Typological Similarity between Languages Modulates the Neural Mechanisms of Selective Attention in Bilinguals

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1. Background

Bilingualism has been shown to modulate the neural mechanisms of auditory selective attention, arguably as a result of the constant need to select the target language and inhibit the unwanted one during lexical processing where both languages are activated in parallel[1,2]. However, the impact of typological similarity between spoken languages, as a key factor that could affect the cognitive demand of language differentiation and selection, has not been sufficiently explored. Therefore, to further investigate the impact of typological similarity between bilinguals' languages on attentional modulation, this study evaluated the neural adaptation of auditory selective attention in early bilinguals speaking very dissimilar languages (Chinese-English), and compared their results to existing data for English monolinguals, and bilinguals speaking more similar languages using the same dichotic listening paradigm[3,4] .

Listeners all attended to continuous natrual speech in their native language under interference with different intellegibility by manipulating the type of competing streams in the other ear. The neural encoding of stimuli was represented by the cross-correlation functions of EEG signals with the temporal envelope of attended and unattended streams over time.

2. Experimental Conditions

	Early Proficient Chinese-English Bilinguals (N = 30)	
	Attended stream	**Unattended stream**
Chinese – Chinese (Native - Native)	Chinese narrative (Native language)	A different Chinese narrative
Chinese – Serbian (Native – Unknown)	Chinese narrative (Native language)	A Serbian narrative (Unknown language)
Chinese – Musical Rain (Native – Non-Linguistic)	Chinese narrative (Native language)	Musical Rain (Non-linguistic stimulus)
Single Talker (No Interference)	Chinese narrative (Native language)	N/A

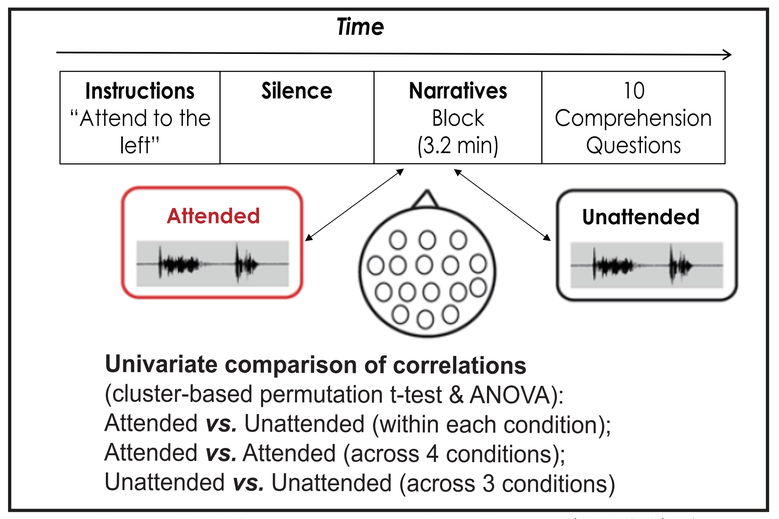
3. Methods

Participants. 30 healthy Chinese-English bilinguals from 18 to 38 years old were recruited. All were native Mandarin Chinese speakers who learned English as L2 no later than at the age of six, and were fully proficient in English, as shown by the self-reported questionnaire and English test. The project also utilized data from subjects in previous studies [3,4]: a group of 22 English monolinguals , a group of 22 Spanish-English bilinguals , and a group of 18 Dutch-English bilinguals. All were proficient English speakers.

Stimuli. Children's stories with 120 sentences in each (each sentence lasts ~3s). Each story was evenly divided into two blocks, with 60 sentences per block (~3.2 min).

Procedure. In each condition, participants attended to 4 blocks of Chinese narratives (4 x 60 = 240 attended sentences) counterbalanced between their L and R ear, while simultaneously ignoring the competing streams (Native language, Unknown language, or Musical rain) presented in the other ear.The Single Talker condition always came the first. The rest conditions were presented in a random order. There were 960 attended and 720 unattended sentences / trials in total per participant.

Comprehension. After each block, participants completed 10 True/False questions about the story they just attended to, resulting in 160 responses per participant. Average accuracy was 93%, implying good attention. There was no significant difference in behavioural performance (comprehension accuracy) across four conditions.

