

Low-frequency Neural Activity Tracks Semantic Properties of Mandarin Words

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How human brain integrates lower levels of linguistic units (e.g. syllables, words) into higher level units (e.g. phrases, sentences) has become a focal point in neural oscillation studies. One spectrum of existing studies argues that our brain combines words into phrases and sentences by solely relying on the semantic information of words without recourse to the hierarchical syntactic information, whereas the other spectrum claims that neural activity tracks syntactic information instead of semantic properties of words. The current study addressed this debate by conducting a speech perception experiment using the frequency-tagging paradigm. We were interested to see whether cortical activity tracks semantic or syntactic information. Two types of sequences, antonym pairs and subject-predicate structure, were constructed, containing synthesized continuous isochronous disyllabic Mandarin words (see Table 1), with each sequence consisting of 24 disyllabic words and each word lasting for 500ms. Antonym pairs contained words with semantic association only; and subject-predicate structure contained words with syntactic association only. Participants ($N=42$, $Mean_{age}=23;3$, 27 girls) were asked to listen to these different types of sequences while their neural activity was recorded by EEG. We observed a significant 2Hz peak in both conditions (see Figs. 1 and 2), meaning that neural activity tracks every single word information; and a significant 1Hz peak was observed in the antonym pairs, but not in the subject-predicate structure, suggesting that our brain cannot integrate words into phrases relying solely on syntactic information. In addition, we constructed a perplexity model to simulate how the semantic properties of words contribute to the neural responses to the sequences. Again, we found a significant 2Hz peak in both conditions (see Figs. 3 and 4); and a significant 1Hz peak was observed in the antonym pairs, but not in the subject-predicate structure, consistent with the EEG results. Implications of the findings were discussed.

Table 1. Experimental conditions

Condition	Speech Sequence
Antonym pairs	N ₁ N ₂ N ₁ N ₂ N ₁ N ₂ N ₁ N ₂ ... 真话谎言赢家败者城市乡村白天夜晚..... Truth lie winner loser city country day night...
subject-predicate structure	NVNVNVNV... 大海丢失细胞讲课果汁扫地厨房生长..... Sea lost cell teach juice sweep kitchen grow...

