Following spoken instructions in school-aged children and young adults: Does giving more time or repeating instructions help?

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Author Note

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Conflict of interest

The authors have no competing interests to declare.

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Abstract

The ability to follow instructions is essential for learning and classroom participation and, more broadly, for academic success. Yet, following instructions is challenging, especially for children, as it relies on working memory. In the present study, we used insights from working memory research to design and test ways to improve short-term maintenance of instructions in young adults and school-aged children. Swiss-based participants memorized and executed sequences of spoken instructions under a baseline and three experimental conditions: additional free time, active verbal repetition, and passive repetition. In young adults, free time substantially improved performance. Passive repetition also improved performance, but not beyond the effect of free time. Active repetition, on the other hand, slightly impaired performance. In 9-year-olds, active repetition also impaired performance, but free time provided little benefit. These findings demonstrate that providing more free time during instruction delivery improves performance in young adults but is far less effective in children, suggesting important developmental differences in the short-term maintenance of instructions and the (strategic) use of free time.

The ability to follow instructions is widely regarded as essential for children's success in school (e.g., Gathercole et al., 2008). Kaplan and White (1980) showed that teachers frequently give instructions throughout lessons, making this ability a key requirement in the classroom. When children struggle to remember and execute teacher instructions, it can hinder their classroom participation and lead to missed learning opportunities, ultimately slowing their academic progress. It is therefore important to investigate whether certain conditions can enhance instruction-following performance. We addressed this question in the present study.

Cognitive demands of instruction-following

Following instructions requires memorizing a series of action-based steps and executing them in the specified order. For example, a teacher might say: "*take your book from the shelf, come sit on the carpet, and read pages 3 and 4*", requiring children to keep three instruction steps in memory once the auditory trace of the instructions has faded. Successfully following such instructions depends on working memory, the cognitive system that allows temporary maintenance and manipulation of information. Because working memory capacity is limited in adults and even more so in school-aged children (Cowan, 2016; Dempster, 1981; Gathercole et al., 2004), following multi-step instructions can be challenging. Consistent with the notion that working memory supports instruction-following, Engle et al. (1991) showed that this ability improves with age in school-aged children (see also Foellinger & Trabasso, 1977; Kaplan & White, 1980), and that variation in instruction-following was predicted by variation in children's working memory capacity, as measured with traditional span tasks (see also Gathercole et al., 2008; Jaroslawska et al., 2016).

Although the importance of following instructions is well established, and working memory is known to limit this ability, insights from working memory research have rarely been leveraged to optimize instruction-following. In this study, we drew on findings from working memory research (primarily in adults, but also in children where available) to identify promising ways to improve the short-term maintenance of instructions. We then tested these conditions in both young adults and school-aged children.

Improving instruction-following performance

Research suggests that physically executing instructions during encoding can improve memory performance (e.g., Allen & Waterman, 2015; Allen et al., 2020, in adults; Waterman et al., 2017, in children). Here, we explore alternative ways to support instruction-following: (1) providing more time between successive instruction steps (*free time*), (2) having participants orally repeat each instruction step before the next one is presented (*active repetition*), and (3) presenting each instruction step a second time before the next one is presented (*passive repetition*). Below, we outline the rationale and relevant findings for each approach.

Free time. Presenting memory lists more slowly or providing longer stretches of free time between list items improves recall performance in young adults for simple verbal stimuli such as letters and words (e.g., De Schrijver & Barrouillet, 2017; Dornbush, 1968; Fell & Laugherty, 1969; Rhodes et al., 2021). Although some studies suggested that this benefit is weaker or absent when information is presented auditorily (e.g., Dornbush, 1969), Oberauer (2022) recently showed that slower presentation improves recall in both visual and auditory modalities in young adults. This benefit is often attributed to spontaneous maintenance processes strengthening or reactivating memory traces when time allows (e.g., Baddeley, 1986; Barrouillet et al., 2004; Tan & Ward, 2008; but see Mizrak & Oberauer, 2021). Since several maintenance mechanisms appear to be functional from around age 7, or even earlier (e.g., gaze-based rehearsal in Morey et al., 2018; refreshing in Barrouillet et al., 2009; verbal rehearsal in Flavell et al., 1966, and Elliott et al., 2021), providing more time for these mechanisms to operate should improve working memory performance in school-aged children. Accordingly, Murray and Roberts (1968) found that slower presentation improved digit recall in 10-year-olds, but not in 7-year-olds, although no such benefit was found for auditorily presented materials. To test whether free time enhances instruction-following, we included a condition in which additional free time was provided between successive instruction steps.

