Exposure to Parental Verbal Abuse is Associated with Increased Gray Matter Volume in Superior Temporal Gyrus

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ABSTRACT

Objective: Exposure to parental verbal aggression (PVA) during childhood increases risk for the development of psychopathology, particularly mood and anxiety disorders. Other forms of childhood abuse have been found to be associated with alterations in brain structure. The aim of this study was to ascertain whether exposure to PVA was associated with discernible effects on brain morphology.

Methods: Optimized voxel based morphometry was performed on 21 unmedicated, right-handed subjects (18-25 years) with histories of PVA and 19 psychiatrically healthy controls matched for age and sex. Group differences in gray matter volume (GMV) –

covaried by age, gender, parental education, financial stress, and total GMV – were assessed using high-resolution, T1-weighted, volumetric MRI data sets (Siemens 3T trio scanner).

Results: GMV was increased by 14.1% in the left superior temporal gyrus (STG, BA 22) (P = 0.004, corrected cluster level). GMV in this cluster was associated most strongly with levels of maternal ($ß$ = 0.544, $P < 0.0001$) and paternal ($ß$ = 0.300, $P < 0.02$) verbal aggression and inversely associated with parental education ($ß$ = –0.577, $P < 0.0001$).

Conclusion: Previous studies have demonstrated an increase in STG GMV in children with abuse histories, and found a reduction in fractional anisotropy in the arcuate fasciculus connecting Wernicke's and frontal areas in young adults exposed to PVA. These findings and the present results suggest that the development of auditory association cortex involved in language processing may be affected by exposure to early stress and/or emotionally-abusive language.

INTRODUCTION

Brain development is largely guided by genetic factors, but the final form is sculpted by environmental factors and early experience. Exposure to traumatic events such as childhood abuse and neglect, have been associated with alterations in the size or functional activity of a variety of brain regions (e.g., (Andersen et al 2008; Bremner et al 1997; De Bellis et al 1999a; De Bellis et al 2002c; De Bellis and Kuchibhatla 2006; Richert et al 2006; Teicher et al 2004; Teicher et al 1997; Tomoda et al 2009b)). We have recently conducted a voxel-based morphometry (VBM) study in young adults with histories of exposure to repeated episodes of childhood sexual abuse (CSA) and found that the most significant differences were bilateral reductions in gray matter volume (GMV) in the visual cortex (Tomoda et al 2009a). Similarly, our laboratory conducted an analysis of fiber tract integrity in young adults exposed to parental verbal aggression (PVA) using diffusion tensor imaging (DTI) and tract based spatial statistics (TBSS), and observed a reduction in fractional anisotropy in three fiber tracts including the arcuate fasciculus that interconnects Wernicke's and frontal regions (Choi et al 2009). These findings fit with an emerging hypothesis that exposure to early adversity may be associated with alterations in sensory systems that process and convey the adverse sensory experience (Teicher et al 2006a).

PVA is a specific form of emotional abuse that some studies suggest may be associated with particularly severe psychiatric consequences (Ney 1987; Ney et al 1994) (Johnson et al 2001). However, unlike other forms of abuse, such as CSA, physical abuse (PA) and witnessing domestic violence (WDV), PVA is not considered a traumatic event by DSM-IV A1 and A2 criteria, and is often given little credence by mandated reporters (Manning and Cheers 1995; Saulsbury and Campbell 1985). We however, have shown that exposure to PVA was associated in early adulthood with elevated symptoms of depression, anxiety, anger-hostility, dissociation, and 'limbic irritability' (Teicher et al 2006a). Effect sizes for exposure to PVA were equivalent to those for WDV and non-familial CSA, and exceeded those for parental PA (Teicher et al 2006a). Delineating the association between exposure to PVA and alterations in brain structure may help to increase awareness regarding the importance of this common but insidious form of childhood abuse.

