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An MRI Study of Amygdala in Schizophrenia and Psychotic Bipolar Disorder

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Abstract

Meta-analyses report larger amygdala in subjects with bipolar disorder compared to schizophrenia. However, few studies have compared the size of amygdala in psychotic bipolar disorder with schizophrenia. Here we examine size of amygdala in a sample of 36 patients with psychotic bipolar disorder, 31 patients with schizophrenia and 27 healthy comparison subjects. Patients with schizophrenia had smaller amygdala compared with patients with psychotic bipolar disorder ($p=0.014$). These results suggest that change in volume of amygdala may represent a morphologic feature distinguishing psychotic bipolar disorder from schizophrenia.

1. Introduction

Epidemiologic and genetic studies suggest a shared susceptibility to bipolar disorder and schizophrenia (Craddock and Owen, 2010). Of interest is whether there are also common neuroanatomical changes associated with these disorders. The amygdala has been of particular interest as it plays a role in emotion. Stimulation of amygdala in humans evokes emotions as well as complex hallucinations (Gloor et al., 1981; Gloor et al., 1982). Several structural magnetic resonance imaging (MRI) studies have compared morphometry of amygdala in schizophrenia and bipolar disorder, yielding conflicting results (Altshuler et al., 1998; Altshuler et al., 2000; Brown et al., 2011; Pearlson et al., 1997; Swayze et al., 1992). Recently, several meta-analyses have reported enlarged amygdala in bipolar disorder as compared to schizophrenia (Arnone et al., 2009; Ellison-Wright and Bullmore, 2010; Yu et

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Conflict of Interest

The authors declare no conflicts of interest.

Contributors

Dr. Mahon conceptualized the study, conducted analyses and drafted the manuscript. Ms. Eldridge, Crocker, Postell, Notes and Gindes aided in data analysis. Ms. King assisted with recruitment and data collection. Dr. Potash aided in interpretation of results and drafting the manuscript. Dr. Ratnanather assisted in data analysis, interpretation and drafting the manuscript. Dr. Barta directed data collection and aided in conceptualization of the study, interpretation of the results and drafting the manuscript.

al., 2010). However, bipolar individuals in these samples have been heterogeneous for presence of psychotic features.

A potentially informative distinction can be made between subtypes of bipolar disorder presenting with and without psychosis. Psychotic bipolar disorder may be more similar to schizophrenia than to bipolar disorder without psychosis (Potash, 2006). Psychotic bipolar disorder and schizophrenia co-aggregate in families and identified candidate genes predispose to both disorders. In addition, the overall neuroanatomical features of psychotic bipolar disorder, rather than bipolar disorder without psychosis, may be more similar to what is seen in schizophrenia (Strasser et al., 2005). Frazier et al (2008) were not able to detect an overall difference in volume of amygdala in early-onset psychotic bipolar disorder and early-onset schizophrenia. However, they did find a sex-specific effect where a larger left amygdala volume was seen in bipolar males as compared to males with schizophrenia or controls and the difference was more pronounced in bipolar disorder without psychosis than in bipolar disorder with psychosis. In a study of first-episode psychosis subjects with psychotic affective disorders were observed to have a larger right amygdala than subjects with schizophrenia (Velakoulis et al., 2006). In order to shed light on this issue, we assessed whether size of amygdala differed between subjects with psychotic bipolar disorder, schizophrenia and healthy comparison subjects.

2. Methods

2.1 Subjects

Ninety-four subjects were selected from schizophrenia and bipolar disorder studies at the Division of Psychiatric Neuroimaging at Johns Hopkins University School of Medicine. The subjects were classified in three groups for neuroanatomical comparison, subjects with schizophrenia, psychotic bipolar disorder, and healthy comparison subjects. Subjects were matched such that distributions on the variables age and sex were similar across the three study groups. Healthy comparison subjects were screened for presence of mental illness using two instruments, either the MINI (Sheehan et al., 1998) and DIGS (Nurnberger et al., 1994) or the SCAN (Wing et al., 1990) and CIDI-SF (Kessler et al., 1998). Consensus diagnosis of bipolar disorder or schizophrenia was determined by a research psychiatrist and a research assistant using a semi-structured interview and two instruments, either the DIGS and MINI or SCAN and CIDI-SF. All bipolar disorder patients had at least one episode of psychotic symptoms, such as hallucinations or delusions in the context of an affective episode (manic or depression) in clear consciousness. All subjects with bipolar disorder or schizophrenia were medicated. None of the subjects with schizophrenia were on mood stabilizers. Potential participants with either a lifetime history of substance dependence or current substance abuse were excluded from the study. All subjects were right-handed (Annett, 1970). Socioeconomic status was assessed using the Hollingshead Scale (Hollingshead, 1975).