Active repetition. We next considered whether actively repeating each instruction step, rather than simply providing more free time, could enhance instruction-following. Verbal rehearsal has been proposed as a maintenance mechanism that reactivates information via the speech system (e.g., Baddeley, 1986). Verbal recall suffers greatly when the speech system is occupied such that it is unavailable for verbal rehearsal, both in adults (e.g., Baddeley et al., 1984; Camos et al., 2009) and children (e.g., Hitch & Haliday, 1983; Hitch et al., 1989). Some studies show that instructing the use of verbal rehearsal improves verbal recall, both in adults (e.g., Tan & Ward, 2008; but see Souza & Oberauer, 2018) and children (e.g., Attout & Monnier, 2023). If verbal rehearsal benefits memory for simple verbal stimuli, such as letters and words, it may similarly support the maintenance of spoken instructions. To test this, we included a condition in which participants were given the same amount of additional time as in the free time condition but with the explicit instruction to repeat the just-heard instruction step aloud during that time.

Passive repetition. Finally, we considered whether additional exposure to the instructions could enhance instruction-following. Increased stimulus duration improves memory in traditional working memory tasks (e.g., Eng et al., 2005; Oberauer & Eichenberger, 2013), with longer exposure leading to better recall of verbal materials in both adults (e.g., Barrouillet et al., 2013; Tan & Ward, 2008) and children (Boswell et al., 1974, although using very short time scales). Longer exposure may facilitate deeper encoding (e.g., Barrouillet et al., 2013), resulting in more robust memory representations (e.g., Ricker and Cowan, 2014). To test whether increased exposure benefits memory for spoken instructions, we presented each instruction step a second time during the additional time from the free time condition, rather than simply slowing the speech rate. Unlike artificially slowed speech, passive repetition allows additional encoding while preserving a natural speech pattern.

METHOD

Participants and Design. We tested 40 young adults (32 women, 7 men, 1 "other"; mean age = 21.50 years, SD = 2.39, range = 18.16-27.60) and 41 5th-grade children (20 girls, 21 boys; mean age = 9.01 years; SD = .26, range = 8.59-9.53)[1] in Switzerland. Sample size was chosen to match previous relevant studies. Adults were undergraduate students at the University of Geneva, tested individually in the lab for partial course credit. Children were recruited from Geneva public schools (see Supplementary materials for more details). All participants provided informed consent. The study was approved by a University of Geneva ethics committee. Adults completed four conditions: Baseline, Free time, Active repetition, and Passive repetition. Children completed only three conditions, due to time constraints[2]: Baseline, Free time, and Active repetition. Because of a technical error, data for one child was not recorded, resulting in a final sample of 40 adults and 40 children.

Materials and Procedure. The task (Figure 1) was administered using E-prime 3 (Psychology Software Tools). Adults memorized sequences of six instructions, children sequences of four. On each trial, instructions were randomly drawn without replacement from a pool of 16 instructions, created following previous studies using stationary items (e.g.,

[1] Other demographic characteristics such as gender, socioeconomic status, race/ethnicity, disability status and sexual orientation cannot be reported because they were not collected, due to local regulations.
[2] A few children were tested including the same four conditions as in the adult experiments. These children took over an hour to complete the experiment, which is too long, both for practical reasons and for reasons related to fatigue of the children. Therefore, we opted to drop one of the four conditions. We dropped the Passive repetition condition as we deemed this condition to have less theoretical and empirical support than the other experimental conditions.

