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Proceedings of the Annual Meeting of the Cognitive Science Society

Title

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Journal

Proceedings of the Annual Meeting of the Cognitive Science Society, 48(0)

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Publication Date

2026

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Not a Linear Path: Three Neural Signatures of Native versus Non-Native Instructional Learning

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Abstract

Learning complex content in a non-native language is widely perceived as effortful, yet neurocognitive evidence underlying this process remains poorly understood. We conducted the first fMRI study using a naturalistic instructional video to examine real-time neural dynamics in native English speakers (N=16), high-proficiency L2 learners (N=17), and medium-proficiency L2 learners (N=19). Using intersubject correlation (ISC) and neural encoding of linguistic embeddings (i.e., GPT2 embeddings), we quantified how strongly the participants' language network (LAN) and multiple-demand network (MD; cognitive control) were engaged by the stimuli. Results reveal three distinct profiles: Native speakers showed strong LAN engagement (high ISC/encoding) with moderate MD engagement. High-proficiency learners exhibited native-like LAN engagement plus effective LAN–MD integration. Medium-proficiency learners showed heterogeneous LAN and MD engagement and ineffective coupling characterized by excessive MD involvement in language processing. These findings provide insights into English-medium instructional challenges, identifying neurocognitive signatures distinguishing successful compensation mechanisms from ineffective processing. Our study provides insights into non-native instructional learning design.