Hence, the aim of this study was to investigate whether exposure to PVA exerts an enduring effect on GMV. VBM was used to provide an unbiased, even-handed, whole-brain, voxel-by-voxel assessment in a community sample of late adolescents/young adults

exposed to VA during childhood. Our sample was screened to exclude extraneous factors that might influence brain development. Further, we sought to assess whether alterations in regional GMV correlated with symptom ratings. We hypothesized that exposure to childhood PVA would be associated with alterations in the developmental trajectory of brain regions involved in processing verbally abusive stimuli, and would also affect brain regions regulating emotion, aggression, attention, and cognition.

MATERIALS AND METHODS

1. Recruitment

The McLean Hospital Institutional Review Board approved all procedures. Participants for the study were recruited from the community through an advertisement entitled "Memories of Childhood." Screenings were conducted on 1,455 volunteers using a detailed online assessment instrument with 2,342 entry fields that provided a vast array of information regarding developmental history and psychiatric symptoms. The questionnaire also included demographic information, such as subjects' and parents' educational levels, annual household income, and race/ethnicity. Subjects provided written informed consent prior to completing the online instrument, and again before interviews and brain imaging.

All potentially eligible subjects from the screenings were invited in for interviews. Those meeting inclusion, exclusion and imaging-safety criteria came in for two additional visits. The goal was to recruit a healthy, unmedicated group of subjects from the community, regardless of psychiatric history (except substance abuse). Selecting subjects with PVA meeting criteria for a specific disorder such as post-traumatic stress disorder would potentially overemphasize the effects of exposure by selecting the most seriously affected subjects. Similarly, selecting subjects without any psychiatric history would potentially underestimate the effects of exposure. The goal was to select a sample that would be representative of subjects exposed to PVA but to no other forms of abuse in order to assess the specific impact of exposure to verbal abuse. About 10% of young adults in the community report exposure to PVA but to no other forms of abuse (Teicher et al 2006a).

Exclusion criteria included any histories of substance abuse (as this could affect trajectories of brain development), any recent substance use, head trauma with loss of consciousness, significant fetal exposure to alcohol or drugs, perinatal or neonatal complications, neurological disorders, or medical conditions that might adversely affect

growth and development. Customary MRI exclusions included pacemakers, cerebral aneurysm clips, a cochlear implant, metal fragments lodged within the eye, dental braces, claustrophobia or pregnancy.

Subjects were enrolled in the PVA group if they had a self-reported history of exposure to PVA – defined by an average (i.e., maternal and paternal) ratings $\geq$ 40 on the Verbal Aggression Scale (VAS) (Teicher et al 2006b), or a maximal (maternal or paternal) VAS score $\geq$ 50 – and if this history was confirmed during interview. Participants who had no significant history of exposure to PVA nor any history of Axis I disorders were grouped into the control group.

2. Subjects

The PVA group consisted of 21 young adults (9 males, 12 females; mean age, 21.2 ± 2.4 years) with substantial exposure to PVA during childhood (Table I). The control group consisted of 19 young adults (7 males, 12 females; mean age, 21.1 ± 1.9 years) with neither a current nor past DSM-IV Axis I disorder. Control subjects had no histories of exposure to

abuse, traumatic events, or harsh corporal punishment. All participants were right-handed and unmedicated.

3. Procedures

The first visit was a face-to-face interview to obtain the subject's developmental history and current or lifetime diagnoses of psychiatric disorders using the Structured Clinical Interview for DSM-IV Axis I and II Disorders (SCID-I and SCID-II) (First et al 1997) supplemented by the ADHD section of the K-SADS-PL (Kaufman et al 1996). The semi-structured Traumatic Antecedents Interview (TAI) was used to provide detailed information on exposure to varying forms of abuse and discipline. Subjects needed to be consistent on self-report and interview.

During the second visit subjects were assessed using a variety of standardized psychometric tests, including the Wechsler Adult Intelligence Scale III (WAIS-III) (Wechsler 1997), the Woodcock-Johnson Tests of Achievement-Revised, and the Memory Assessment Scale (Golden et al 1999). During the third visit they were escorted to the Brain Imaging

Center for neuroimaging on the centers 3T Siemens Trio Scanner. Imaging protocols including T1-volumetrics, DTI and T2-relaxometry scans.

