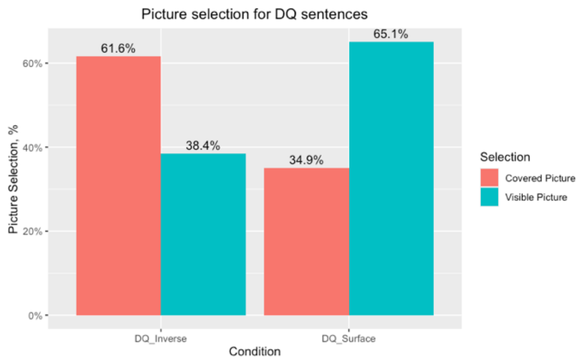
Quantifier scope interpretation in L2: contributions of language proficiency, working memory and executive control

Background: Quantifier scope in English allows ambiguity, as seen in sentences like "Every horse didn't jump over the fence," which can mean either "none of the horses jumped over the fence" (surface scope, SS) or "only some horses jumped over the fence" (inverse scope, IS). In contrast, Mandarin permits only the SS reading, lacking scope ambiguity (Aoun & Li, 1993; Huang, 1998). Similarly, doubly quantified sentences, such as "A child climbed every tree," are ambiguous in English but not in Mandarin. IS readings are generally harder to process than SS due to greater syntactic complexity (Anderson, 2004). While L2 input may provide evidence for IS, Mandarin-speaking learners of English struggle with IS due to Mandarin's lack of scope ambiguity. Previous studies have explored L1 transfer, L2 input, and semantic-pragmatic integration (Chu et al., 2014; Chung, 2012; Chung & Shin, 2022; Wu & Ionin, 2022; Özçelik, 2018), but the role of cognitive factors (working memory and executive control), L2 proficiency, and individual differences remains underexplored, which are the focus of inquiry in this study.

Experiments: Studies on quantifier scope often use truth-value judgment tasks. This study adopted the covered box paradigm (CBP) (Huang et al., 2013) to avoid metalinguistic judgments and direct comparisons between readings. In CBP, participants read a sentence, then choose either the visible picture if it matches the sentence or the covered picture if they believe it better fits the interpretation. The task included 48 critical items (12 per condition for surface and inverse scope readings of doubly quantified (DQ) and negatively quantified (NQ) sentences) and 96 fillers. Each session started with 5 training items, from which participants could know that either the visible picture or the covered picture could be the correct choice. A total of 71 L2 participants completed the task. L2 proficiency was measured using a lexical decision task (Lemhöfer & Broersma, 2012), working memory (WM) with backward digit span test (Wechsler, 1981), and executive control (EC) with the Simon task (Bialystok et al., 2004).

Results & Discussion. As in Figures 1 and 2, participants showed a strong preference for SS over IS for both DQ and NQ (*ps* $< .001$), attributed to the greater syntactic complexity of IS. For DQ sentences, logistic mixed-effects models revealed a marginal interaction among interpretation (SS, IS), WM, and EC ($b = -0.25$, $p = .0589$), suggesting that greater WM could facilitateIS access but only for participants at high proficiency levels. A significant three-way interaction ($b = 3.09$, $p = .0034$) revealed that EC enhanced IS access for learners with mid-to-high proficiency (Figure 3). For NQ sentences, WM significantly interacted with interpretation ($b = -0.63$, $p = .00055$), with higher WM improving IS access (Figure 4). Similarly, EC significantly interacted with interpretation ($b = 1.75$, $p = .02$), as higher EC boosted IS performance, particularly at high EC levels. This study is the first to confirm that cognitive factors—WM and EC—positively influence IS processing albeit mediated by L2 proficiency. WM supports IS by managing the cognitive load required, while EC inhibits competing SS interpretations. These findings highlight the importance of considering cognitive factors when investigating processing and interpretations of complex logical structures.



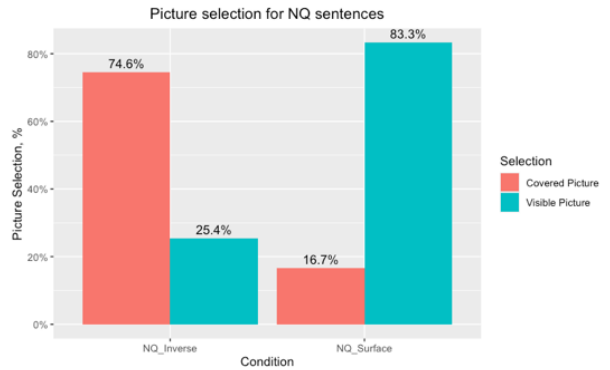
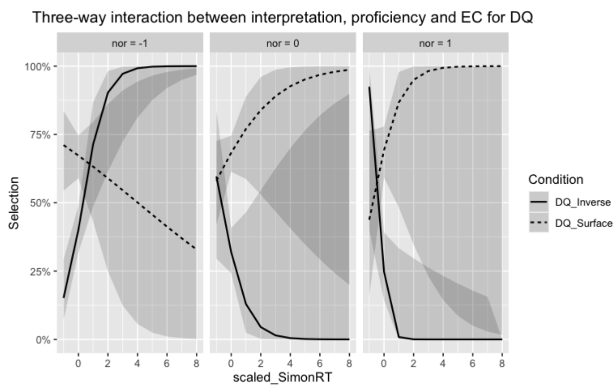


Figure 1. Picture selection by condition for DQ

Figure 2. Picture selection by condition for NQ



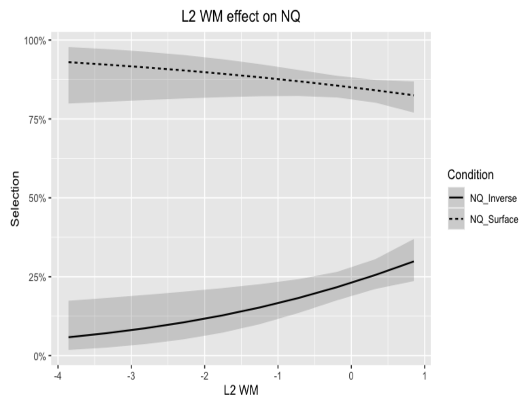


Figure 3. Three-way interaction for DQ

Figure 4. Interaction of WM and interpretation for NQ

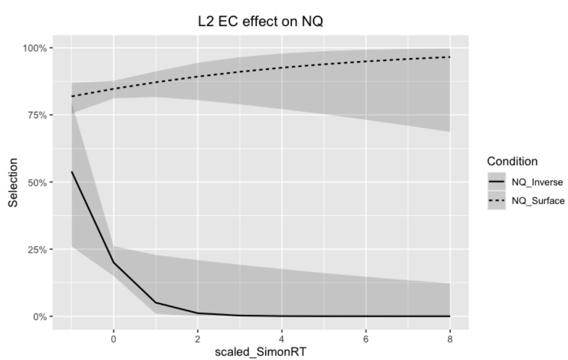


Figure 5. Interaction of EC and interpretation for NQ

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