Jaroslawska et al., 2018). We selected eight actions (color, draw, trace, decorate, attach, stamp, punch, and cut), each action paired with two different objects that varied in color (e.g., brown vs. pink marker) or shape/size (e.g. small vs. large paper clip). This resulted in 16 unique instructions, see Supplementary materials. Within each sequence, half of the instructions were color-based and half were shape-based. Instructions were pre-recorded in French with a female voice, and presented auditorily via computer.

Adults completed four experimental conditions; children completed three. In both groups, trials for each experimental condition were presented in a single block, with block order counterbalanced across participants. Each block started with an explanation of the upcoming task. Next, four or five experimental trials were presented for children and adults, respectively.

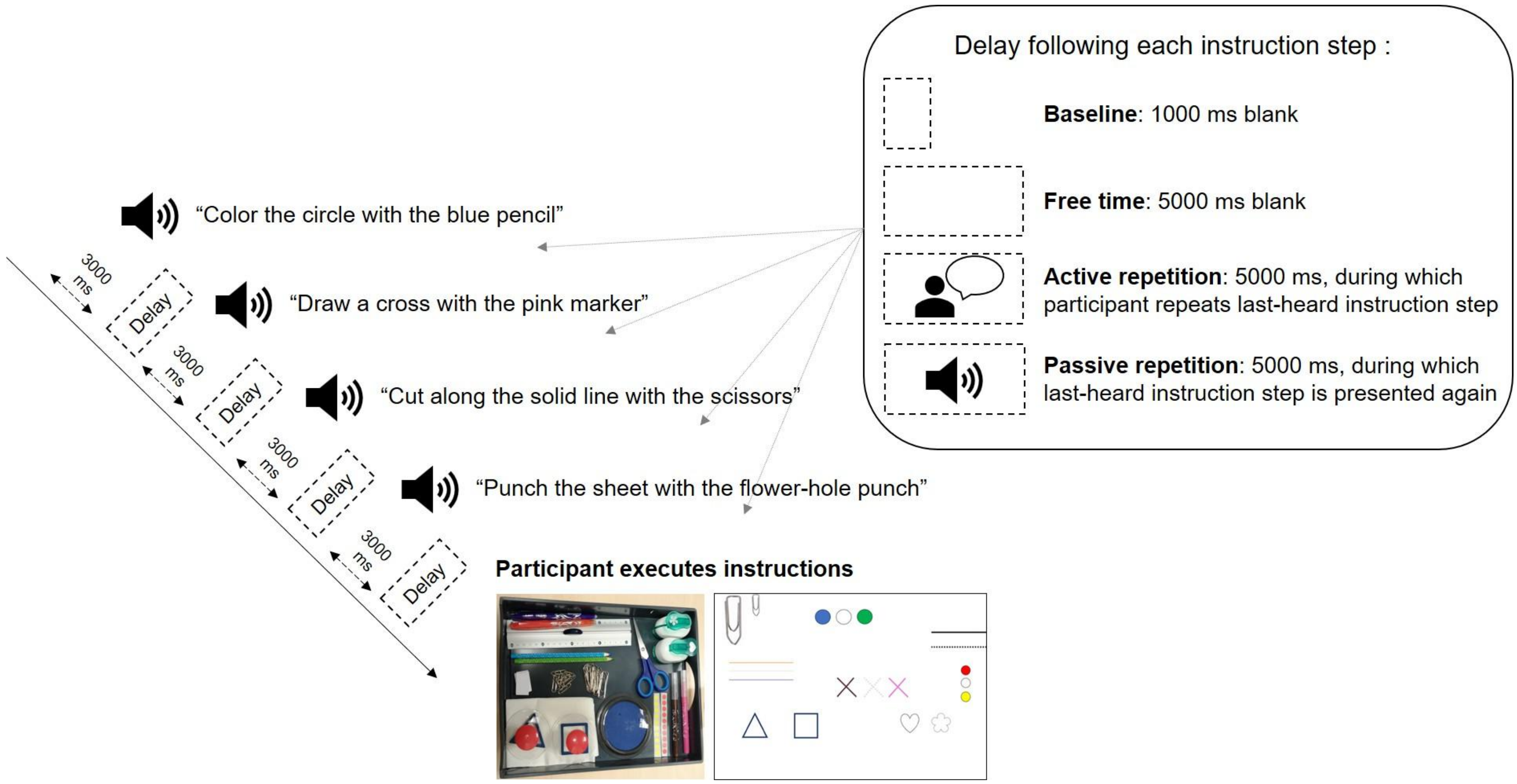
During each trial, the screen remained blank; information was delivered exclusively auditorily. Each trial began with 500 ms of silence, followed by the first instruction. Four or six instructions were presented sequentially, each within a 3000 ms time frame, with the instruction lasting 2850 ms. In the Baseline condition, each 3000 ms time frame containing an instruction was followed by a silence of 1000 ms before the next instruction was presented. In the experimental conditions, each instruction was still presented within a 3000 ms time frame but was followed by a longer, 5000 ms interval. In the Free time condition, this interval was silent. In the Active Repetition condition, participants used this interval to repeat the instruction aloud. In the Passive Repetition condition, the interval began again with 1000 ms of silence, followed by a second presentation of the same instruction (3000 ms time frame), and another 1000 ms silence.