4. Assessment Measures

Exposure to PVA was assessed with the Verbal Aggression Scale (VAS) (Teicher et al 2006b). The VAS consists of 15 items that cover the key components of verbal abuse—scolding, yelling, swearing, blaming, insulting, threatening, demeaning, ridiculing, criticizing, belittling, etc. In a separate group of college students, the questionnaire showed high internal consistency as applied to both maternal and paternal behaviors (Cronbach alphas, 0.98 and 0.94, respectively). The VAS provides a continuous measure of exposure. A cut off score (average maternal and paternal VAS $\geq$ 40) or maximal (maternal or paternal) VAS $\geq$ 50 was used to identify subjects exposed to a substantial degree of verbal aggression (Choi et al 2009).

Self-report ratings of psychiatric symptoms were obtained using Kellner's Symptom Questionnaire (SQ; (Kellner 1987)). The SQ is a 92-item yes/no questionnaire used to elicit four symptom scales (depression, anxiety, anger-hostility, somatization) and

four well-being subscales (content, relaxed, friendly, somatic well-being). It was developed to readily detect response to psychotropic medications, and, with the well-being items, is very sensitive to subtle differences from normal. (Kellner 1987). Ratings of dissociation and 'limbic irritability', were obtained using the Dissociative Experience Scale (Bernstein and Putnam 1986) and limbic system checklist-33 (LSCL-33) (Teicher et al 1993). Scores on these scales are elevated by exposure to other forms of childhood traumatic stress (Teicher et al 2006b), and have been found in previous studies to correlate with regional alterations in structure or function associated with maltreatment (Anderson et al 2002; Choi et al 2009). Hence, we used these ratings in an exploratory manner to delineate potential functional correlates of regions of altered GMV.

Low income and poverty may be important developmental risk factors for psychopathology. Young adult subjects were often uncertain about parental income while they were growing up. However, they were well aware of the degree of *perceived financial sufficiency,* or stress they experienced during this time. This was rated on a Likert scale ranging from 1 (much less than enough money for our needs) to 5 (much more than enough money for our needs). In all cases, perceived financial sufficiency explained a greater share

of the variance in ratings of depression, anxiety, anger-hostility, 'limbic irritability' and dissociation than combined family income. Instead of a composite measure of socioeconomic status we included both the subject's level of perceived financial stress and parental education as studies suggest that these factors may provide more meaningful covariates than a composite score (Duncan and Magnuson 2003).

5. MRI acquisition and analysis

Image analysis was performed on high-resolution, T1-weighted MRI datasets, which were acquired on a Trio Scanner (3T; Siemens AG, Siemens Medical Solutions, Erlangen, Germany). An inversion prepared 3D MPRAGE sequence was used with an eight-element phased-array RF reception coil (Siemens AG). The GRAPPA acquisition and processing was used to reduce the scan time, with a GRAPPA factor of 2. Scan parameters were: the sagittal plane, TE/TR/TI/flip = 2.74 ms/2.1 s/1.1 s/12 deg; 3D matrix 256 x 256 x 128 on 256 x 256 x 170 mm field of view; bandwidth 48.6 kHz; scan time 4:56.

As a fully automated whole-brain morphometric technique, VBM detects regional structural differences between groups on a voxel-by-voxel basis (Good et al 2001a; Good et

al 2001b). VBM was performed using SPM5 (Statistical Parametric Mapping 5, developed by The Wellcome Department of Imaging Neuroscience, University College London, London, UK; http://www.fil.ion.ucl.ac.uk/spm/software/spm5/) for imaging processing (MATLAB 6.5; The MathWorks Inc., Natick, MA, USA). Images were segmented coarsely into gray matter, white matter, cerebrospinal fluid, and skull/scalp compartments using tissue probability maps. We used a standard template (Ashburner & Friston) (Ashburner and Friston 2000; Ashburner and Friston 2005) which conforms to the space defined by the ICBM, NIH P-20 project. It approximates the space described in the Talairach and Tournoux atlas (Talairach and Tournoux 1988). The transform for this normalization was used to rewrite the original image into standard space. Volume changes induced by normalization were adjusted via a modulation algorithm. Spatially normalized images were segmented into gray and white matter and then smoothed using a 12-mm full-width half-maximum isotropic Gaussian kernel. Regional differences in GMV between groups were analyzed statistically using the general linear model. Potential confounding effects of age, sex, parental verbal abuse, parental education, perceived financial sufficiency, and whole segment GMV were modeled, and variances attributable to them excluded. The resulting set of voxel values used for comparison generated a statistical parametric map of *t*-statistic SPM**{t}** that was transformed

