Fronto-Central Connectivity Discriminates Successful from Unsuccessful Phoneme Perception in Wernicke's Aphasia

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Background: Impaired speech perception is a core symptom of Wernicke's-type aphasia (WA). It is thought to be causally linked to the language comprehension impairment and is a key target in impairment-based neurorehabilitation (e.g. Woodhead et al., 2017). Speech perception impairments manifest as phonological discrimination difficulties. However, accurate discrimination can be observed when phonological changes are sufficiently acoustically distinct (Robson et al., 2014). At the neural level, perception success is not always discriminated by magnitude of neural activity in either the aphasia or the neurotypical population (Robson et al., 2014; Sharma et al., 1993). This study tested the hypothesis that phonological perception success is reflected in inter-regional connectivity within the speech perception network, observable in scalp-level connectivity measures.

Method: Data from seven WA and seven neurotypical participants from Robson et al., 2014 were re-analysed. EEG was recorded while participants listened to a multiple deviant mismatch negativity (MMN) paradigm while watching a silent film. Participants heard standard and deviant CVC nonword stimuli. Deviant stimuli were either perceptible or non-perceptible changes from the standard, based on prior behavioural testing. Deviant stimuli were additionally presented in a standard "deviant alone" condition.

EEG data were preprocessed and the imaginary coherence, a measure of functional connectivity, (IC: Nolte et al., 2004) between all sensor pairs was calculated in the theta, alpha, beta and gamma bands for three time windows: (1) pre-MMN (-100-100ms); (2) MMN (100-300ms) and (3) post-MMN (300-500ms). IC MMN change was calculated as the difference in IC during the MMN window in comparison to the deviant-alone stimuli and the surrounding pre and post time windows.

The IC MMN change between the peak ERP MMN response electrodes (FCz, Cz) and 9 sensor sub-sets was isolated and averaged (Figure 1) and subjected to inferential statistics.

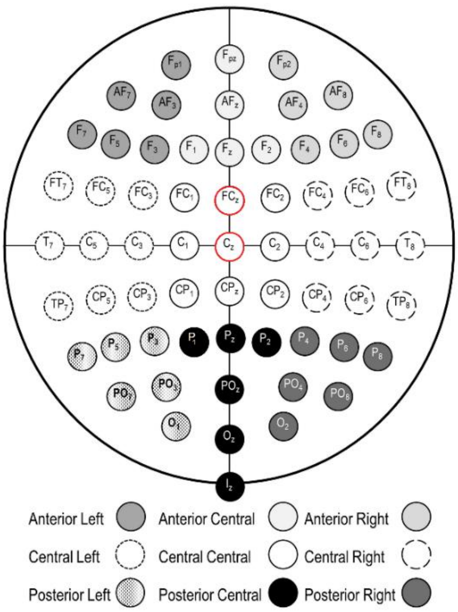

Figure 1: IC MMN Change calculated between F_z and FC_z and the average of each sensor region

Results: 2x2x3x3 ANOVA (group x perceptibility x anterior-posterior sets x left-right sets) found a main effect of perceptibility for IC MMN change in the theta band ($F_{(1,1)}$=7.7, p=0.02) (Figure 2B.). Due to low group numbers, follow-up Wilcoxon test explored theta IC MMN change over each sensor sub-set. A significant perceptibility difference was found for IC between central and right anterior sensors for the WA group (Z=-2.2, p=0.03) (Figure 2A), corresponding to peak ERP activity.

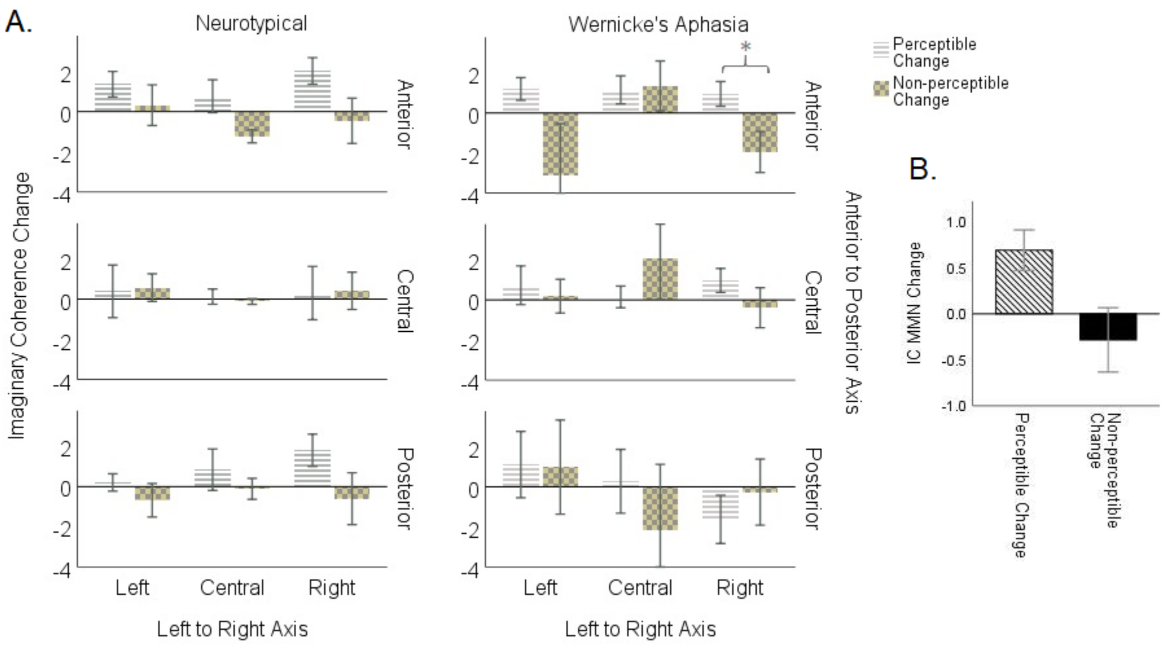

Figure 2: Regional (A) and Main Effect (B) Theta Imaginary Coherence Change

Conclusions: In-line with previous findings, theta band connectivity was associated with MMN auditory change detection (Hsaio et al., 2009). Theta connectivity distinguished phoneme perception success, irrespective of aphasia status or stimulus type. Theta oscillations may support integration of phonological information throughout the residual speech perception and attention networks. These results concord with previous findings that functional connectivity between residual network components better accounts for behaviour in aphasia than response magnitude within local neuron populations (e.g. Baldassarre et al., 2019) and could be used to evaluate the outcome of therapy research. Future analyses will use permutation testing to further explore significance at the group and case series levels.

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