Role of working memory in preschool children's production of relative clauses

The link between working memory (WM) and language production has been well-established (e.g. Acheson & MacDonald, 2009). However, most prior research focused on adults, with limited evidence on the role of WM in young children's language production (Mettler et al., 2024). This study seeks to fill this gap by examining the connection between Mandarin-speaking preschoolers' production of complex structures (i.e. relative clauses, RCs) and their WM capacity. The production of complex structures like RCs is well suited for investigating the role of WM, because it requires the integration of various linguistic components across potentially long distances within a sentence, thereby directly engaging WM capabilities (Gibson, 2000). The present study focused on two components of WM (phonological WM and central executive) and explored their interactions with children's grammatical knowledge.

Thirty-five 4-year-olds and 35 5-year-olds were examined using an elicited production task. The task involved two experimenters, one acting out stories using toys, and one acting as a blindfolded puppet. Children were informed that the puppet could not see but only hear the stories, so their task was to help her understand the stories by answering her questions. The puppet's questions were designed to elicit RCs. An example story and the prompt questions are provided (see the **example trial**). RC productions were analyzed based on **gap positions** (subject RCs vs. object RCs) and **embeddedness** (subject-modifying vs. object-modifying clauses), yielding four RC types (SS, SO, OS and OO). Children's WM capacity was assessed using a N-back (0-back) task and a nonword repetition task.

As shown in Figure 1, the 5-year-olds consistently outperformed the 4-year-olds across all clause types. The frequency rank of the productions of the four RC types by the 4-year-olds is OS>SO>SS=OO, which is different from the 5-year-olds' pattern SS>OS>SO>OO. Generalized linear mixed models (GLMMs) were used to analyze the data. Table 1 presents the results of the best-fitting model. Both age and clause type were reliable predictors of children's performance, and SRCs were easier to produce than ORCs. In addition, children's scores in the nonword repetition task demonstrated a significant main effect, highlighting the contribution of phonological WM to RC productions. Children's scores in the 0-back task also showed a significant main effect. Note that the 0-back task assesses children's central executive, i.e. the ability to allocate attention and to maintain verbal information for a short period of time (Miró-Padilla et al., 2020), which is closely relevant to the storage of temporary information essential for language production. For the 0-back task, significant interactions were also observed with age and clause type.

GLMMs were further used to analyze the roles of different WM components in RC production within each age group. The 4-year-olds exhibited significant effects of the nonword repetition and the 0-back tasks, suggesting their reliance on phonological memory and central executive. In contrast, the 0-back task had no significant effect on the 5-year-olds' production, indicating a reduced reliance on central executive when producing complex structures. The findings show that compared with younger children, older children process complex structures with less cognitive effort, which presumably reflects a shift towards a more efficient grammatical encoding. We discuss the findings in relation to the dynamic interaction between different WM components and children's grammatical knowledge.

Example trial. Note that the original story was presented in Mandarin. The story included two identical apples (seemingly similar in appearance) and the two apples can only be distinguished by using the property denoted by a relative clause, one is plucked from a tree and one was picked up from the ground.

Experimenter: *A villain came to the animal village and wanted to disturb the animals. The village guard, the little mouse, stood watch at the village entrance. Whenever he spotted the villain, he would quickly alert the other animals. One morning, the villain appeared all of a sudden! The little mouse did not have time to send a message to the others. Thinking quickly, he said, "There are plenty of apples here, I can use them as weapons to chase the villain away!" Without hesitation, the little mouse plucked an apple (from the tree) and threw it hard at the villain, but the villain dodged it with ease. Not giving up, the little mouse picked up another apple (from the ground) and threw it again—this time, it hit the target! The villain, struck by the apple, cried and promised, "I will never come back to disturb the village."*

(Prompt question) Puppet: *"I can't see what happened in the story. I only heard that the little mouse picked up an apple and plucked an apple . Can you tell me which one hit the villain?"*

(Target response) Participant: *"The apple that the little mouse picked up hit the villain."*

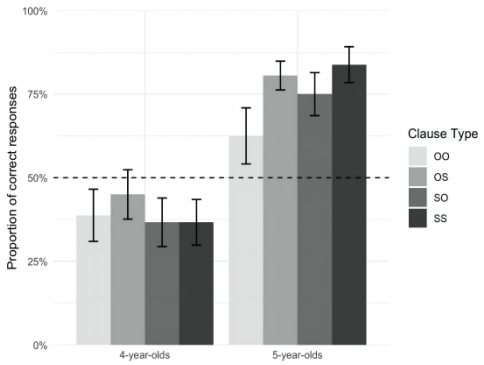

Figure 1. Mean proportions of target responses for the four types of RCs by age group. Error bars indicate SEs.

Table 1. Fixed effects from the best-fitting model.

Effect	Estimate	SE	Z value
(Intercept)	-0.08	0.23	-0.34*
ClauseType1 (SRC vs. ORC)	0.41	0.21	1.92*
AgeGroup2 (4-year-olds vs. 5-year-olds)	1.15	0.29	3.91***
Nonword	0.91	0.19	4.69***
NBack0	0.83	0.25	3.53***
NBack0:AgeGroup2	-0.96	0.36	-2.64**
NBack0:ClauseType1	0.53	0.29	1.82

Note: ClauseType1 refers to the SRCs. AgeGroup2 refers to the 5-year-olds. * $p < .05$, ** $p < .01$, *** $p < .0001$

Selected references

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