to a unit normal distribution (SPM**{Z}**). Statistical threshold was set at $P < 0.05$ with correction for multiple comparisons at cluster level (height threshold of $Z > 3.09$) because of the increased sensitivity of clusters to detect spatially extended signal changes (Hayasaka et al 2004; Moorhead et al 2005). Inference testing was based on the theory of Gaussian fields (Friston et al 1996). We corrected for potential problems relating to non-isotropic smoothness, which can invalidate cluster level comparisons (Ashburner and Friston 2000), by adjusting cluster size from the resel per voxel image (Hayasaka et al 2004; Worsley et al 1999).

6. Statistical analyses

Overall, the two groups were well matched except for measures of perceived financial stress, which was included as a nuisance covariate in the analyses. SPM5 was used to identify regions that differed significantly between groups, and to assess the degree of association between alterations in GMV in the identified cluster and degree of exposure to parental VAS. Further analyses were conducted using PASW Statistics 17 (SPSS Inc., Chicago, IL) to ascertain the degree to which GMV in the identified primary cluster was associated with levels of maternal VAS, paternal VAS and key covariates. Further, partial

correlation analysis was used to explore the relationship between GMV in the identified cluster, neuropsychiatric measures and symptom ratings while controlling for age, gender, parental education, perceived, financial sufficiency and whole brain GMV. Distribution of STG GMV and paternal VAS values did not depart significantly from being normally distributed based on the Kolmogorov-Smirnov test. We used the false discovery rate method of Benjamini and Hochberg (Hochberg and Benjamini 1990) to minimize the risk of type I errors in multiple comparisons. This method rank-orders observed p-values and only accepts those above a critical threshold as significant in order to limit the overall False Discovery Rate, which was set as < 0.05 to balance Type-I and Type-II risk in an exploratory analysis.

RESULTS

Overall, there were no significant differences between subjects in the two groups with one exception (Table I). The two groups were equivalent in age and gender distribution. There was a slight predominance of females in both groups. There were no differences in education levels or extent of parental education. However, PVA subjects experienced a greater degree of perceived financial stress growing up than control subjects ($P = 0.001$). PVA subjects indicated that their family's financial resources were on average adequate,

while controls indicated that they were more than adequate. Subjects in both groups did not use drugs and only consumed alcohol to a limited extent. There were no significant differences between groups selected for this study in measures of IQ and memory performance.

As expected, subjects in the PVA group had substantially higher levels of anxiety, depression, somatization and anger-hostility. Altogether, 48% of the subjects in the PVA group had a history of mood disorders, and 24% had a history of anxiety disorders. Almost all were currently in remission.

The most prominent neural finding was a significant increase in GMV in the left superior temporal gyrus (STG) in individuals exposed to VA (BA 22; Talairach's coordinates x= –61 - –50, y= –34 - –18, z= –1 - 13, cluster size = 676, P = 0.004, corrected cluster level) (Fig. 1). On average there was a 14.1% increase n GMV in this cluster in the VA subjects. No other areas of increase were found with a corrected cluster probability value that approached significance.

A significant correlation was found between the left STG GMV and PVAS scores at the corrected cluster level ($P = 0.002$), FWE corrected voxel level ($P = 0.001$), and FDR corrected voxel level ($P = 0.002$). GMV of this region correlated significantly across all subjects ($r = 0.521$, $P = 0.001$). This relationship was particularly strong for the subjects with PVA ($r = 0.55$, $P = 0.01$), but was not apparent in healthy control subjects ($r = 0.238$, $P > 0.3$).