At the end of each trial, the participant executed the instructions in correct order, prompted by a “beep”. They used a fixed set of objects, arranged identically on a tray across trials and participants (see Figure 1 and Supplementary materials). To prevent visual encoding of the materials, the tray was covered with a cardboard during instruction presentation. After the final instruction and the beep, the lid was removed, and participants were given a response sheet (see Figure 1 and Supplementary materials). The same materials and response sheet were used for all trials and participants. The experimenter wrote down each action performed by the participant, including the object used and the order of execution. Once all actions had been completed, the experimenter pressed the space bar to display a motivational image (e.g., balloons, confetti) to maintain engagement. The experimenter then covered the tray, and the next trial or block began.

Transparency and Openness. The study was not preregistered. All decisions regarding design and analysis are transparently reported, along with all data exclusions, all manipulations, and all measures that were recorded. All data, analysis code, and computer-based research materials are available on OSF (https://osf.io/wzvcx/). The data were analyzed in R (R core team, 2022; version 4.1.3), using the BayesFactor package with default settings (Morey & Rouder, 2022; version 0.9.12-4.4). The data were analyzed by the first author (EV), and were independently reproduced by the co-author (NL). ChatGPT 4 was used for editing purposes when drafting and revising the current manuscript (OpenAI, 2025), see Supplementary materials for the required details.

Figure 1

Illustration of a trial.



RESULTS

We first analyzed adults and children separately, examining performance across all conditions within each group, and then analyzed both groups together on the three common conditions to assess developmental differences in the predicted benefits of free time and active repetition. In both groups, performance was measured as mean proportion of correct responses. A response was scored as correct if the recalled action and object in a given position matched the pairing presented during encoding. Mean accuracy was calculated across serial positions for each trial and then aggregated across trials.

Adults. The adult data were analyzed using a Bayesian analysis of variance (BANOVA) with Condition (4 levels: Baseline, Free time, Active repetition, and Passive repetition) as within-subjects variable. The model including the main effect of Condition was found to be much better than the null model, $BF_{10} = 5.88 \times 10^9$.

To test the predicted benefit of free time, we ran a one-sided t-test, testing whether performance was better in the Free time than in the Baseline condition. This provided strong evidence that additional free time after each instruction step improved performance (BF_{10} = 9715).

To test the benefit of active repetition, we ran two one-sided t-tests: one comparing performance to the Baseline condition, and one to the Free time condition. Both provided strong evidence against the predicted benefit (BF_{01} = 16.69 and BF_{01} = 12.05, respectively). As shown in Figure 2, active repetition may even have slightly impaired performance.

Finally, to test the benefit of passive repetition, we ran again two one-sided t-tests: one comparing performance to the Baseline condition, and one to the Free time condition. There was strong evidence for a benefit relative to the Baseline condition (BF_{10} = 32.81), but strong evidence *against* a benefit relative to the Free time condition (BF_{01} = 15.22). This suggests that hearing each instruction step twice offered no added benefit beyond the extra time it introduces between successive instruction steps.

