BRAIN RESEARCH 1360 (2010) 205–212

available at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/brainres

BRAIN RESEARCH

Research Report

Enlarged right superior temporal gyrus in children and adolescents with autism

Roger J. Jou[a,*], Nancy J. Minshew[b], Matcheri S. Keshavan[c], Matthew P. Vitale[d], Antonio Y. Hardan[e]

[a]Child Study Center and Investigative Medicine Program, Yale University School of Medicine, New Haven, CT, USA
[b]Department of Psychiatry, Western Psychiatric Institute and Clinic, University of Pittsburgh School of Medicine, Pittsburgh, PA, USA
[c]Department of Psychiatry, Beth Israel and Deaconess Medical Center and Massachusetts Mental Health Center, Harvard Medical School, Boston, MA, USA
[d]Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA
[e]Department of Psychiatry and Behavioral Science, Stanford University School of Medicine, Stanford, CA, USA

ARTICLE INFO

Article history:
Accepted 2 September 2010
Available online 9 September 2010

Keywords:
Autism
Biological motion
Language
Social brain
Structural MRI
Superior temporal gyrus

ABSTRACT

The superior temporal gyrus has been implicated in language processing and social perception. Therefore, anatomical abnormalities of this structure may underlie some of the deficits observed in autism, a severe neurodevelopmental disorder characterized by impairments in social interaction and communication. In this study, volumes of the left and right superior temporal gyri were measured using magnetic resonance imaging obtained from 18 boys with high-functioning autism (mean age=13.5±3.4 years; full-scale IQ=103.6±13.4) and 19 healthy controls (mean age=13.7±3.0 years; full-scale IQ=103.9±10.5), group-matched on age, gender, and handedness. When compared to the control group, right superior temporal gyral volumes was significantly increased in the autism group after controlling for age and total brain volume. There was no significant difference in the volume of the left superior temporal gyrus. Post-hoc analysis revealed a significant increase of the right posterior superior temporal gyral volume in the autism group, before and after controlling for age and total brain volume. Examination of the symmetry index for the superior temporal gyral volumes did not yield statistically significant between-group differences. Findings from this preliminary investigation suggest the existence of volumetric alterations in the right superior temporal gyrus in children and adolescents with autism, providing support for a neuroanatomical basis of the social perceptual deficits characterizing this severe neurodevelopmental disorder.

* *Corresponding author*. Yale Child Study Center, 230 South Frontage Road, New Haven, CT 06519-1124, USA. Fax: +1 203 785 7400.
E-mail address: roger.jou@yale.edu (R.J. Jou).

Abbreviations: STG, superior temporal gyrus; HFA, high-functioning autism; TDC, typically-developing control; TBV, total brain volume; FSIQ, full-scale IQ; fMRI, functional magnetic resonance imaging; PET, positron emission tomography; SPECT, single photon emission computed tomography; ERP, event-related potential; cc, cubic centimeter

0006-8993/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.brainres.2010.09.005

1. Introduction

Autism is a pervasive developmental disorder characterized by impairments in reciprocal social interaction, verbal and nonverbal language and communication, and a restricted range of interests and repetitive behavior (A.P.A., 2000). Sensory and motor signs and symptoms, inattention with hyperactivity, emotion dysregulation, and intellectual disability are also integral aspects of this syndrome in many, though not all, affected individuals (Rogers and Dawson, 2009). The myriad social, language, cognitive, emotional, and behavioral problems observed in autism suggest that the syndrome affects a functionally diverse and widely distributed set of neural systems as evidenced by the wide range of structural abnormalities that have been reported (Brambilla et al., 2003; Palmen and van Engeland, 2004). Several brain regions have been examined extensively; however, the superior temporal gyrus (STG), an established node in the "social brain" network (Baron-Cohen et al., 1999; Bigler et al., 2007; Brothers and Ring, 1992), has received relatively little attention. In fact, a very limited number of morphometric investigations have been conducted to examine the size of the STG, a key structure that has been implicated in several neuropsychological and physiological functions thought to be abnormal in this severe neurodevelopmental disorder (Pelphrey et al., 2004).