Multiple regression analysis indicated that GMV in left STG (BA 22) correlated significantly with parental VAS and parental education. As indicated in Table 2, the overall correlation was high ($r = 0.810$, adjusted $r^2 = 0.573$, $P < 0.0001$) with the major determinants being maternal VAS ($ß = 0.457$, $P < 0.0001$), paternal VAS ($ß = 0.300$, $P = 0.018$), and level of paternal education ($ß = –0.577$, $P < 0.0001$) (Fig 2). Interestingly, in the PVAS group maternal VAS ($ß = 0.763$, $P = 0.006$) and paternal VAS ($ß = 0.629$, $P = 0.013$) were significant independent variables, but parental education was not. In contrast, parental education ($ß = –0.705$, $P = 0.013$) was a strong determinant in controls, but maternal and paternal VAS were not (Table II).

No significant partial correlations were found between GMV in left STG and measures of

memory or intelligence. There were also no significant corrected correlations between psychiatric symptom ratings and STG GMV. The only significant correlation that emerged was between left STG GMV and consumption of hard liquor ($r = 0.497$, $P < 0.002$).

Using a lower criteria for statistical significance revealed a 10.5% increase in GMV in the left parahippocampal gyrus (BA 36; Talairach's coordinates $x= -38$, $y= -37$, $z= -10$, cluster size = 129, $P < 0.001$, uncorrected voxel level) in PVA subjects. Examination of voxels with reduced GMV in PVA subjects identified no significant corrected voxel level-cluster regions. One tiny region of reduced GMV in PVA subjects was identified. There was a 9.4% reduction in GMV in the right middle frontal gyrus (BA 9, $x= 30$ $y= 32$ $z= 28$, cluster size = 4) that was significant at the uncorrected voxel level ($Z = 3.15$, $P = 0.001$).

DISCUSSION

During the last few decades, researchers have made considerable progress in elucidating the neurobiological consequences of exposure to child abuse or maltreatment. Most studies have focused on individuals exposed to multiple forms of trauma (typically CSA and/or PA) who are highly symptomatic (Bremner et al 1997; Carrion et al 2007; De Bellis et

al 2002a; De Bellis et al 1999b; De Bellis et al 2002b; De Bellis et al 2002c; Jackowski et al 2008; Richert et al 2006; Stein et al 1997; Teicher et al 2004; Vermetten et al 2006; Vythilingam et al 2002). These studies have predominantly identified alterations in corpus callosum, hippocampus and frontal cortex.

We have recently focused on the potential consequences of exposure to specific forms of childhood maltreatment and have included in the analysis both symptomatic and asymptomatic individuals. What we have learned from this approach is that sensory systems involved in processing and relaying the aversive sensory input may be specifically affected. Hence, we observed alterations in GMV in primary and secondary visual cortex in individuals exposed to repeated episodes of CSA (Tomoda et al 2009a), and reduced FA in a portion of the arcuate fasciculus in individuals exposed to PVA (Choi et al 2009). We have also collected data indicating that the visual-limbic pathway is affected in individuals who witnessed domestic violence, and cortical pain pathways affected in individuals exposed to harsh corporal punishment (Tomoda et al 2009b).

The present study expands on this body of knowledge by showing that exposure to PVA

was associated with alterations in left STG/BA22. This region plays a critical role in processing of language and speech. Lesions in the posterior portion of BA22 typically result in the development of Wernicke's aphasia (Gartus et al 2009). Hence, it makes sense that exposure to high levels of PVA would selectively target this region.

The most curious aspect of this finding was that GMV was increased in direct proportion to their degree of exposure. We had predicted that GMV would have been reduced in this region, analogous to the reduction in visual cortex GMV observed in subjects with CSA. However, in retrospect this present finding makes sense. Recent studies indicate that this region continues to mature into late adolescence/early adulthood with a progressive decline in regional cerebral blood flow, presumably associated with dendritic pruning (Devous et al 2006). Hence, a relatively low level of GMV in subjects within this age range may be indicative of typically healthy development. This seems plausible given our finding of an inverse relationship between left STG/BA22 GMV and parental education. One potential explanation is that parents with higher levels of education may tend to provide their children with a greater or richer degree of verbal stimulation, and this may be reflected in a developmental trajectory that emphasizes both a high degree of overproduction prior to

puberty and by extensive pruning during adolescence, as previously reported to occur in subjects with superior IQs (Shaw et al 2006). Exposure to PVA may interfere with the development of the left STG/BA22 by delaying its development or attenuating the degree of pruning.

