SES, and sex was examined by using hierarchical multiple regressions. After looking at all participants together and controlling for sex, additional follow-up correlations were performed on each sex separately, evaluating the relationships of brain structure with masculinity scores, femininity scores, and the continuum scores. To limit the number of comparisons and reduce the chance of Type I errors, the correlations were conducted only on those brain regions that showed a significant gender effect in the hierarchical regression analysis.

3. Results

3.1 Relationship between gender role behaviors and sex

A correlation analysis was performed between masculine/feminine continuum score and sex. A higher score (more masculine) on the masculine/feminine continuum was positively associated with male sex ($r = .542, p < .001$). Although this was a highly significant correlation, it is low enough to support the notion that sex and gender, at some level, are different such that accounting for sex does not fully account for gender (or the reverse). Additionally, gender scores were not significantly correlated with FSIQ scores.

3.2 Sex effects

Table 2 shows the raw volumes for both males and females, as well as the sex effects, for overall areas as well as each cerebral lobe. Our sex effects validated the most consistent findings of previous research. After adjusting for height and cerebrum tissue respectively, males were found to have greater intracranial volume ($F = 24.14, p < .001$) and greater white matter ($F = 6.35, p = .02$). Females were found to have a greater overall proportion of gray matter ($F = 5.45, p = .04$). For subcortical areas, it was found that females had a significantly greater proportion of gray matter in the putamen and thalamus, as well as a greater proportion of white matter in the putamen. Males were found to have a significantly greater proportion of white matter in the thalamus. There were no significant sex by hemisphere interactions.

3.3 Gender role behavior effects after controlling for sex

Table 3 shows the effects of masculinity/femininity after controlling for sex in a hierarchical regression. Age and SES were included in step one, sex was entered in step two, and gender was entered in step three. After controlling for the effect of sex, gender role behavior scores added significantly to the prediction of frontal white matter volume and temporal gray matter volume. For frontal white matter, sex accounted for 34% of the variance. The addition of gender scores significantly increased prediction to 36% of variance ($R^2_{\text{change}} = .02$; $F(4, 103) = 16.16$, $p = .05$). That is, higher scores on the masculine/feminine continuum predicted higher frontal white matter volume. For temporal gray matter, there was no significant sex effect. However, gender accounted for 11% of variance ($R^2_{\text{change}} = .33$; $F(4, 103) = 3.23$, $p = .05$). Lower scores on the masculine/feminine continuum predicted higher temporal gray matter volume.

3.4 Gender role behavior effects within each sex

Table 4 shows the partial correlations between gender scores (masculinity, femininity, and continuum) and regional volumes that had a significant gender effect, separately for males and females. These correlations controlled for age and SES. Interestingly, the only significant correlations between gender and brain volume measures were in the females and limited to masculinity scores. For females only, the masculine score correlated with temporal gray matter at $r = -0.354$, $p = .04$, indicating that higher masculine scores are associated with lower temporal gray matter volumes. Conversely, in females, higher masculine scores were positively correlated with frontal white matter ($r = 0.287$, $p = .04$) indicating that the higher the masculine scores, the greater the white matter volume. Although the pattern of correlations between masculinity scores and brain volumes were similar for the male group, none of these correlations reached statistical significance. Finally, femininity scores were not significantly correlated with any brain measure for either the male or the female group.

4. Discussion

Consistent sex differences previously found in adult samples were validated in the current sample of children. Males had overall greater total intracranial volume as well as a greater proportion of cerebral white matter. Females had a greater proportion of cerebral gray matter. These overall findings are mostly consistent with sex differences in brain structure reported in adults and children. However, in adults, it has been shown that males have an overall greater proportion of CSF than females (Gur et al., 1999). In this sample, it was the opposite trend with females having larger volumes of CSF compared to males. In children, previous studies have shown greater amounts of CSF in females than males (Reiss et al., 1996). This difference could be due to the fact that females' brains are more mature at a younger age. At an average age of 12, females have been shown to be approximately one year ahead of males in the developmental process of cortical pruning which leads to decreased cortical tissue (Giedd et al., 1999).

Another sex difference found in the present study was that females showed greater proportional volume of gray matter in certain subcortical areas (putamen, and thalamus).