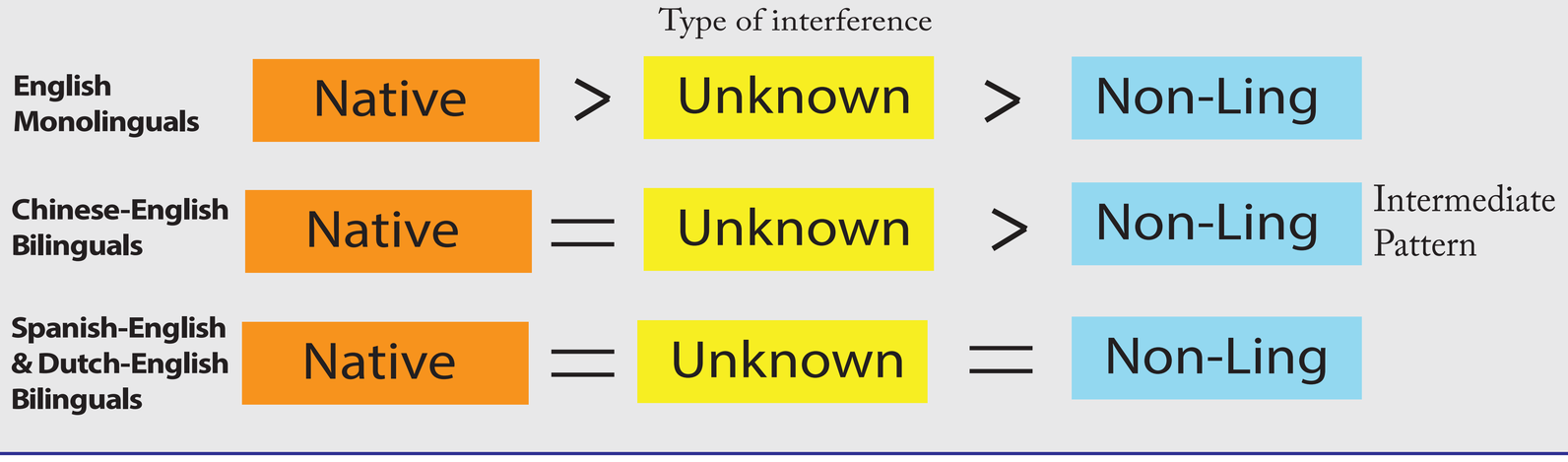


Data collection & analysis. EEG data collected using a 128-channel net. 36 outer electrodes were excluded. Speech envelopes of audio signals were extracted using Mel frequency cepstral coefficients (MFCC). Attended and unattended speech envelopes for each sentence/trial were cross-correlated with corresponding EEG data in each channel as a function of time lag (200ms pre-onset to 600ms post-onset).

