Journal of Fluency Disorders xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Fluency Disorders

journal homepage: www.elsevier.com/locate/jfludis

Planum temporale asymmetry in people who stutter

Patricia M. Gough[a], Emily L. Connally[b], Peter Howell[c], David Ward[d], Jennifer Chesters[b], Kate E. Watkins[b,*]

[a] Department of Psychology, Maynooth University, Maynooth, Co. Kildare, Ireland
[b] Department of Experimental Psychology, University of Oxford, South Parks Road, Oxford, OX1 3UD, UK
[c] Department of Psychology, University College London, Bedford Way, London, WC1E 6BT, UK
[d] School of Psychology and Clinical Language Sciences, University of Reading, Harry Pitt Building, Earley Gate, Reading, RG6 7BE, UK

ABSTRACT

Purpose: Previous studies have reported that the planum temporale – a language-related structure that normally shows a leftward asymmetry – had reduced asymmetry in people who stutter (PWS) and reversed asymmetry in those with severe stuttering. These findings are consistent with the theory that altered language lateralization may be a cause or consequence of stuttering. Here, we re-examined these findings in a larger sample of PWS.

Methods: We evaluated planum temporale asymmetry in structural MRI scans obtained from 67 PWS and 63 age-matched controls using: 1) manual measurements of the surface area; 2) voxel-based morphometry to automatically calculate grey matter density. We examined the influences of gender, age, and stuttering severity on planum temporale asymmetry.

Results: The size of the planum temporale and its asymmetry were not different in PWS compared with Controls using either the manual or the automated method. Both groups showed a significant leftwards asymmetry on average (about one-third of PWS and Controls showed rightward asymmetry). Importantly, and contrary to previous reports, the degree of asymmetry was not related to stuttering severity. In the manual measurements, women who stutter had a tendency towards rightwards asymmetry but men who stutter showed the same degree of leftwards asymmetry as male Controls. In the automated measurements, Controls showed a significant increase in leftwards asymmetry with age but this relationship was not observed in PWS.

Conclusions: We conclude that reduced planum temporale asymmetry is not a prominent feature of the brain in PWS and that the asymmetry is unrelated to stuttering severity.

1. Introduction

Historically, altered language dominance has been considered a cause of developmental stuttering. This idea was expressed in the "Cerebral Dominance Theory" that dates back to Orton and Travis (Orton, 1928; Travis, 1931). Recently, brain-imaging studies indicating reduced functional lateralization during speech processing in people who stutter (PWS) lent support to this theory (see meta-analyses by Belyk, Kraft, & Brown, 2015; Budde, Barron, & Fox, 2014; Brown, Ingham, Ingham, Laird, & Fox, 2005). One language-related structure that typically shows leftwards asymmetry is the planum temporale (PT) in the posterior temporal lobe. The relevance of the PT to the altered laterality theory of stuttering arises from the suggestion that the PT is larger and its asymmetry reduced in PWS (Foundas et al., 2001Foundas, Bollich, Corey, Hurley, & Heilman, 2001) and has atypical rightwards asymmetry in

* Corresponding author.
E-mail address: kate.watkins@psy.ox.ac.uk (K.E. Watkins).

http://dx.doi.org/10.1016/j.jfludis.2017.06.003
Received 29 September 2016; Received in revised form 7 June 2017; Accepted 15 June 2017