Previous research on brain structure in children has shown increased volumes in the caudate in females (Caviness et al., 1996; Giedd, 2004; Sowell et al., 2002). However, recent studies in adults (Rijpkema et al., 2012) and children (BDCG, 2012) have shown that males have overall greater volumes in the putamen (with no sex differences in the caudate or thalamus). While this previous research is somewhat contradictory with regards to sex differences in overall volumes of these structures, our current findings are differences in the proportion of gray matter.

Importantly, sex and gender role behavior scores were related, but not completely. While there was a significant correlation between gender role scores and sex, the two were not perfectly correlated. This correlation shows that overall, males tended to identify with more masculine gender roles, while females identified with more feminine gender roles. However, the strength of this correlation is only moderate. While masculine gender roles were significantly correlated with being male, there are males who display feminine gender characteristics, and females who display masculine gender characteristics. There are some females who identify as more masculine than some males, and vice versa. This is important when looking at the predictive value of masculinity/femininity over and above biological sex. If gender role behaviors and sex were perfectly correlated, it would be impossible to separate the effects of the two. Because they are not, we are able to look at the effects of gender role behaviors apart from those of biological sex.

In our regression analysis, we found that masculinity/femininity significantly predicted regional brain volumes even after controlling for the effects of sex. In the frontal lobes, males had proportionately larger volumes of white matter than females. However, we found that higher scores on the masculinity/femininity continuum predicted greater white matter volume in the frontal lobes after controlling for this sex effect. Additionally, while there were no significant sex differences, lower scores on the masculinity/femininity continuum predicted greater gray matter volume in the temporal lobes. These findings suggest that the volumes of frontal lobe white matter and temporal lobe gray matter are also associated with masculinity/femininity, above and beyond the effects of sex.

In our regression analysis, we looked at the predictive value of the masculine/feminine continuum score on regional brain volumes. From this, we were unable to tell whether increased masculinity or decreased femininity was related to larger frontal white matter volumes and smaller temporal gray matter volumes. As well as this continuum score, our data also included separate scales each for masculinity and femininity. We further specified our original results by performing correlations between regional volumes and these separate gender scores for each sex. For both sexes, the direction of the effect was the same as that found in the overall regression. However, in our follow-up correlations we found that only the *masculine* score was significantly correlated with these regional brain matter volumes, and only in *females*. That is, frontal white matter volume was positively correlated with masculinity scores (larger volumes correlated with higher scores), and temporal gray matter volume was negatively correlated with masculinity scores (larger volumes correlated with lower scores), but only in females. A previous study using the Bem Sex Role Inventory also found that the masculinity scores (and not femininity scores) were correlated with behavior on an emotion identification task (Bourne and Maxwell, 2010). These results may provide

support for the idea that masculinity is a better predictor of brain volumes and behavior than femininity.

The current methodology evaluated global regions of the cerebrum. As the cerebrum is divided into specific functional regions, further research will need to utilize methods such as cortical parcellation and diffusion tensor imaging to evaluate more specific regions that may be associated with gender as well as what specific cognitive skill or behavior may be associated with those regions.

One potential reason why only masculinity scores significantly correlated with brain volumes in our study could be because females are more likely to score high on the masculinity scale, while males are less likely to score high on the femininity scale. In our sample, the femininity score was more variable between sexes. Females had a much higher femininity score than males; however, the masculinity score was more similar between groups. Because the femininity scores were more stratified for each sex, the effect of femininity may be getting masked by the overall gender effect. However, because masculinity scores are more variable within females, this is where the gender effect is strongest.

A potential mechanism for this sex-specific effect (masculine scores correlated with brain volumes only in females) could be variation in levels of prenatal testosterone. Previous studies have reported a relationship between prenatal testosterone levels and gender role behavior in children (Auyeung et al., 2009), with one study reporting that this effect was significant for girls, but not boys (Hines et al., 2002). That is, preschool age girls who were subject to higher levels of prenatal testosterone showed more masculine behavior. Additionally, increased prenatal testosterone levels have been shown to be associated with “masculinized” brain structure in children (Peper et al., 2009). Potentially, the girls in our sample with higher masculine scores on the CSRI also experienced higher levels of prenatal testosterone, and thus, showed more “masculine” brain structure (greater frontal lobe white matter). The converse could be true for the effect of temporal lobe gray matter. In boys, this effect may not be significant because there is a ceiling effect of the effect of testosterone; boys already have higher prenatal testosterone levels than girls, so normal variation may not have as great an effect on their gender role behavior and brain structure.