Previous studies on the effects of early abuse did not report results for STG, with one notable exception. Our finding of increased GMV in left STG are commensurate with a previous report from De Bellis *et al.* (De Bellis et al 2002b), who conducted a volumetric MRI study of abused female pediatric subjects with PTSD. He found that STG GMV was increased bilaterally, particularly on the right side.

We have recently reported in a subset of subjects that high-level exposure to PVA was associated with reduced fractional anisotropy in the left arcuate fasciculus (Choi et al 2009). Alterations in FA were associated with slight changes in verbal IQ and verbal comprehension. Together these findings suggest that left temporal lobe structures may be particularly susceptible to exposure to PVA. How these alterations may affect function is unclear. We observed no differences between groups in verbal IQ, verbal comprehension, or verbal

memory. We suspect that the potential effects may be much more subtle and may influence the subject's response to emotionally laden content or to highly personal communications.

The main limitation of this study is the relatively small sample size. A large, initial sample of 18- to 25-year-olds from the community were surveyed to identify an ideal healthy sample of subjects exposed only to PVA and to no other forms of trauma or early adversity to provide the most direct test of our hypotheses. Exposure to high levels of PVA but to no other forms of abuse is a relatively common occurrence, reported by about 10% of subjects in this age range. Our findings should generalize well to subjects experiencing PVA but no other forms of abuse, as we selected subjects without regard to psychopathology (except substance abuse). It remains to be seen if the same findings emerge in subjects exposed to PVA along with other forms of maltreatment.

VBM studies provided an unbiased, even-handed, assessment of regional alterations in GMV. However, these studies have a significant number of limitations. Care was taken to make sure that there were no issues with alignment. Subjects in the two groups were of virtually identical age, and selected from a narrow age range to minimize any potential

developmental differences in template registration. All subjects were scanned on the same machine over the same time-period. There were no significant differences between groups in gender distribution and degree of drug and alcohol use. There was a slight but highly significant difference in degree of perceived financial stress, which were controlled for statistically. The primary finding of increased GMV in left STG was observed with a corrected $P = 0.004$ at the cluster level. Additional findings of increase in GMV in left parahippocampal gyrus and reduced GMV in right middle frontal gyrus were only observed at the uncorrected voxel level and mentioned for completeness. There is no guarantee that these were not false-positive results or that all relevant brain areas were identified.

Although this study revealed a strong association between a self-reported history of PVA and increased GMV in left STG, it should be emphasized that the finding is correlational and does not prove that PVA caused the increased. A variety of alternative explanations could be advanced, such as the possibility that individuals with increase STG GMV may be prone to over-interpret verbal communications as abusive. Prospective longitudinal studies may help to better establish a causal relationship. Nevertheless, these findings are consistent with a causal relationship and suggest that exposure to PVA may act as a

traumatic stressor to alter the development of the superior temporal gyrus. If so, these results underscore efforts to prevent children from experiencing verbal abuse from parents, other adults or peers.

These findings may also be relevant to the development of therapeutic strategies for treating survivors of childhood maltreatment. Most forms of psychotherapy require patients to verbally process their therapists' feedback and guidance, and patients rely on language to communicate their experiences and emotional states. However, if speech processing and language comprehension abilities are altered due to past abusive experiences, then novel treatment methodologies may be need to effectively cope with these neurobiological differences.

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The authors reported no biomedical financial interests or potential conflicts of interest.

FIGURE LEGENDS

Fig. 1. Significant differences between subjects exposed to high levels of parental verbal abuse and healthy controls. Significantly elevated gray-matter densities in VA subjects were measured in the left superior temporal gyrus (STG, BA22). Crosshairs placed at x= –50, y= –18, z= –1, the left superior temporal gyrus. Color scale: 0–5 represent t-values.

