Title

Language differences shape a universal brain network

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Abstract

Every child is able to master their mother tongue regardless of fundamental differences among the languages of the world. Despite this apparent universality, the linguistic communities of the world give rise to a multitude of languages with distinct phonological, syntactic, and semantic systems [1]. These differences in the languages of the word give rise to specific processing demands, which have been shown in electrophysiological studies [2], but also in language acquisition [3] and in language breakdown in aphasia [4]. Brain plasticity must therefore allow a predetermined neural language network to adapt to the specific needs of each language. To assess this hypothesis, we performed diffusion magnetic resonance imaging tractography to investigate the structural connectivity of the language network of mother tongue speakers of different languages. Here, we show that three languages that represent different processing demands in language—Mandarin Chinese, English, and German—lead to differences in the white matter fiber tracts connecting relevant language regions (Figure 1). German speakers exhibited a stronger dorsal connectivity to the frontal cortex, which we associate with the prolific morphosyntactic cues in this language regarding the hierarchical relationships within a sentence [5]. English speakers show in turn a stronger ventral connectivity, which might be due to the fact that they rely more on cues about the association of meanings and thus have a stronger pathway for semantic processing. Finally, Chinese speakers display a greater inter-hemispheric connectivity and dorsal connectivity to the parietal cortex. This can be associated with the specific demands of processing a tonal language, with a greater bilateral involvement, and with the additional efforts to disambiguate homophones during online sentence processing [6]. These data thus provide first evidence of how the life-long use of a specific language leaves structural traces in the neural language network of its speaker. This study demonstrates for the first time that the use of different

languages with their respective processing demands lead to structural differences in the neural language network. More generally, our findings evidence the brain's flexible balance between its predetermined biological nature and environmental requirements.

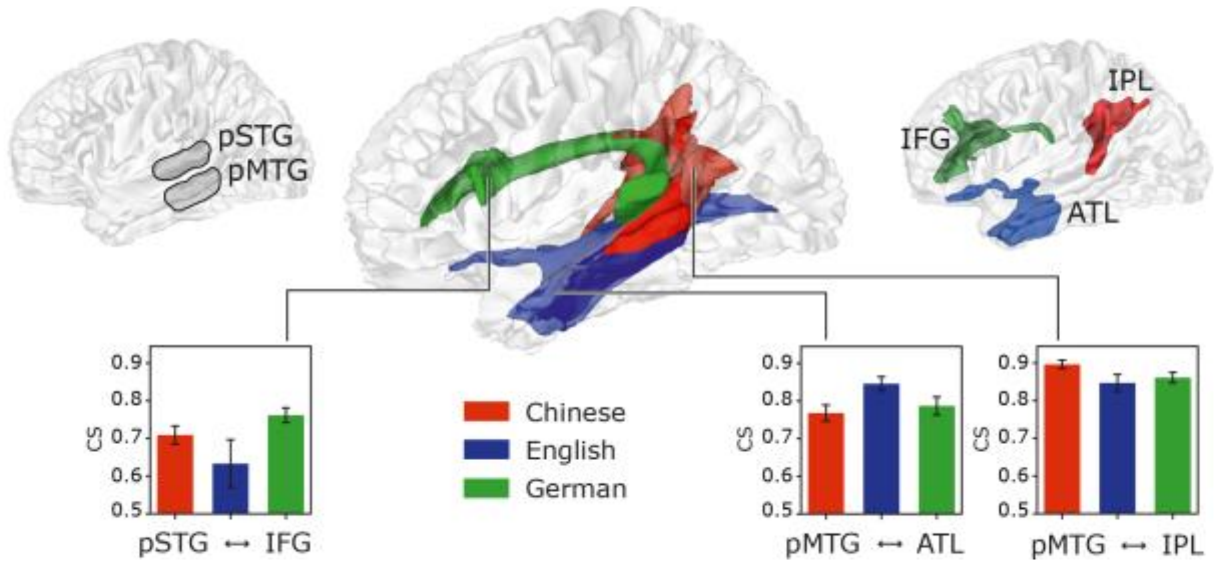

Figure 1. Cross-linguistic connectivity differences from Wernicke's area. Upper left corner: Seed regions of interest for probabilistic tractography in the posterior temporal cortex. Upper right corner: Significant clusters with stronger connectivity for each language in comparison with the other two in conjunction analysis ($p<0.05$ FWE) Center: Probabilistic tractography between ROIs in Wernicke's area and areas with significantly higher connectivity in each of the three groups. The bar graphs show the relative connectivity strengths (CS, mean ± 2 SEM) to target areas with significant connectivity differences for the different languages: stronger dorsal connectivity to the frontal cortex in German speakers (in green), stronger ventral connectivity in English speakers (in blue), and stronger dorsal connectivity to the parietal cortex in Chinese speakers (in red). Abbreviations: p (posterior), STG (superior temporal gyrus), MTG (middle temporal gyrus), IFG (inferior frontal gyrus), IPL (inferior parietal lobe), ATL (anterior temporal lobe).

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