The present findings indicate that in addition to biological sex, gender role behaviors may be an important variable in predicting differences in brain volumes. Interestingly, an interaction between sex and gender role behaviors was seen, so that this gender effect was only present in females. While there is a dearth of previous research on sex differences in brain structure and function, very few studies look at gender role behaviors. Gender roles may be a more fine-grained measure of sex; looking at both biological sex and psychological gender role behaviors can provide a more accurate picture of a person's gendered self. Because gender is a measure of phenotype (i.e., behavior), gender role scores will add insight into relationships between sex, brain structure, and behavior.

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Figure 1.
Distribution of masculine/feminine continuum score.

Table 1

Demographic Information.

	Males (n = 56)		Females (n = 52)		t	p-value
	M	SD	M	SD		
Age	12.18	2.80	12.62	2.93	-0.795	.428
Full-scale IQ	113.39	16.84	109.35	13.83	1.359	.177
Parental SES	2.31	0.57	2.26	0.48	0.520	.604

Table 2

CSRI Performance.

	Males (n = 56)		Females (n = 52)		t	p-value
	M	SD	M	SD		
Masculine Score	2.05	.40	2.83	.46	2.62	.010
Feminine Score	2.94	.38	3.40	.50	-5.272	<.001
Continuum Score	.10	.50	-.56	.55	6.578	<.001

Table 3

Results of Analysis of Brain Measures.

	Raw Volumes				Ratios ^a		Sex Effect ^b	
	Male		Female		Male	Female	F-value	p-value ^d
	Mean	SD	Mean	SD				
ICV	1448.778	112.293	1327.202	88.337	9.538	8.701	24.141	<.001
Tissue	1402.291	109.014	1275.988	86.975	0.967	0.961	4.915	.058
CSF	46.486	17.040	51.214	24.227	0.032	0.038	4.915	.058
Cerebrum	1217.629	95.702	1108.309	76.681	0.868	0.868	0.213	1.29
Cortex	734.669	53.719	675.079	48.312	0.603	0.608	5.453	.042
White Matter	380.711	48.058	339.275	37.448	0.311	0.305	6.346	.026
Cerebellum	149.007	12.511	135.905	10.112	0.106	0.106	0.006	1.87
Frontal Lobe								
Gray Matter	295.870	22.194	272.206	19.685	0.121	0.123	5.454	.147
White Matter	167.881	19.998	149.046	15.913	0.069	0.067	7.148	.063
Parietal Lobe								
Gray Matter	163.938	13.259	151.297	12.923	0.067	0.068	5.115	.182
White Matter	104.860	14.523	94.241	10.829	0.043	0.042	1.983	1.13
Temporal Lobe								
Gray Matter	188.357	13.874	171.234	11.729	0.077	0.077	0.012	6.40
White Matter	68.672	8.493	60.832	7.219	0.280	0.270	6.978	.070
Occipital Lobe								
Gray Matter	86.502	7.397	80.341	7.774	0.035	0.036	4.416	.266
White Matter	39.511	6.906	35.156	5.832	0.016	0.016	2.315	.917
Caudate								
Gray Matter ^c	7.521	0.800	7.055	0.928	618	637	2.873	.280
White Matter ^c	0.411	0.053	0.366	0.053	33	33	2.261	.472
Putamen								
Gray Matter ^c	9.464	0.979	8.855	0.947	780	800	4.840	.021
White Matter ^c	2.386	0.542	2.266	0.790	196	204	5.830	.007

	Raw Volumes				Ratios ^a		Sex Effect ^b	
	Male		Female		Male	Female	F-value	p-value ^d
	Mean	SD	Mean	SD	Adj Mean	Adj Mean		
Thalamus								
Gray Matter ^c	7.246	0.936	7.339	1.060	596	662	8.479	<.001
White Matter ^c	7.362	0.832	6.596	0.962	605	596	14.279	<.001

Notes.