Children. The child data were analyzed using a BANOVA with Condition (3 levels: Baseline, Free time, and Active repetition) as within-subjects variable. The best model included the main effect of Condition but was preferred over the null model by only a factor of 1.19, indicating that the children's data were about equally likely under the null model. To directly assess the evidence regarding the predicted benefits of free time and of active repetition in children, we used the same one-sided t-tests as in the adults.

There was no evidence that simply providing additional free time improved performance in children. Instead, there was weak evidence against the predicted benefit ($BF_{01} = 2.10$).

Finally, there was strong evidence against performance in the Active repetition condition being better than in either the Baseline ($BF_{01} = 14.63$) or the Free time condition ($BF_{01} = 17.65$).

Developmental differences. To formally assess the evidence in the data for developmental differences, we conducted two BANOVAs on the combined dataset.

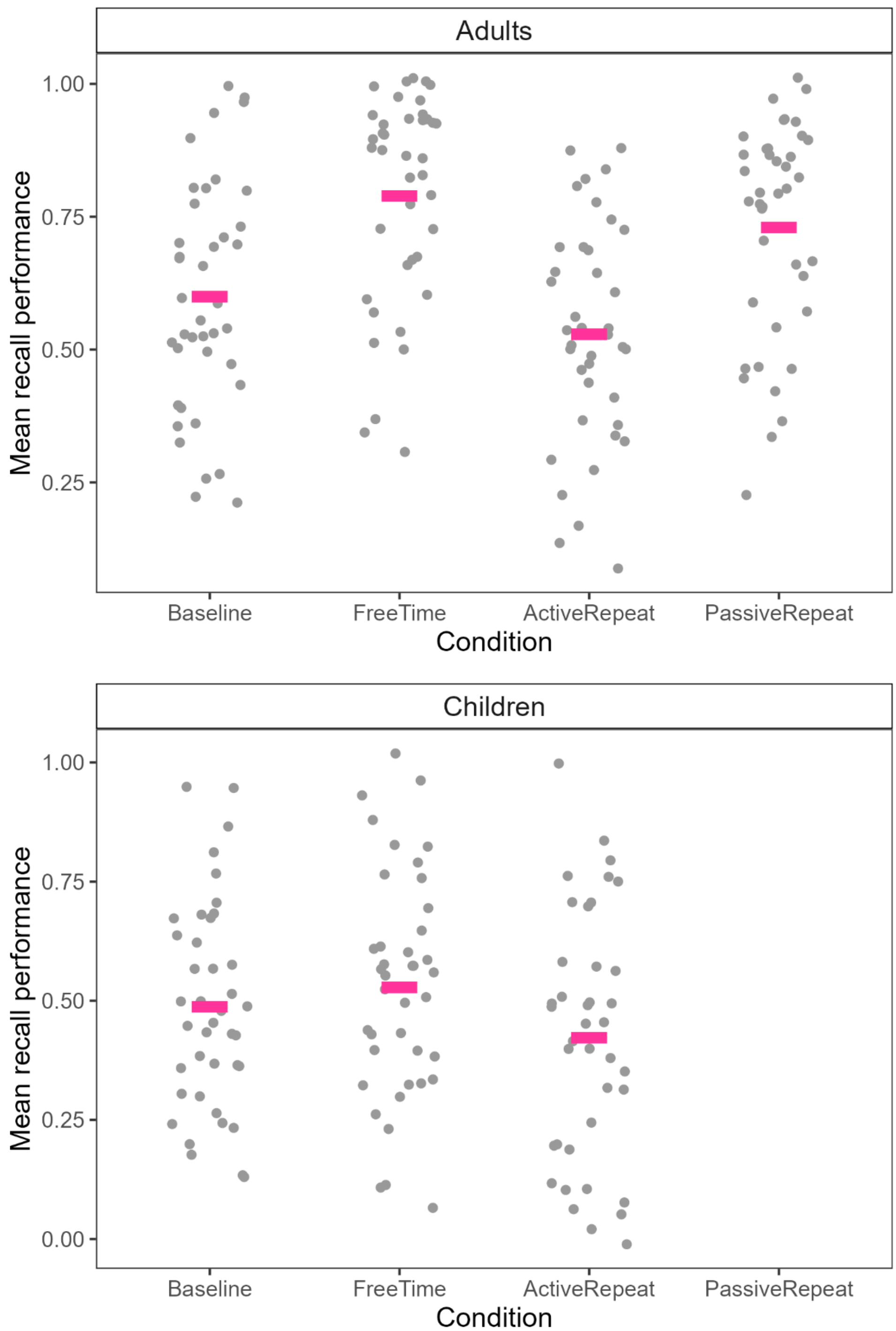
For the benefit of free time, we ran a BANOVA with Condition (Baseline vs. Free time) as within-subjects variable and Age group (children vs. adults) as between-subjects variable. The best model was the full model including both main effects and their interaction. This model was almost 7 times better than the model with the two main effects only, confirming that the effect of free time differed between children and young adults.