Investigating STG abnormalities in autism is a logical endeavor given its important roles in language processing and social perception. The STG is perhaps best known for the former as it consists of the primary auditory cortex and Wernicke's area. Abnormalities in these regions can result in profound language difficulties as illustrated in the extreme cases of cortical deafness and receptive aphasia (Eggert, 1977; Wernicke, 1874). Since the description of cortical deafness, it has been known that the STG is bilaterally involved in the initial stages of auditory perception (Zilbovicius et al., 1995). While the STG's important role in language processing has been known since the 19th century, its role in social perception has a much more recent history. There exists now an extensive body of literature demonstrating the STG's role in social perception. The STG's importance in social perception was spawned by the use of functional magnetic resonance imaging (fMRI) in cognitive neuroscience research. Numerous tasks tapping social perception have been used in conjunction with fMRI to demonstrate the involvement of the superior temporal region such as the STG and superior temporal sulcus, and these studies have been reviewed extensively elsewhere (Pelphrey and Carter, 2008b; Redcay, 2008). Furthermore, the STG is highly connected to other key regions of the brain such as the superior temporal sulcus, frontal and parietal lobes, and the limbic and associated sensory systems (Gloor, 1997; Pandya and Yeterian, 1985; Seltzer and Pandya, 1978). Therefore, the STG may play a critical role in processing and integrating different types of information in order to give proper meaning to the surrounding world, and it has been suggested that temporal region dysfunction is implicated in almost all deficits observed in autism (Boddaert and Zilbovicius, 2002).

Numerous studies implementing a wide range of research modalities have reported different types of STG abnormalities in autism. In an influential postmortem study of the cytoarchitecture of the cerebral cortex, Casanova et al. (2002) reported abnormal cortical minicolumns (a basic functional neuronal unit) in the STG of patients with autism when compared to healthy controls. In voxel-based MRI investigations, Waiter et al. (2004) and Salmond et al. (2003) also reported STG abnormalities such as increased gray matter volume. Moreover, a number of positron emission tomography (PET) (Boddaert et al., 2003; Castelli et al., 2002; Muller et al., 1999; Zilbovicius et al., 1995), single photon emission computed tomography (SPECT) (Mountz et al., 1995; Ohnishi et al., 2000), fMRI (Baron-Cohen et al., 1999; Boddaert et al., 2003; Gomot et al., 2006; Pelphrey and Carter, 2008a; Pelphrey et al., 2005), event-related potential (ERP) (Bruneau et al., 2003; Bruneau et al., 1999), and magnetoencephalography (MEG) (Gage et al., 2003; Roberts et al., 2010; Rojas et al., 2008) studies have also revealed STG abnormalities in autism, reporting abnormal STG activation/activity both during rest and while performing various tasks.

Despite this broad array of evidence supporting STG abnormalities in autism, a limited number of studies have been conducted specifically examining the size of this structure. Of these limited number of studies, most looked exclusively at asymmetry rather than group comparison of STG volume (De Fosse et al., 2004; Gage et al., 2009; Herbert et al., 2002, 2005). There are, however, at least two studies directly comparing STG volume between autism and control groups. One volumetric study examined total STG volume in autism and found no significant volumetric differences when compared to a matched control group (Bigler et al., 2007). In contrast, the voxel-based MRI study mentioned previously, found increased STG gray matter volume when compared to controls (Waiter et al., 2004). In light of these inconsistent findings, this study was carried out to examine the total left and right STG size in high-functioning male children and adolescents with autism. Given that overgrowth has been associated with dysfunction at least during young ages (Courchesne et al., 2004), the replicable finding of increased brain volume (Piven et al., 1995), and evidence suggesting the frontal/temporal lobes are most affected (Courchesne et al., 2004), it is hypothesized that STG volumes will be increased in subjects with autism when compared to healthy controls.

2. Results

Examination of the scatter plots depicting all participants' STG volumetric data by study group (Fig. 1) revealed one typically-developing control (TDC) subject who was an outlier in all volumetric measures, including left STG (TDC mean = 18.67 ± 2.41 cc, outlier value = 25.06 cc) and right STG (TDC mean = 17.76 ± 2.26 cc, outlier value = 23.89 cc). No outliers were present in the high-functioning autism (HFA) group. This outlier is clearly identified using box plots as depicted in Fig. 2.

In light of the potential problem of a single oultier in a small sample, final analysis was conducted after excluding this subject (N = 37; HFA = 18, TDC = 19). The resultant HFA and TDC groups did not differ in mean age, full-scale IQ (FSIQ),