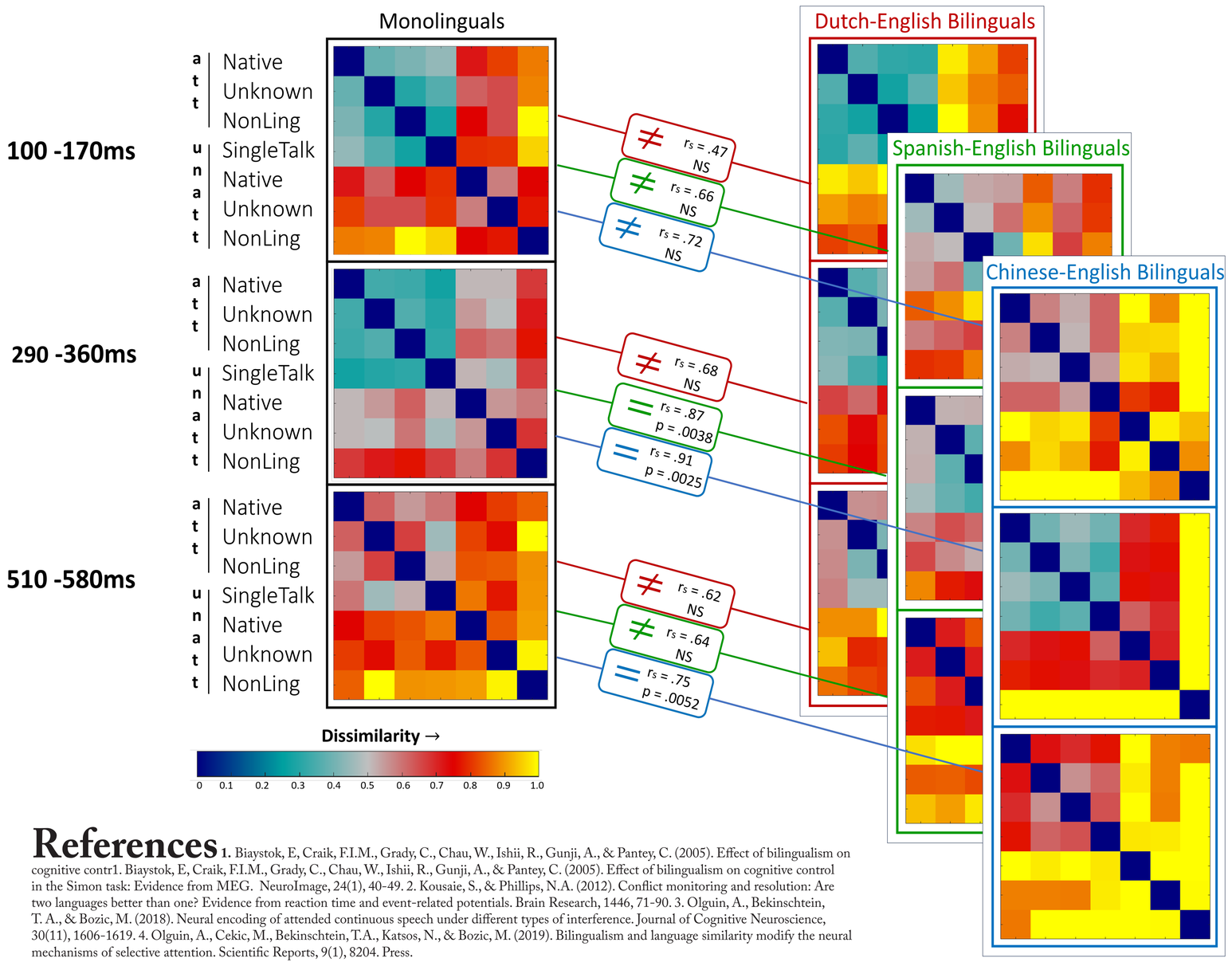
4. Results :

4.1. In each condition, Attended > Unattended - Strenth of neural encoding modulated by attention

4.2. Compare across groups: Neural encoding of attended stream by condition



4.3.1. Compare across groups over time (3 time windows post-stimulus): Representational Similarity Analysis (RSA) for the overall neural encoding patterns



4.3.2. Compare across groups over time (5 time windows): RSA for the overall neural encoding patterns

time windows post-stimulus	*monolingual vs. Dutch-English bilingual*	*monolingual vs. Spanish-English bilingual*	*monolingual vs. Chinese-English bilingual*
	Similarity (r_s)	Similarity (r_s)	Similarity (r_s)
50-150ms	0.5636	0.7065	0.7909*
150-250ms	0.6805	0.7974	0.7844 *
250-350ms	0.8039 *	0.8468 *	0.9052 *
350-450ms	0.5247	0.5325	0.6623
450-550ms	0.6429	0.3610	0.7390 *

* Indicates significant similarity / Spearman correlation between the compared groups in this time window

Compared with other bilinguals, Chinese-English bilinguals have more similarities with the monolingual baseline over time (less modulation).

5. Summary and Conclusions

1. Results showed significantly more robust neural encoding of attended than of unattended auditory streams across all conditions.

2. For Chinese-English bilinguals, the attentional encoding increased as the distractor changed from non-linguistic (Musical Rain) to linguistic (narratives) but did not differ between conditions of linguistic interference (native or unknown); a pattern half-way between the existing data for monolinguals and typologically-similar bilinguals.

3. Using RSA, activation patterns of different bilinguals were directly compared with English monolinguals as a baseline. Of all bilingual groups, the overall patterns of neural encoding in Chinese-English bilinguals were the closest to those of monolinguals, manifested as significant similarities in most time windows tested.

4. Taken together, the neural mechanisms of auditory selective attention are modified by bilingualism, and this modulation is moulded by the typological similarity between bilinguals' L1 and L2 - with higher dissimilarity leading to less modulation and a more monolingual-like pattern of neural encoding.

5. This is consistent with the hypothesis that bilinguals speaking more similar languages experience stronger competition during lexical selection and higher cognitive demands for differentiation or inhibition, as a result requiring more robust adaption of the neural mechanisms of selective attention.

6. The study provides ecologically valid evidence of adaptive neuroplasticity and flexible modulations as a result of environmental demands placed by various L2 experiences.

References

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