For the benefit of active repetition, we ran a BANOVA with Condition (Baseline vs. Active repetition) as within-subjects variable and Age group (children vs. adults) as between-subjects variable. The best model included only the two main effects and was about 4 times better than the full model including the interaction. Relative to baseline, performance was slightly poorer under active repetition in both groups.

Additional analyses, excluding participants with low recall performance and using a more lenient scoring method, confirmed these patterns (see Supplementary materials).

Figure 2

Mean recall performance as a function of Condition and Age group. Grey points show individual data, pink lines the means per condition.



DISCUSSION

The present study drew on working memory research to identify conditions that might enhance short-term maintenance of instructions and, in turn, improve instruction-following performance in both young adults and children.

Young adults following instructions

In young adults, we found that providing additional free time between instruction steps substantially improved performance. Presenting the just-heard instruction step a second time during this additional time did not offer any further benefit beyond that of free time alone. Requiring participants to repeat the instruction aloud during the additional time not only eliminated the benefit of free time but slightly impaired performance relative to baseline. Thus, simply providing extra free time was the most effective way to support instruction-following in young adults.

The beneficial effect of free time on instruction-following in young adults is consistent with previous findings that working memory performance for simple materials, such as digits, letters, or words, improves when memory lists are presented more slowly, even with auditory presentation (e.g., Oberauer, 2022). Our findings extend this to more real-life memory materials, showing that more free time also benefits memory for spoken sentences describing novel, to-be-executed action-object pairings.

There is an ongoing debate about why extra free time is beneficial in young adults (e.g., Mizrak & Oberauer, 2021). Proposed explanations include maintenance mechanisms such as verbal rehearsal (e.g., Camos et al., 2009), refreshing (e.g., Barrouillet et al., 2004), or elaboration (e.g., Leproult et al., 2024). Other proposed mechanisms are consolidation (e.g., Ricker & Hardman, 2017), response reconfiguration (Joseph & Morey, 2022), and replenishment of encoding resources (Popov & Reder, 2020). While our data do not clearly favor one of these competing accounts, and distinguishing between them was beyond the scope of the study, some aspects of our findings suggest that neither maintenance mechanisms alone nor resource replenishment alone can fully explain the observed benefit of free time, see Supplementary materials.

Presenting instruction steps a second time during the additional time did not produce an additional benefit in young adults, suggesting that the benefit of passive repetition is likely driven by the additional time it provides between instruction steps. Practically, simply providing more free time seems a more efficient and equally effective way to support instruction-following in young adults.

In contrast, requiring adults to actively repeat the instruction during the free time did not improve performance and may have interfered with the processes producing the free time benefit, perhaps due to the additional cognitive load induced by the explicit requirement to repeat the just-heard instruction step, relative to baseline (see Bartsch et al., 2018; Souza & Oberauer, 2018; Vergauwe, 2018, for similar findings).

In sum, for young adults, simply providing additional free time between instruction steps was the most effective way to enhance instruction-following, increasing overall performance by about 20 percentage points (from .60 to .79).