Fig. 2. Scatter plots portraying the relation between gray matter volume in the left superior temporal gyrus (BA 22; Talairach's coordinates x= –48, y= –18, z= –1) and exposure to maternal and paternal verbal abuse and degree of paternal education.

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4. Table

Table I. Demographic characteristics and ratings of control and parental verbal abuse grou

Characteristics	Controls N = 19	Parental Verbal Abuse N = 21	Statistics (Anova, other)	p-value
Gender (Males/Females)	7M/12F	9M/12F	Fisher	0.76
Age (years)	21.1 ± 1.9	21.2 ± 2.4	0.02	0.90
Subject Education (years[a])	14.3 ± 1.5	14.0 ± 1.6	0.87	0.36
Parental Education (years)	15.8 ± 2.5	15.7 ± 3.0	0.00	0.98
Preceived Financial Sufficiency	3.9 ± 0.7	3.0 ± 0.9	**11.77**	**0.001**
Drug use (days/month)[a,b]	0.0 ± 0.0	0.0 ± 0.0		
Alcohol use (drinks/month)[a,b]	3.1 ± 5.2	5.6 ± 9.8	0.95	0.34
Maternal Verbal Abuse Score	13.4 ± 9.7	54.2 ± 22.8		
Paternal Verbal Abuse Score	11.7 ± 7.8	34.6 ± 25.7		
Memory Assessment Scale				
Short-term memory[a,b]	107.2 ± 16.5	104.1 ± 16.4	0.34	0.57
Verbal memory[a,b]	112.3 ± 14.5	112.2 ± 12.3	0.00	0.99
Visual memory[a,b]	111.7 ± 9.5	108.1 ± 14.2	0.78	0.39
Global memory[a,b]	113.7 ± 10.0	112.1 ± 12.7	0.19	0.66
Wechsler Adult Intelligence Scale				
Verbal IQ[a,b]	125.2 ± 12.6	121.4 ± 12.1	0.85	0.36
Performance IQ[a,b]	117.5 ± 10.5	115.0 ± 11.1	0.52	0.48
Full Scale IQ[a,b]	122.8 ± 11.4	119.9 ± 11.4	0.59	0.45
Verbal Comprehension Index[a,b]	124.5 ± 11.9	123.4 ± 12.2	0.08	0.77
Perceptual Organization[a,b]	119.8 ± 10.2	116.2 ± 12.4	0.93	0.34
Working Memory Index[a,b]	115.1 ± 16.1	112.9 ± 13.5	0.21	0.65
Processing Speed Index[a,b]	116.4 ± 13.9	111.1 ± 14.0	1.27	0.27
Kellner Symptom Questionnaire				
Anxiety[a,b]	3.9 ± 3.2	8.3 ± 5.9	**8.74**	**0.005**
Depression[a,b]	3.4 ± 3.7	8.0 ± 5.7	**8.94**	**0.005**
Somatization[a,b]	3.4 ± 3.2	6.5 ± 4.5	**5.86**	**0.02**
Anger-hostility[a,b]	2.9 ± 2.1	5.6 ± 4.8	**5.82**	**0.02**

Adjusted for[a]age, [b]gender

Table II. Multiple Regression Analysis Indicating Relationship between Gray Matter Volume in Superior Temporal Gyrus and Exposure to Verbal Aggression

	All Subjects		Parental Verbal Abuse		Control Subjects	
Measures	Beta	p-value	Beta	p-value	Beta	p-value
Maternal Verbal Abuse	**0.544**	**<0.0001**	**0.763**	**0.006**	0.331	0.21
Paternal Verbal Abuse	**0.300**	**0.018**	**0.629**	**0.013**	0.086	0.78
Age	0.073	0.53	-0.015	0.94	0.306	0.20
Gender	0.265	0.13	0.135	0.59	0.353	0.39
Parental Education (yrs)	**-0.577**	**<0.0001**	-0.378	0.08	**-0.705**	**0.013**
Perceived Financial Sufficiency	0.222	0.11	0.087	0.66	0.055	0.85
Total Gray Matter Volume	**0.378**	**0.028**	0.359	0.13	0.473	0.21
Overall Correlation	**0.810**	**<0.0001**	**0.847**	**0.02**	**0.845**	**0.03**