2.2 MRI

Prior to MRI scanning, all subjects gave informed consent after the risks and benefits of participation were explained to them. T1 weighted 3D volumes were acquired using a 1.5 T Philip MR system and MPRAGE sequence (repetition time = 13.40 ms, echo time = 4.6 ms, flip angle = 20, number of acquisition = 1, matrix 256×256), with 1-mm³ isotropic resolution across the entire cranium. Skullstripping was performed and total intracranial volume (ICV) was calculated in Freesurfer 3.0.5 (Segonne et al., 2004). Semi-automated segmentation of amygdala was performed in MRISudio software (Jiang et al., 2006), utilizing the LDDMM algorithm (Oishi et al., 2009) and the JHU-MNI-SS Type II atlas (www.mristudio.org). All segmentations were manually checked for accuracy and rerun if

errors were detected. All segmentation procedures were conducted by study personnel blind to diagnosis.

2.3 Statistical Analysis

Comparisons of demographic and clinical characteristics across study groups were conducted using F-tests or t-tests for continuous variables and χ^2 -tests for categorical variables. Diagnostic differences among the three groups (psychotic bipolar disorder, schizophrenia, healthy comparison subjects) for mean volume of amygdala was evaluated using linear mixed models with repeated measures in SPSS 19 (2010). Amygdala volume was the dependent variable and hemisphere was the repeated measure. Diagnostic category and sex were factors in the model and age and total intracranial volume were included in the model as covariates. Years of education and socioeconomic status did not contribute significantly and were not included in the final model. We first tested a factorial model, however none of the interaction terms were statistically significant ($p > 0.1$) and they did not contribute to the model. Thus, our final model included main effects only. Post hoc comparisons of the adjusted means across diagnostic groups were performed using t-tests and were Bonferroni-adjusted for multiple comparisons.

3. Results

The patient and comparison groups were not significantly different in age, sex or total ICV (see Tables 1 and 2). Additionally, the schizophrenia patient and bipolar patient groups did not differ significantly in their duration of illness. Patients with schizophrenia had fewer years of education on average than patients with psychotic bipolar disorder ($t = -3.55$, $p = 0.0007$). Conversely, patients with psychotic bipolar disorder had lower mean socioeconomic status than either patients with schizophrenia ($t = 2.53$, $p = 0.0139$) or healthy comparison subjects ($t = 2.26$, $p = 0.0270$). Independent of diagnosis, a significant sex difference was observed in amygdala bilaterally, with females having significantly smaller volumes than males ($p_{\text{left}} = 0.009$, $p_{\text{right}} = 0.018$). There was significant laterality of amygdala shown by repeated measures analysis, with left amygdala larger than right amygdala on average (adjusted mean difference = 118.1 mm^3 , $\text{s.e.} = 15.0$, $p < 0.001$).

The unadjusted mean volume of amygdala by study group is presented in Table 2. We detected a significant main effect of diagnosis on size of amygdala (See Figure; $F_{2,170} = 4.38$, $p = 0.014$). There was no evidence of a sex-by-diagnosis or hemisphere-by-diagnosis interaction. Pairwise comparisons showed that subjects with schizophrenia had significantly smaller amygdala than subjects with psychotic bipolar disorder (adjusted mean difference = 51.4 mm^3 , $\text{s.e.} = 18.0$, adjusted $p = 0.014$). We detected a trend of smaller amygdala in the schizophrenia group as compared to the healthy control group (adjusted mean difference = 42.3 mm^3 , $\text{s.e.} = 19.6$, adjusted $p = 0.096$). There was no difference in size of amygdala between the psychotic bipolar disorder and healthy comparison groups (adjusted mean difference = 9.1 mm^3 , $\text{s.d.} = 18.2$, adjusted $p = 1.0$).

