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Exploring the Impact of Semantic Diversity in Second Language Learning: A Computational and Neural Approach

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Abstract:	The study involved two separate experiments with participants who were native Mandarin Chinese speakers learning English as a second language. Both experiments followed identical training and testing procedures but differed in their modalities of stimulus presentation: visual words in Experiment 1 (N = 30) and auditory words in Experiment 2 (N = 13). In Experiment 2, we also recorded participants' magnetoencephalography (MEG) signals. The training involved reading or listening to thirty English paragraphs, adapted from The Conversation and Voice of America. These paragraphs were transformed into context vectors using the Universal Sentence Encoder. We then divided the paragraphs into two groups based on the cosine similarity of their context vectors, creating conditions of high and low semantic diversity. In each group, certain nouns appearing in the paragraphs were replaced with pseudowords. Participants encountered three pseudowords in each semantic diversity condition, each repeated five times across different paragraphs. Following the training, participants completed a recognition task, identifying whether they had previously encountered the stimuli. The study's primary focus was on the participants' behavioral and neural responses to the target pseudowords during the test phase. We found that participants showed significantly higher accuracy in recognizing pseudowords in high semantic diversity contexts in both experiments. Additionally, MEG analysis in Experiment 2 revealed increased brain activity in response to high semantic diversity pseudowords, particularly in the left superior temporal cortex and the left inferior frontal cortex. The findings provide substantial neural evidence supporting the influence of semantic diversity on second language learning. Specifically, we observed that new words presented in varied contexts were more effectively recognized than those in more uniform contexts. The increased brain activity in areas associated with semantic processing under high diversity conditions suggests a heightened neural engagement in resolving semantic ambiguity. Furthermore, this study demonstrated the significant contribution of computational models in understanding the behavioral and neural dynamics of second language acquisition.
Suggested Reviewers:	

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Purpose: In studies of lexical representation, computational models have been introduced to objectively quantify the semantic representation of words, sentences, and discourses. This allows for a comparison of their semantic dissimilarity, regardless of the language type. This research aims to explore the role of semantic diversity, as determined by context vectors, on the behavioral and neural responses of individuals learning English as a second language.

Method: The study involved two separate experiments with participants who were native Mandarin Chinese speakers learning English as a second language. Both experiments followed identical training and testing procedures but differed in their modalities of stimulus presentation: visual words in Experiment 1 (N = 30) and auditory words in Experiment 2 (N = 13). In Experiment 2, we also recorded participants' magnetoencephalography (MEG) signals. The training involved reading or listening to thirty English paragraphs, adapted from *The Conversation* and *Voice of America*. These paragraphs were transformed into context vectors using the Universal Sentence Encoder. We then divided the paragraphs into two groups based on the cosine similarity of their context vectors, creating conditions of high and low semantic diversity. In each group, certain nouns appearing in the paragraphs were replaced with pseudowords. Participants encountered three pseudowords in each semantic diversity condition, each repeated five times across different paragraphs. Following the training, participants completed a recognition task, identifying whether they had previously encountered the stimuli.

Results: The study's primary focus was on the participants' behavioral and neural responses to the target pseudowords during the test phase. We found that participants showed significantly higher accuracy in recognizing pseudowords in high semantic diversity contexts in both experiments. Additionally, MEG analysis in Experiment 2 revealed increased brain activity in response to high semantic diversity pseudowords, particularly in the left superior temporal cortex and the left inferior frontal cortex.

Conclusion: The findings provide substantial neural evidence supporting the influence of semantic diversity on second language learning. Specifically, we observed that new words presented in varied contexts were more effectively recognized than those in more uniform contexts. The increased brain activity in areas associated with semantic processing under high diversity conditions suggests a heightened neural engagement in resolving semantic ambiguity. Furthermore, this study demonstrated the significant contribution of computational models in understanding the behavioral and neural dynamics of second language acquisition.

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