5. Figure 1

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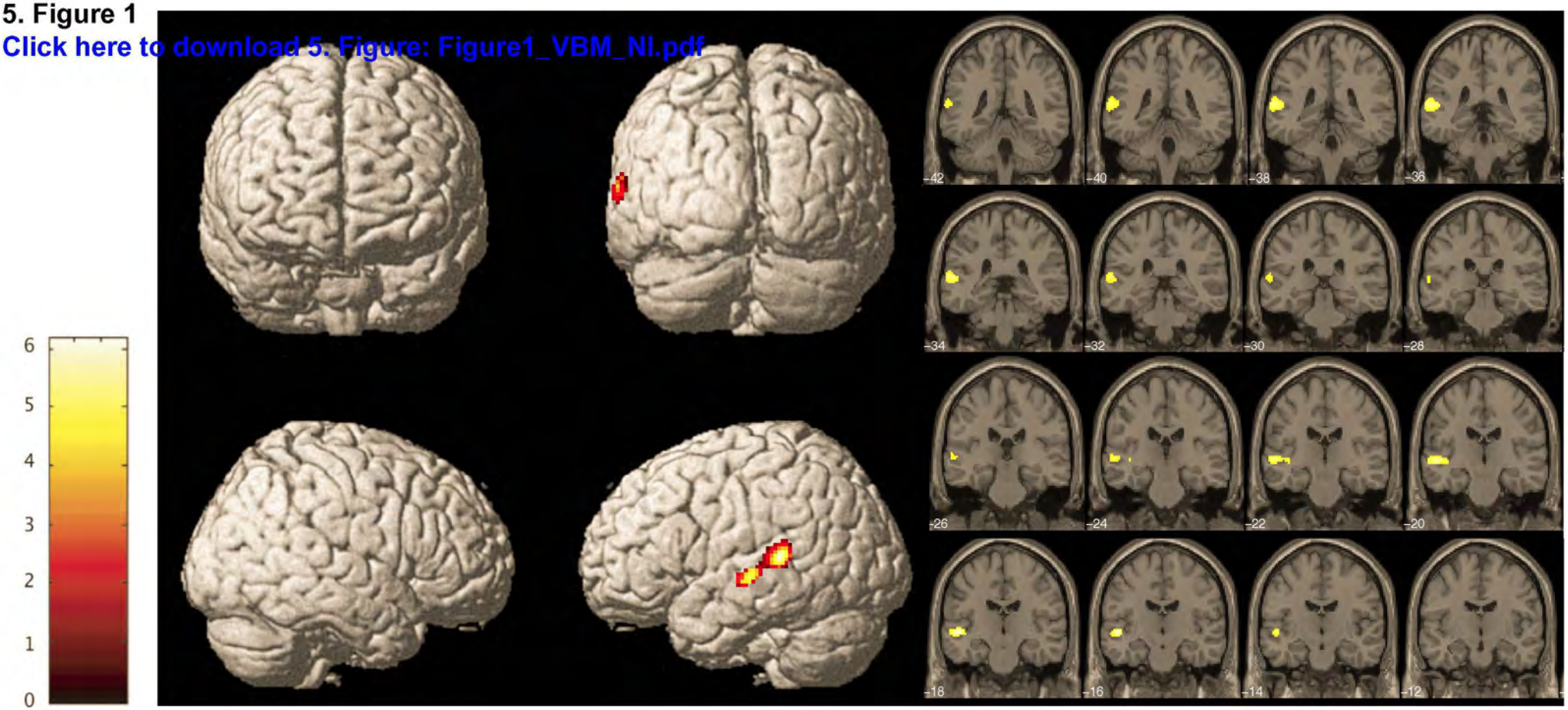

5. Figure 2

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