Working Memory Predicts Grammar but Not Vocabulary in Cantonese-Speaking Preschoolers: A Modality- and Component-Specific Profile

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Background. Based on Baddeley's multicomponent model [1], Alloway et al. [2] demonstrated that by age 4, children possess three functionally separable working memory (WM) components: domain-specific verbal and visuospatial storages (short-term memory; STM) and a domain-general central executive for information manipulation. Forward span tasks were used as indices of STM, whereas backward span tasks were used as indices of WM involving storage and manipulation, in both verbal and visuospatial modalities [2]. Previous research in Indo-European languages primarily emphasized verbal STM and WM contributions to vocabulary and grammar [3]. In Chinese, given its logographic characteristics and opaque character-sound mappings, visuospatial memory has been considered potentially relevant to language development [4]; whether such effects are detectable in preschool oral language, before structured literacy instruction begins at school, remains unclear. Therefore, this study systematically explores how memory modality (verbal vs. visuospatial) and component (STM: storage vs. WM: storage and manipulation) relate to language outcomes in Cantonese-speaking preschoolers.

Method. Ninety-seven Cantonese-speaking 4-year-old children (M_{age} = 4.53 years, *SD* = 0.26; 48 girls) completed verbal and visuospatial STM and WM tasks (digit span and Corsi block-tapping; both forward/backward [5]), plus standardized assessments of receptive and expressive vocabulary and grammar. A linear mixed-effects model examined modality (verbal/visuospatial), component (STM/WM), and their interaction on memory scores [6], controlling for age, gender, and nonverbal IQ. Hierarchical regressions tested incremental WM/STM contributions to language outcomes, prioritizing manipulation-based verbal WM based on Indo-European literature [3], followed by verbal STM, visuospatial WM, and visuospatial STM.

Results. The mixed-effects model revealed significant effects of modality, component, and critically their interaction (*p*s < .001). Forward tasks were easier than backward tasks across modalities; however, the forward-to-backward decrement was substantially larger in the verbal than visuospatial modality (see Figure 1), indicating particular difficulty in verbal WM at age 4. Hierarchical regressions yielded domain- and component-specific results. Better verbal WM significantly predicted better grammar comprehension (*p* < .001) and grammar production (*p* = .001); verbal STM explained additional variance in grammar comprehension (*p* = .039, see in Figure 2). No other memory components explained additional variance in grammar outcomes (*p*s > .121). No memory components predicted vocabulary (*p*s > .140).

Discussion. The results align with findings that verbal WM is particularly challenging [6], while smaller visuospatial decrements align with models showing stronger visuospatial storage-processing links at ages 4–6 [2]. Verbal WM's particular contribution to grammar mirrors findings in Italian [7], given the sentence-level processing demands. The additional contribution of verbal STM to grammar comprehension, but not production, likely reflects the higher phonological retention demands of the comprehension task, where children must hold sentences in storage for picture matching. The absence of visuospatial memory effects may reflect the developmental stage of our sample: age 4.5 precedes the peak of formal Chinese character instruction, and visuospatial memory's relevance to Chinese language may only become pronounced as literacy demands intensify [4]. Notably, no memory components predicted vocabulary, diverging from Indo-European patterns where verbal STM/WM consistently predicts word learning [8]. One possibility is that Cantonese vocabulary's morphological simplicity and mono-/disyllabic structure impose relatively fewer phonological storage demands compared to morphologically complex Indo-European languages [9].

Conclusion. This study provides a comprehensive profile of WM and WM-language relationships in Cantonese-speaking preschoolers. The findings underscore the importance of a multidimensional approach to WM-language research, with implications for understanding memory-language relationships across development and languages.

References

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Figure 1. Modality × Component Interaction

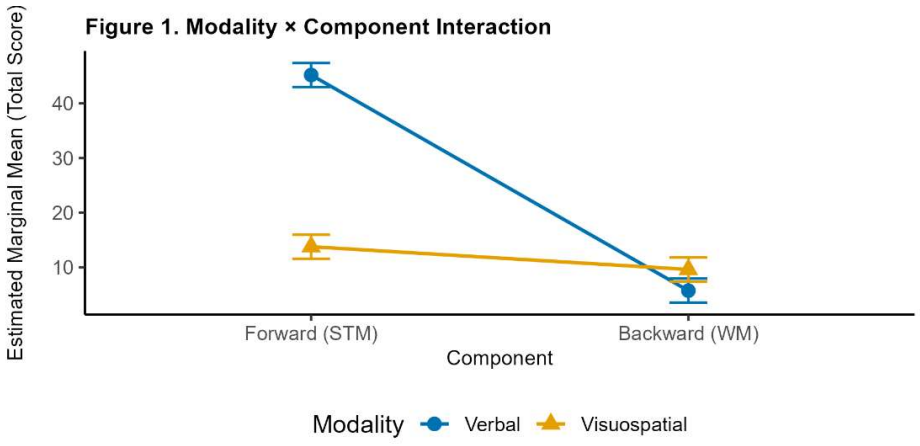

Figure 2. Incremental R^2 from Hierarchical Regression (Grammar Outcomes Only)