4. Discussion

This study expands upon previous work comparing volume of amygdala in patients with bipolar disorder and schizophrenia. In this context, studying psychotic bipolar disorder is of special interest as it has symptomatic overlap with schizophrenia (Coryell et al., 2001) as well as potentially a shared genetic etiology (Potash et al., 2003). We examined whether volume of amygdala was different or similar in psychotic bipolar disorder and schizophrenia.

Our finding of a significant effect of diagnosis on size of amygdala is consistent with previous studies. Specifically, we found that amygdala was smaller in our schizophrenia group than in the psychotic bipolar disorder group. Velakoulis et al (2006) found that first-episode psychosis subjects with schizophrenia had larger right amygdala than subjects with first-episode psychotic affective disorders. Frazier et al (2008) reported a sex-specific effect where a smaller left amygdala volume was seen in males with first-episode schizophrenia as compared to males with first-episode bipolar disorder and the difference was more pronounced in bipolar disorder without psychosis than in bipolar disorder with psychosis. Differences in methodology used contribute to the difficulty in directly comparing our results to previous studies. Importantly, the definition of phenotype used and the delineation of the boundaries of amygdala differed across studies. Velakoulis et al (2006) examined morphological differences between first-episode schizophrenia and first-episode psychotic affective disorders, not limited to bipolar disorder. In contrast, Frazier et al (2008) limited their analysis to the early-onset forms of schizophrenia, bipolar disorder with psychosis and bipolar disorder without psychosis. In our study, we compared patients with schizophrenia to those with psychotic bipolar disorder. For segmentation of amygdala, we utilized a semi-automated method based on the JHU-MNI-SS Type II atlas boundaries, while other studies utilized the method of Convit et al (1999) or Filipek et al (1994).

We also observed that females had smaller amygdala bilaterally than males, independent of diagnosis. Evidence of a sex effect on volume of amygdala from previous studies is conflicting. Some studies have found that the volume of the amygdala was smaller in women compared with men after controlling for ICV (Fjell et al., 2009; Goldstein et al., 2001), while other studies have not (Kim et al., 2012; Gur et al., 2002; Pruessner et al., 2000). Larger amygdala in men than in women may underlie well established sex differences in emotional regulation (Gur et al, 2002).

A limitation of the current study is that we did not have available a bipolar without psychosis group and so we were not able to make any comparisons to this group. Also, we did not have available to us information about potential confounders such as global cognitive ability. Further studies including a bipolar without psychosis comparison group and assessing additional potential confounding variables would shed further light on the relationship between psychosis and amygdala size.

Patients with bipolar disorder and schizophrenia are necessarily treated with different classes of medications. Notably, patients with bipolar disorder are commonly treated with mood stabilizers such as lithium, which has been shown to increase volume of amygdala over time (Lyoo et al., 2010). Many of our bipolar patients were treated with lithium, while none of the patients with schizophrenia were taking mood stabilizers. Antipsychotics, a standard treatment for schizophrenia, have not been shown to affect size of amygdala (Szeszko et al., 2003; Velakoulis et al., 2006). Thus, we cannot rule out the possibility that the larger amygdala in psychotic bipolar disorder may be a treatment effect rather than a disease effect. However, there are important clinical implications to either of these explanations. In the case of a disease effect, these data suggest further studies in which the disease state is better characterized than in our study. In the case of a treatment effect, these results are consistent with previous studies suggesting the possibility that treatment with lithium might lead to neurotrophic or neuroprotective effects (Bowley et al., 2002; Machado-Vieira et al., 2009). It will be important for future studies to attempt to disentangle potential medication effects from effects of disorder.

Taken together, these results suggest that change in volume of amygdala may represent a morphologic feature distinguishing bipolar disorder subjects from subjects with schizophrenia, even though psychotic symptoms can be found in both. Potential mechanisms

whereby size of amygdala may change include response to chronic stress, response to medication, changes in intercellular fluid, changes in number or size of neurons and glia or changes in connective tissue (Altshuler et al., 2000; Vyas et al., 2002). While the nature of abnormalities of the amygdala in bipolar disorder and schizophrenia differ, this brain region might still be the locus of a partially shared pathophysiology between these disorders.