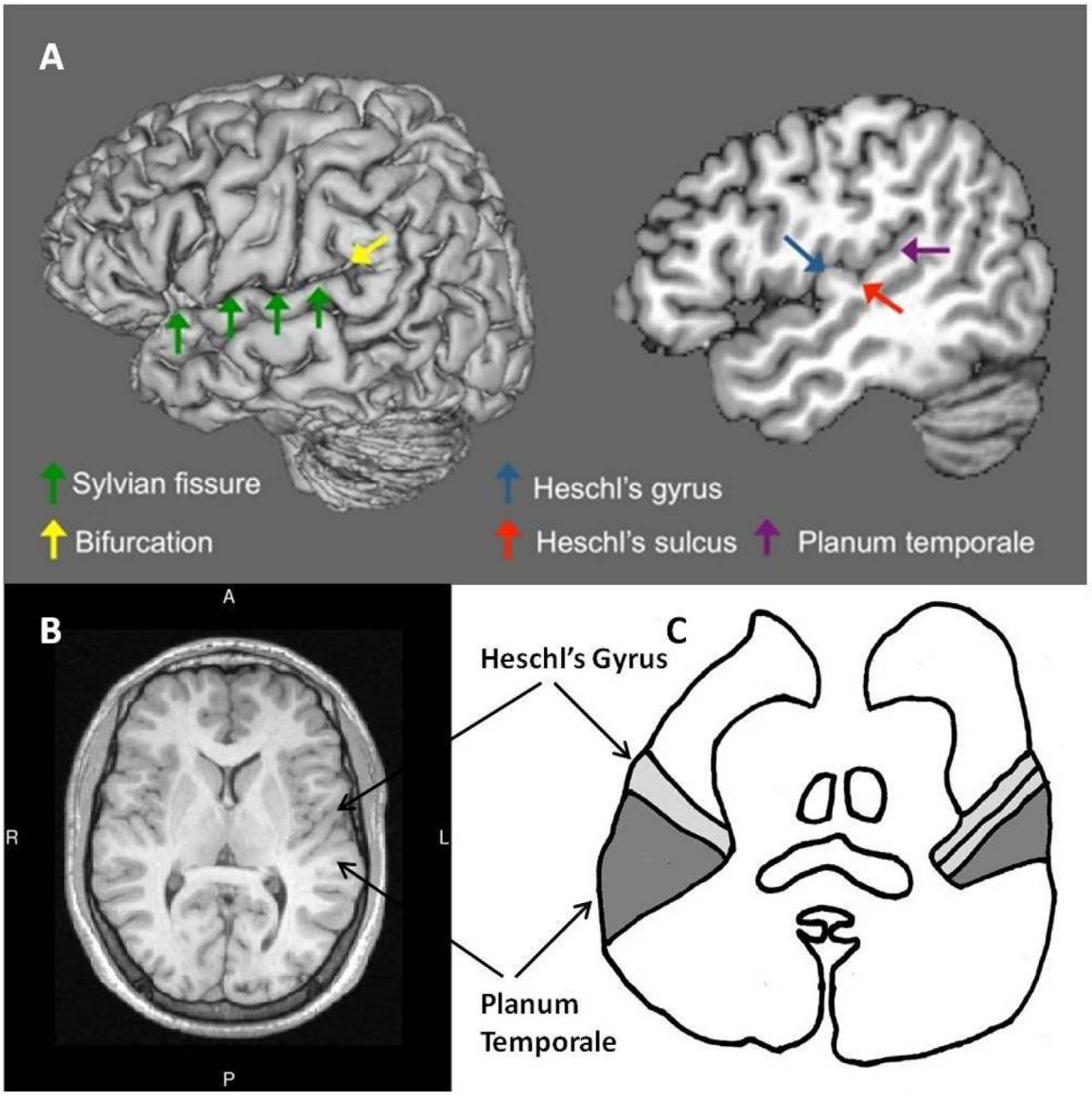

Fig. 1. Location and shape of the Planum Temporale (PT). (A) Lateral surface view (left) of the left hemisphere indicating the Sylvian fissure (green arrows) and the bifurcation at its posterior limit into ascending and descending rami (yellow arrow). Sagittal slice (right) through the left hemisphere at 48 mm from the midline indicating Heschl's gyrus (blue arrow), Heschl's sulcus (red arrow), and the PT (purple arrow). (B) Axial slice from a structural scan for one participant in this study. A – anterior, P – posterior, R – right, L – left. (C) Simplified line drawing based on Geschwind & Levitsky's (1968) figure showing the location of Heschl's gyrus and the PT. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

those with severe stuttering (Foundas et al., 2004).

The PT is located on the horizontal surface of the superior temporal gyrus and extends to the first transverse gyrus (Heschl's gyrus) anteriorly (Pfeifer, 1936), to the insula medially, and posteriorly to the bifurcation of the Sylvian fissure into the posterior ascending and descending rami (e.g. Foundas et al., 2001, 2004) (see Fig. 1). When viewed from the superior surface of the temporal lobe, the PT has the appearance of a triangle with its longest side at the lateral extent and its "tip" located medially (see Fig. 1C). The PT is considered to be secondary auditory cortex and is thought to be important for speech and complex sound processing (Binder, Frost, Hammeke, Rao, & Cox, 1996; Caplan, Gow, & Makris, 1995; Griffiths & Warren, 2002) and auditory-motor integration (Hickok, Okada, & Serences, 2009).

In the typically developed brain, asymmetry between the left and right PT is a robust observation − the left side being larger. This was first described based on post-mortem examinations of brains (Geschwind & Levitsky, 1968) and has been confirmed by others using manual and automated measurements of MRI data (e.g. Foundas, Leonard, Gilmore, Fennell, & Heilman, 1994; Watkins et al., 2001). Because of its spatial proximity to the receptive language centre in "classic" neurological models of language in the left hemisphere ('Wernicke's area'), the asymmetry of the PT has been taken as a proxy for functional lateralization of language. It was