Brain Volume Measurements Correlate with Impulsivity and Aggression

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Purpose: Structural alterations have been implicated in impulsivity and aggression by clinical findings in brain injury and studies suggesting associations with altered neurotransmitter function[1]. However, brain morphology has not been extensively studied in relation to individual differences in these personality traits. In this study, whole brain and tissue specific volume measurements were determined by an automatic brain segmentation protocol[2] and compared in individuals classified as impulsive aggressive and control subjects. In addition, the volume measures were examined for patterns of relationship to ratings from psychometric instruments designed to evaluate the individual personality traits of impulsivity and aggression.

Methods: Participants included 14 impulsive aggressive (mean age: 46.57; 10 males, 4 females) and 13 control subjects (mean age: 44.23; 9 males, 4 females). Groups did not differ in age or education. Subjects were classified as impulsive aggressive using a standardized psychiatric interview (Mini International Neuropsychiatric Interview)[3]. Individual differences in impulsivity and aggressivity were also measured using a battery of validated psychometric instruments, including the Life History of Aggression (LHA)[4], the Buss-Perry Aggression Questionnaire (BPAQ)[5] and the Barratt Impulsivity Scale for Motor (acting without thinking), Attention (difficulty focusing on the task at hand) and Non-Planning (not planning ahead) impulsiveness (BIS11)[6]. Subjects were scanned with a GE 1.5T MR system. 44 contiguous axial slices covering the whole brain were acquired using a spin echo dual echo sequence. (TR/TE: 3300/80). In plane resolution was $0.9725 \times 0.9725 \times 3 mm^3$. Image post processing was conducted using Sienax (Version 2.3)[2]. The observed T2 was registered to Talairach space for the estimation of a scaling factor. The brain was then segmented into white matter, gray matter, and CSF with a chain of automated operations including skull removal, inhomogeneity correction based on a hidden Markov random field model and an associated Expectation –Maximization algorithm (Figure 1). To control for head size variation, the estimated normalization factor was applied to the parenchyma and brain tissue volumes derived from this segmentation. The brain parenchyma value (parenchyma volume / intracranial volume) was also estimated.

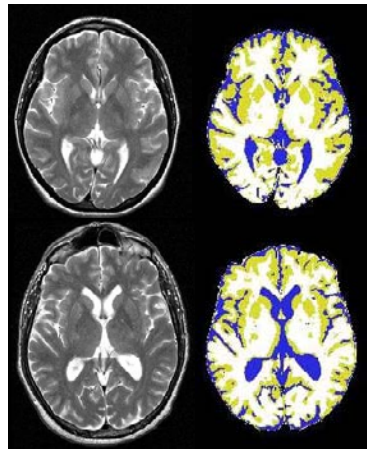

Figure 1: Top: T2 image (left) and segmented image (right) of a control subject. Bottom: T2 Image (left) and segmented Image (right) of an Imp. Agg. Subiect

Results: Brain parenchyma value (BPV) was significantly reduced in the impulsive aggressive group (mean (SD): 0.81(0.049) vs. 0.85 (0.036) for controls; $t(25)=-2.16$; $p=.04$). There were no significant differences for normalized volumes of gray matter (GM) or white matter (WM), however both measures were generally lower in the impulsive aggressive group. Further analyses examined correlations between brain volumes and personality measures shown in Table 1. All statistical tests were conducted in SPSS (release 12.0; Chicago, IL) and were two-tailed, using a significance level of 0.05. **Aggression:** The LHA overt Aggression score was significantly correlated with BPV ($p=.02$); LHA Total score was significantly correlated with WM volume ($p=.01$). The BPAQ Anger score was significantly correlated with BPV ($p=.04$); BPAQ Total score was significantly correlated with WM volume ($p=.04$). **Impulsivity:** BIS11 Attention ($p=.05$) and Total ($p=.03$) scores were significantly correlated with WM volume.

Table 1: Correlations: Volumes and Psychometric Scales

	BPV	GM	WM
Life History of Aggression			
Overt Aggression	-.44*	.00	-.27
Total	-.26	.30	-.49**
Buss-Perry Aggression			
Anger	-.40*	.02	-.28
Total	-.31	.17	-.40*
Barratt Impulsiveness Scale			
Motor	-.36	.18	-.36
Attention	-.09	.24	-.38*
Non-planning	-.11	.31	-.29
Total	-.23	.31	-.42*

Pearson correlation coefficients. *pLE.05; **pLE.01

Conclusion: Brain parenchyma values were significantly reduced in the impulsive aggressive group. Brain volume measures were also significantly correlated with individual differences in impulsivity and aggression, as indicated by ratings from psychometric instruments. Reduced BPV volumes were significantly correlated with higher levels of overt aggression and anger. For both studied aggression instruments, reduced white matter volume was significantly correlated with higher overall aggression ratings. Reduced white matter volume was also significantly correlated with measures of impulsivity, including attentional difficulty and overall impulsiveness. Consistent findings have been obtained in studies directly examining impulsivity and/or aggression in the context of psychiatric disorders that are often associated with these traits. A volumetry study found that regional structural integrity of gray matter was associated with impulsivity in Borderline Personality Disorder [7]. Diffusion Tensor Imaging studies have found that schizophrenic patients exhibit regional white matter microstructural alterations in relation to increased impulsivity and aggressivity[8,9]. Similar evidence has been reported among cocaine-dependent subjects in relation to increased impulsivity[10]. Findings from this study suggest white matter involvement in aggression and impulsivity. Factors influencing overall brain volume may be relevant to an understanding of aggression. Normal brain maturation is associated with increasing overall white matter volume and region-specific myelination which occurs over a prolonged period through childhood, adolescence and into early adult life[11]. Neurodevelopmental or other factors that influence white matter integrity may play a role in the observed pattern of neurobehavioral correlations.

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