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Reference List

- SPSS for Windows. 19. Chicago: SPSS Inc.; 2010.
- Altshuler LL, Bartzokis G, Grieder T, Curran J, Jimenez T, Leight K, Wilkins J, Gerner R, Mintz J. An MRI study of temporal lobe structures in men with bipolar disorder or schizophrenia. *Biol Psychiatry*. 2000; 48:147–162. [PubMed: 10903411]
- Altshuler LL, Bartzokis G, Grieder T, Curran J, Mintz J. Amygdala enlargement in bipolar disorder and hippocampal reduction in schizophrenia: an MRI study demonstrating neuroanatomic specificity. *Arch Gen Psychiatry*. 1998; 55:663–664. [PubMed: 9672058]
- Annett M. A classification of hand preference by association analysis. *Br J Psychol*. 1970; 61:303–321. [PubMed: 5457503]
- Arnone D, Cavanagh J, Gerber D, Lawrie SM, Ebmeier KP, McIntosh AM. Magnetic resonance imaging studies in bipolar disorder and schizophrenia: meta-analysis. *Br J Psychiatry*. 2009; 195:194–201. [PubMed: 19721106]
- Bowley MP, Drevets WC, Ongur D, Price JL. Low glial numbers in the amygdala in major depressive disorder. *Biol Psychiatry*. 2002; 52:404–412. [PubMed: 12242056]
- Brown GG, Lee JS, Strigo IA, Caligiuri MP, Meloy MJ, Lohr J. Voxel-based morphometry of patients with schizophrenia or bipolar I disorder: a matched control study. *Psychiatry Res*. 2011; 194:149–156. [PubMed: 21924872]
- Convit A, McHugh P, Wolf OT, de Leon MJ, Bobinski M, De SS, Roche A, Tsui W. MRI volume of the amygdala: a reliable method allowing separation from the hippocampal formation. *Psychiatry Res*. 1999; 90:113–123. [PubMed: 10482383]
- Coryell W, Leon AC, Turvey C, Akiskal HS, Mueller T, Endicott J. The significance of psychotic features in manic episodes: a report from the NIMH collaborative study. *J Affect Disord*. 2001; 67:79–88. [PubMed: 11869754]
- Craddock N, Owen MJ. The Kraepelinian dichotomy - going, going... but still not gone. *Br J Psychiatry*. 2010; 196:92–95. [PubMed: 20118450]
- Ellison-Wright I, Bullmore E. Anatomy of bipolar disorder and schizophrenia: a meta-analysis. *Schizophr Res*. 2010; 117:1–12. [PubMed: 20071149]
- Filipek PA, Richelme C, Kennedy DN, Caviness VS Jr. The young adult human brain: an MRI-based morphometric analysis. *Cereb Cortex*. 1994; 4:344–360. [PubMed: 7950308]
- Fjell AM, Westlye LT, Amlie I, Espeseth T, Reinvang I, Raz N, Agartz I, Salat DH, Greve DN, Fischl B, Dale AM, Walhovd KB. Minute effects of sex on the aging brain: a multisample magnetic resonance imaging study of healthy aging and Alzheimer's disease. *J Neurosci*. 2009; 29:8774–8783. [PubMed: 19587284]
- Frazier JA, Hodge SM, Breeze JL, Giuliano AJ, Terry JE, Moore CM, Kennedy DN, Lopez-Larson MP, Caviness VS, Seidman LJ, Zablotsky B, Makris N. Diagnostic and sex effects on limbic volumes in early-onset bipolar disorder and schizophrenia. *Schizophr Bull*. 2008; 34:37–46. [PubMed: 18003631]

