Japanese Speakers' Second Language Sentence Processing: ERP and Behavioral Evidence

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Abstract: This study explores how native Japanese speakers process various linguistic cues during second language (L2) English sentence comprehension. Behavioral and EEG results revealed significant difficulty in syntactic and phonological judgments, with ERP data suggesting implicit sensitivity despite poor overt performance. These findings illustrate asymmetries in L2 processing across linguistic domains.

Keywords: Neurolinguistics, second-language comprehension, linguistic processing, event-related potential (ERP)

Introduction

The present study investigates how second-language (L2) learners process different types of linguistic information during sentence comprehension. Particularly, we examine how native Japanese speakers with intermediate English proficiency respond to syntactic, semantic, and phonological aspects of spoken English. These linguistic domains engage distinct cognitive and neural mechanisms, and their processing may be differentially influenced by the learners' first language (L1) background.

Previous research has independently examined how L2 learners process syntax, semantics, and phonology. Syntactic processing has been shown to involve late ERP components such as the P600, often reflecting reanalysis or repair processes in L2 speakers [1]. Semantic anomalies typically elicit N400 responses, with reduced amplitude or delayed onset in non-native speakers, indicating greater processing demands. Phonological processing, particularly in Japanese learners of English, presents unique challenges due to L1–L2 sound mismatches, such as the /r/–/l/ contrast, and has been linked to both behavioral difficulties and distinct ERP patterns [2,3].

However, these domains have rarely been compared within a unified task, leaving open questions about their relative difficulty and the nature of neural engagement across linguistic levels in L2 comprehension. By using a sentence judgment task that systematically varies the type of linguistic violation, this study aims to provide a comprehensive understanding of how native Japanese speakers detect and evaluate syntactic, semantic, and phonological anomalies in real time.

To capture both conscious and implicit processing, behavioral performance was assessed alongside neural activity using event-related potentials (ERPs).

Methods

Thirty-one right-handed native Japanese speakers with intermediate English proficiency participated, providing informed consent in line with ethical standards. We acquired the EEG by using 32 Ag/AgCl electrodes (actiCAP, Brain Products; Neurofax EEG-1200, Nihon Kohden). All electrode impedances were maintained below 45 kΩ throughout the experiments. The ERPs were amplified and bandpass filtered (1–30 Hz) and sampled at 1,000 Hz. During EEG recording, participants performed a sentence judgment task, evaluating auditory English sentences based on a cue (Grammar, Meaning, or Phonology). Stimuli comprised five sentence types, synthesized using native-speaker text-to-speech and checked for accuracy. The stimuli included 240 sentences across four linguistic sets: agreement, prepositions ("on"/ "of"), countability, and articles. Each set had 15 sentences in four conditions: syntactically correct, syntactically incorrect, phonological error, and semantic violation (e.g., *The cat chases the mouse* vs. *The cat chase the mouse*). ERP analyses targeted components indexing linguistic processing (e.g., N400, P600), with data segmented by condition and three regions. MRI data were collected but are not reported here.

Results

Participants demonstrated the highest sentence judgment accuracy in the control condition (M = 76.03%), followed by the semantic condition (M = 63.00%). Accuracy was lower in the phonological (M = 40.16%) and syntactic (M = 39.86%) conditions, indicating greater difficulty in detecting phonological and grammatical violations—patterns consistent with prior findings on L2 processing challenges [Figure 1]. A one-way repeated measures ANOVA revealed a significant main effect of condition, $F(1.82, 50.94) = 61.50$, $p < .001$. Post-hoc pairwise comparisons (Tukey-adjusted) showed that the control condition yielded significantly higher accuracy than all others ($p < .001$–$.032$). The semantic condition was significantly more accurate than phonological and syntactic conditions ($p < .001$), while no significant difference was observed between phonological and syntactic conditions ($p = .92$).

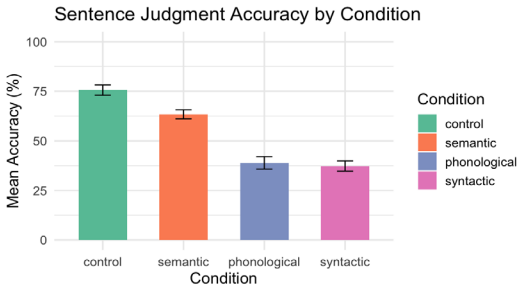

Figure 1: Mean accuracy across experimental conditions.

A two-way repeated-measures ANOVA revealed a significant interaction between condition and brain region ($F(6, 180) = 2.25$, $p = .040$). In the 300–500 ms window, a repeated-measures ANOVA revealed a significant main effect of region ($F(2, 60) = 12.43$, $p < .001$) and a significant condition × region interaction ($F(6, 180) = 3.73$, $p = .004$), but no main effect of condition ($F(3, 90) = 1.10$, $p = .354$). Follow-up paired-samples t-tests indicated that phonological errors elicited significantly larger amplitudes than control ($t(30) = 3.32$, $p = .002$, $d = 0.55$), syntactic ($t(30) = 2.24$, $p = .033$, $d = 0.37$), and semantic conditions ($t(30) = 2.15$, $p = .040$, $d = 0.39$) in the parietal region. No other contrasts were significant.

To examine late-stage neural responses, ERP amplitudes in the 500–800 ms window were compared across conditions and regions. Paired-samples t-tests showed no significant differences between control and either syntactic or semantic conditions in any region. However, phonological violations elicited significantly greater amplitudes than control in central ($t(30) = 2.53$, $p = .017$, $d = 0.45$), parietal ($t(30) = 2.96$, $p = .006$, $d = 0.53$), and centroparietal ($t(30) = 2.90$, $p = .007$, $d = 0.52$) regions. A marginal effect was observed for semantic violations at the centroparietal site ($t(30) = 1.98$, $p = .056$, $d = 0.36$).

Discussion

These findings reveal asymmetries in L2 learners' access to linguistic representations. Semantic cues were processed more accurately, whereas syntactic and phonological anomalies posed greater challenges. Specifically, syntactic violations elicited the lowest accuracy. Interestingly, however, ERP data indicated heightened neural sensitivity to phonological mismatches in the 500–800 ms window, suggesting implicitly processing despite poor behavioral performance. Phonological errors evoked enhanced N400 amplitudes (300–500 ms), especially over parietal regions, reflecting increased orthographic processing demands.

Combining behavioral and ERP measures allowed detection of dissociations between conscious performance and neural activity. Nonetheless, limitations include the use of synthetic speech and a homogeneous sample, which may contribute to low accuracy and task difficulty.

Despite these results, ERP patterns aligned with prior research on implicit processing in late bilinguals. The results suggest that L2 learners may recruit compensatory mechanisms for difficult contrasts. Future studies should examine whether phonological training or more natural stimuli can enhance both implicit processing and explicit comprehension.

Conclusions

L2 sentence comprehension reflects uneven access to linguistic representations. For native Japanese speakers, syntactic and phonological processing is particularly challenging, marked by low accuracy and heightened late-stage ERP responses. Phonological violations evoke early neural effects, despite weak behavioral performance. These results highlight implicit processing and emphasize the value of integrating behavioral and neurophysiological measures to better understand and address gaps between sensitivity and performance.

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