Instruction-following in school-aged children and Developmental differences

In children, however, none of the tested conditions produced a sizeable benefit. Although providing additional free time between instruction steps descriptively appeared to slightly improve performance, there was no evidence in the data supporting this effect, and the increase was likely too small to consider the condition effective (only about 4 percentage points; from .49 to .53). Furthermore, as in adults, asking children to repeat the just-heard instruction during the free time was detrimental rather than helpful, likely for the same reason (see also Waterman et al., 2017, for similar findings that additional requirements during encoding can impair memory for instructions in school-aged children).

A possible explanation for the lack of a sizeable free time benefit in children is that maintaining four instruction steps was too demanding, leading them to adopt a more passive stance and not use the additional free time to their benefit. While it would be useful to test whether shorter lists or simpler instruction steps change this pattern, the serial position curves show that children's baseline performance was comparable to adults' baseline performance on the last four serial positions, yet adults showed a much larger free time benefit at these positions (see Supplementary Figure 5). This suggests that performance level alone does not explain the developmental difference.

The lack of a sizeable benefit of free time in children contrasts with our findings in young adults but aligns with an early study of Murray and Roberts (1968), who found no benefit of slower presentation rates in school-aged children with auditory presentation. Why do 9-year-olds, unlike young adults, fail to benefit substantially from additional free time? If free time effects in adults rely on strategic mechanisms such as rehearsal, refreshing, elaboration, consolidation, or response reconfiguration, then children should show clear free time benefits when (1) they are old enough to take a more proactive, strategic approach in working memory, and (2) the relevant mechanisms are fully operational. Research shows that proactive behavior in working memory emerges around age 7 (e.g., Chevalier et al., 2014), and mechanisms like rehearsal and refreshing are thought to be functional by this age as well (e.g., Barrouillet et al., 2009; Flavell et al., 1966). Yet, the 9-year-olds showed a much smaller free time benefit than adults. This suggests that while the mechanisms may be operational, they may not yet be used spontaneously, effectively, or strategically. This is consistent with evidence that adults, but not children, shift attention away from the last-presented item during free time, presumably to strengthen the other items in working memory (e.g., Valentini & Vergauwe, 2022, 2025; Vergauwe & Langerock, 2017; Vergauwe et al., 2021). It is harder to explain the sharp developmental difference in the free time benefit under the resource replenishment account, as this seems to be a more automatic, inherent process that should operate at all ages.

Our findings may also reflect developmental differences in metacognitive awareness. For example, Forsberg et al. (2021) showed that children's awareness of their working memory content develops with age, with younger children tending to overestimate their capacity. If our child participants overestimated their capacity, they may have been less likely to use strategies to support their memory. Future studies could test whether explicitly telling children to use the free time to better remember the instructions makes its benefit more comparable to that seen in adults. However, our results in the Active repetition condition show that one should be cautious, as such guidance could induce a cognitive cost.

Another mechanism that may explain the difference between adults and children, especially in the context of following instructions, is response reconfiguration, the mechanism whereby working memory representations are transformed into a response plan (Joseph & Morey, 2022). Young adults may have used this mechanism, whereas children did not, possibly because the objects were hidden during encoding. Without visible objects, response reconfiguration depends entirely on mental representations, which may have been too demanding for children, leading them to use this mechanism ineffectively or not at all. Future studies could test this by making the objects visible during encoding to examine if the free time benefit becomes more pronounced in children. In that case, it would be important, in classrooms, to ensure that materials are visible while instructions are given, which is often not the case when materials are in the child's backpack, in a cupboard, or in a closed book.

To conclude, we identified an effective way to improve instruction-following in young adults: simply providing more free time between instruction steps. This approach proved far less effective in 9-year-olds, indicating important developmental differences in short-term maintenance of instructions and the (strategic) use of free time.

Data availability statement

All data, analysis code, and computer-based research materials are available on OSF (https://osf.io/wzvcx/). DOI 10.17605/OSF.IO/WZVCX

Author Contributions Statement (CRediT)

Evie Vergauwe: Conceptualization; Data curation; Formal analysis; Funding acquisition; Supervision; Resources; Validation; Visualization; Writing – Original draft; Writing – Review & Editing

Naomi Langerock: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Software; Supervision; Validation; Writing – Review & Editing

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