- Gloor, P.; Olivier, A.; Quesney, L. The role of the amygdala in the expression of psychic phenomena in temporal lobe seizures. In: Ben-Ari, Y., editor. *The Amygdaloid Complex*. New York: Elsevier/North Holland; 1981. p. 489-507.
- Gloor P, Olivier A, Quesney LF, Andermann F, Horowitz S. The role of the limbic system in experiential phenomena of temporal lobe epilepsy. *Ann Neurol*. 1982; 12:129–144. [PubMed: 7125603]
- Goldstein JM, Seidman LJ, Horton NJ, Makris N, Kennedy DN, Caviness VS Jr, Faraone SV, Tsuang MT. Normal sexual dimorphism of the adult human brain assessed by in vivo magnetic resonance imaging. *Cereb Cortex*. 2001; 11:490–497. [PubMed: 11375910]
- Gur RC, Gunning-Dixon F, Bilker WB, Gur RE. Sex differences in temporo-limbic and frontal brain volumes of healthy adults. *Cereb Cortex*. 2002; 12:998–1003. [PubMed: 12183399]
- Hollingshead, AB. Four factor index of social status. New Haven, CT: Yale University; 1975. Unpublished manuscript
- Jiang H, van Zijl PC, Kim J, Pearlson GD, Mori S. DtiStudio: resource program for diffusion tensor computation and fiber bundle tracking. *Comput Methods Programs Biomed*. 2006; 81:106–116. [PubMed: 16413083]
- Kessler R, Andrews G, Mroczek D, Ustun B, Wittchen H-U. The world health organization composite international diagnostic interview short form (CIDI-SF). *Int J Methods Psychiatr Res*. 1998; 7:33–55.
- Kim HJ, Kim N, Kim S, Hong S, Park K, Lim S, Park J, Na B, Chae Y, Lee J, Yeo S, Choe I, Cho S, Cho G. Sex differences in amygdala subregions: Evidence from subregional shape analysis. *NeuroImage*. 2012
- Machado-Vieira R, Manji HK, Zarate CA Jr. The role of lithium in the treatment of bipolar disorder: convergent evidence for neurotrophic effects as a unifying hypothesis. *Bipolar Disord*. 2009; 11(Suppl 2):92–109. [PubMed: 19538689]
- Nurnberger JI, Blehar MC, Kaufmann CA, York-Cooler C, Simpson SG, Harkavy-Friedman J, Severe JB, Malaspina D, Reich T. Diagnostic interview for genetic studies. Rationale, unique features, and training. NIMH Genetics Initiative. *Arch Gen Psychiatry*. 1994; 51:849–859. [PubMed: 7944874]
- Oishi K, Faria A, Jiang H, Li X, Akhter K, Zhang J, Hsu JT, Miller MI, van Zijl PC, Albert M, Lyketos CG, Woods R, Toga AW, Pike GB, Rosa-Neto P, Evans A, Mazziotta J, Mori S. Atlas-based whole brain white matter analysis using large deformation diffeomorphic metric mapping: application to normal elderly and Alzheimer's disease participants. *Neuroimage*. 2009; 46:486–499. [PubMed: 19385016]
- Pearlson GD, Barta PE, Powers RE, Menon RR, Richards SS, Aylward EH, Federman EB, Chase GA, Petty RG, Tien AY. Ziskind-Somerfeld Research Award 1996. Medial and superior temporal gyral volumes and cerebral asymmetry in schizophrenia versus bipolar disorder. *Biol Psychiatry*. 1997; 41:1–14. [PubMed: 8988790]
- Potash JB. Carving chaos: genetics and the classification of mood and psychotic syndromes. *Harv Rev Psychiatry*. 2006; 14:47–63. [PubMed: 16603472]
- Potash JB, Zandi PP, Willour VL, Lan TH, Huo Y, Avramopoulos D, Shugart YY, MacKinnon DF, Simpson SG, McMahon FJ, DePaulo JR Jr, McInnis MG. Suggestive linkage to chromosomal regions 13q31 and 22q12 in families with psychotic bipolar disorder. *Am J Psychiatry*. 2003; 160:680–686. [PubMed: 12668356]
- Pruessner JC, Li LM, Serles W, Pruessner M, Collins DL, Kabani N, Lupien S, Evans AC. Volumetry of hippocampus and amygdala with high-resolution MRI and three-dimensional analysis software: minimizing the discrepancies between laboratories. *Cereb Cortex*. 2000; 10:433–442. [PubMed: 10769253]
- Segonne F, Dale AM, Busa E, Glessner M, Salat D, Hahn HK, Fischl B. A hybrid approach to the skull stripping problem in MRI. *Neuroimage*. 2004; 22:1060–1075. [PubMed: 15219578]
- Sheehan DV, Lecrubier Y, Sheehan KH, Amorim P, Janavs J, Weiller E, Hergueta T, Baker R, Dunbar GC. The Mini-International Neuropsychiatric Interview (M.I.N.I.): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *J Clin Psychiatry*. 1998; 59(Suppl 20):22–33. [PubMed: 9881538]