^aRatio denominators were sequential as follows: ICV/Height, Tissue and CSF/ICV, Cerebrum and Cerebellum/Total Tissue, Cortex, White Matter, and all Lobes/Cerebrum Tissue;

^bCovariates = age and socioeconomic status;

^cRatio values are multiplied by 100;

^dBonferroni Correction applied, p-values adjusted for multiple comparisons.

Table 4

Regression of Brain Volumes, Sex, and Gender.

	Model 1			Model 2			Model 3			Final Model			
	R ²	β_1	β_2	R ²	β_3	R ²	R ²	β_4	R ²	β_1	β_2	β_3	β_4
ICV	.513	-.711***	-.035	.093	-.306***	.005		-.086	.611	-.680***	-.055	-.352***	-.086
Tissue	.223	-.447***	-.109	.035	-.188*	.010		.116	.268	-.439***	-.117	-.125	.116
CSF	.223	.447***	.109	.035	.188*	.010		-.116	.268	.439***	.117	.125	-.116
Cerebrum	.056	-.226*	.104	.002	.044	.000		-.004	.058	-.229*	.107	.042	-.004
Cortex	.398	-.630***	-.008	.030	.174*	.005		-.088	.434	-.639***	.000	.126	-.088
White Matter	.369	.607***	.004	.036	-.191*	.006		.089	.411	.617***	-.005	-.143	.089
Cerebellum	.088	.294**	-.080	.000	-.008	.000		-.003	.088	.295**	-.081	-.009	-.003
Frontal Lobe													
Gray Matter	.370	-.611***	.036	.031	.178*	.000		-.001	.401	-.626***	.046	.177*	-.001
White Matter	.319	.537***	.126	.044	-.210**	.023		.179*	.386	.543***	.118	-.113	.179*
Parietal Lobe													
Gray Matter	.399	-.628***	-.022	.028	.169*	.007		-.100	.434	-.636***	-.015	.114	-.100
White Matter	.270	.521***	-.111	.014	-.117	.000		.002	.284	.530***	-.118	-.116	.002
Temporal Lobe													
Gray Matter	.079	-.253**	-.097	.000	-.010	.033		-.216*	.112	-.238**	-.104	-.128	-.216*
White Matter	.285	.537***	-.035	.045	-.213**	.001		.035	.331	.553***	-.047	-.194*	.035
Occipital Lobe													
Gray Matter	.147	-.386***	.035	.035	.187*	.000		-.010	.182	-.401***	.046	.182	-.010
White Matter	.329	.577***	-.036	.015	-.121	.001		.033	.345	.585***	-.042	-.104	.033
Subcortical													
Caudate													
Gray Matter	.057	.095	.208*	.02	.142	.005		-.087	.082	.089	.214*	.094	-.087
White Matter	.052	1.31	1.73	.009	-.095	.000		.009	.061	.139	.167	-.090	.009
Putamen													

	Model 1			Model 2			Model 3			Final Model			
	R ²	β ₁	β ₂	R ²	β ₃	R ²	β ₄	R ²	β ₁	β ₂	β ₃	β ₄	
Gray Matter	.099	-.292**	.153	.024	.155	.003	.066	.126	-.309**	.165	.191	.066	
White Matter	.143	.380***	-.047	.001	.038	.002	.657	.146	.380***	-.046	.011	-.048	
Thalamus													
Gray Matter	.038	-.195*	.017	.159	.400***	.021	.173	.218	-.240**	.046	.495***	.173	
White Matter	.281	.529***	.004	.011	-.106	.004	-.073	.295	.543***	-.005	-.146	-.073	

Notes. Ratio denominators were sequential as follows: ICV/Height, Tissue and CSF/ICV, Cerebrum and Cerebellum/Total Tissue, Cortex, White Matter, and all Lobes/Cerebrum Tissue; R² – R squared; R² = R squared Change; Standardized Betas include: β₁ = Age, β₂ = Socioeconomic Status, β₃ = Sex, β₄ = Gender.

* p = .05
** p < .01
*** p < .001

Table 5

Correlations between gender scores and regional volumes.

	Males (n = 56)		Females (n = 52)	
	Frontal White	Temporal Gray	Frontal White	Temporal Gray
Masculine Score	.059	-.161	.287*	-.354*
Feminine Score	-.128	-.082	-.009	.001
Continuum Score	.185	-.128	.276*	-.285*

*
p < .05