- Strasser HC, Lilyestrom J, Ashby ER, Honeycutt NA, Schretlen DJ, Pulver AE, Hopkins RO, Depaulo JR, Potash JB, Schweizer B, Yates KO, Kurian E, Barta PE, Pearlson GD. Hippocampal and ventricular volumes in psychotic and nonpsychotic bipolar patients compared with schizophrenia patients and community control subjects: a pilot study. *Biol Psychiatry*. 2005; 57:633–639. [PubMed: 15780850]
- Swayze VW, Andreasen NC, Alliger RJ, Yuh WT, Ehrhardt JC. Subcortical and temporal structures in affective disorder and schizophrenia: a magnetic resonance imaging study. *Biol Psychiatry*. 1992; 31:221–240. [PubMed: 1547297]
- Szeszko PR, Goldberg E, Gunduz-Bruce H, Ashtari M, Robinson D, Malhotra AK, Lencz T, Bates J, Crandall DT, Kane JM, Bilder RM. Smaller anterior hippocampal formation volume in antipsychotic-naïve patients with first-episode schizophrenia. *Am J Psychiatry*. 2003; 160:2190–2197. [PubMed: 14638589]
- Velakoulis D, Wood SJ, Wong MT, McGorry PD, Yung A, Phillips L, Smith D, Brewer W, Proffitt T, Desmond P, Pantelis C. Hippocampal and amygdala volumes according to psychosis stage and diagnosis: a magnetic resonance imaging study of chronic schizophrenia, first-episode psychosis, and ultra-high-risk individuals. *Arch Gen Psychiatry*. 2006; 63:139–149. [PubMed: 16461856]
- Vyas A, Mitra R, Shankaranarayana Rao BS, Chattarji S. Chronic stress induces contrasting patterns of dendritic remodeling in hippocampal and amygdaloid neurons. *J Neurosci*. 2002; 22:6810–6818. [PubMed: 12151561]
- Wing JK, Babor T, Brugha T, Burke J, Cooper JE, Giel R, Jablenski A, Regier D, Sartorius N. SCAN. Schedules for clinical assessment in neuropsychiatry. *Arch Gen Psychiatry*. 1990; 47:589–593. [PubMed: 2190539]
- Yu K, Cheung C, Leung M, Li Q, Chua S, McAlonan G. Are Bipolar Disorder and Schizophrenia Neuroanatomically Distinct? An Anatomical Likelihood Meta-analysis. *Front Hum Neurosci*. 2010; 4:189. [PubMed: 21103008]

Figure 1. Volume of amygdala for the three study groups by hemisphere
Volumes are shown as cm³ and adjusted for age and ICV. Standard error bars are shown.

Table 1Demographic and clinical characteristics of the study groups^a

Characteristic	Psychotic Bipolar Disorder Patients(n=36)	Schizophrenia Patients (n=31)	Healthy Comparison Subjects (n=27)	Statistical Test, p-value
Age, years	39.9(11.1)	41.4(9.5)	44.0(15.6)	F=0.93, p=0.400
Males (%)	52.8	54.8	44.4	$\chi^2=0.69$, p=0.707
Education level, years	14.6(2.5)	12.5(2.2)	13.7(2.6)	F=5.61, p=0.005
Socioeconomic status	3.2(1.0)	3.9(1.2)	3.8(1.0)	F=4.10, p=0.020
Duration of illness, years	17.6(12.7)	19.3(11.0)	NA	t ₅₉ =0.54, p=0.593

Abbreviations: NA, not applicable

^aData are given as mean(SD) except where noted

Table 2MRI measurements in the study groups^a

Mean volume, cm ³ (SD)	Psychotic Bipolar Disorder Patients(n=36)	Schizophrenia Patients (n=31)	Healthy Comparison Subjects (n=27)
Total intracranial volume ^b	1,398.1(150.7)	1,326.5(166.0)	1,396.6(132.6)
Amygdala, total ^c	2.07(0.29)	1.91(0.24)	2.05(0.29)
Left	1.10(0.16)	1.01(0.14)	1.08(0.16)
Right	0.97(0.14)	0.90(0.11)	0.96(0.13)

^aVolumes are unadjusted^bF_{2,91}=2.09, p=0.13^cF_{2,91}=4.38, p=0.01