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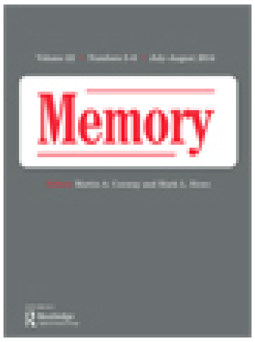

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When motion improves working memory

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ABSTRACT

In the present study, we used a complex span task to explore how memory traces resulting from Self-Performed Task (SPT) and Verbal Task (VT) are maintained in working memory. Participants memorised series of five sentences describing an action either through SPT or VT. Between pairs of sentences, participants performed a concurrent task that varied according to its nature and its cognitive load. The concurrent task was either a verbal task, a low cognitive load motor task or a high cognitive load motor task. A control condition served as a baseline. First, we observed that performance in SPT and VT did not decrease with verbal or motor suppression, but was lower with an increase of the cognitive load. This suggests that memory traces are maintained through attentional refreshing whatever the encoding (SPT or VT). Second, while the enactment effect was replicated in the control condition, it tended to vanish with a verbal concurrent task; moreover, it was reversed with motor concurrent tasks. Surprisingly, the latter effect resulted from an increase of VT memory performance when participants repeated the same gesture between sentences. Finally, our results provide additional evidence that the enactment effect does not rely on attention.

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KEYWORDS
Working memory; motor action; enactment

Introduction

Recently, there has been growing interest in the role of motor aspects of WM. According to Vandierendonck (2016), working memory (WM) must be situated in the context of goal-directed behaviour. WM would enable an agent to maintain and protect goals and to select actions to attain these goals. On this view, WM facilitates meeting daily life requirements which involve maintaining information for future motor actions. Using the Following Instruction paradigm, researchers observed that recall of instructions such as "push the red box" or "pick up a black pencil" is improved when participants enacted these instructions in addition to processing them verbally (Allen & Waterman, 2015; Jaroslawska, Gathercole, Allen, & Holmes, 2016; Waterman et al., 2017; Yang, Gathercole, & Allen, 2014). These findings echo the enactment effect investigated decades ago in long-term memory. This effect shows that memory increases if participants performed the action described in the sentences to be learned such as "peel a banana" or "open the book" (Self-Performed-Task, SPT) instead of merely reading the sentences (Verbal Task, VT) (Zimmer et al., 2001 for a review). In the Following Instruction paradigm, instructions-guided behaviour seem to be supported by WM. Concurrent tasks to tax resources, either of the central executive, the phonological loop, or the visuospatial sketchpad, impacted memory performance of these instructions (Yang et al., 2014; Yang, Allen, & Gathercole, 2016)[1].

One way to better understand the enactment effect is to examine whether memory traces resulting from SPT and VT are maintained in WM using different mechanisms. The Time-Based Resources Sharing (TBRS) model has underlined the central role of attention in WM (Barrouillet & Camos, 2015). Results have been collected in favour of a mechanism of maintenance in WM independent from verbal rehearsal: attentional refreshing based on retrieval and reactivation of memory traces through the focus of attention (Camos et al., 2018; Camos, Lagner, & Barrouillet, 2009). It has been argued that while verbal rehearsal relies on the recirculation a just-perceived auditory signal using a phonological format, attentional refreshing is viewed as the reconstruction of mental representations, which not only integrates percepts but also knowledge stored in long-term memory (Barrouillet & Camos, 2015). One possibility would be that VT is maintained through verbal rehearsal and SPT through attentional refreshing.

Complex span tasks have been extensively used to investigate maintenance mechanisms in WM, especially within the TBRS model (Barrouillet & Camos, 2015). In this model, the two functions of WM, processing and storage, share a unique resource that is attention. In complex span tasks where to-be-remembered items alternate with to-be-processed distractors, when attention is required by the processing task it is not available for maintenance of memory traces. To prevent forgetting, memory traces

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have to be reactivated by attentional refreshing when attention is available. This model relies in part on a very robust empirical phenomenon: the cognitive load effect. It was consistently observed that in complex span tasks, WM performance is a function of the ratio between the time during which processing occupies attention and the total time allowed to perform the intervening task. This proportion is referred to as the *cognitive load* (e.g., Barrouillet, Portrat, & Camos, 2011; Plancher & Barrouillet, 2013). The higher the cognitive load, the lower the recall performance. Because increasing the cognitive load of the concurrent task impedes the attentional refreshing necessary to counteract time-related forgetting, observing a cognitive load effect is viewed as strong evidence in favour of active maintenance in WM through attentional refreshing.

In the present study, three complex span tasks were devised to explore the maintenance mechanisms of memory traces encoded through SPT and VT. They differed according to the nature and the cognitive load of the concurrent task. We expected that if maintenance of memory traces resulting from VT relies on verbal rehearsal, memory performance should decrease with a verbal concurrent task (saying "two" aloud). Recently, Jaroslawska, Gathercole and Holmes (2018) observed that motor suppression reduced the benefit of action on WM. This suggests that memory traces of actions are maintained via motoric representations. We expected that if maintenance of memory traces resulting from SPT relies on motor maintenance, memory performance should decrease with motor suppression (gesturing "two" with both hands). Finally, if the SPT benefit relies on attentional refreshing, an increase of the cognitive load of the concurrent task should give lower performance. The cognitive load was manipulated by comparing a condition where participants gestured different digits with a condition where they gestured the same digit. The cognitive load was greater with unpredictable different digits because participants needed to activate different representations from long-term memory (see Barrouillet, Plancher, Guida, & Camos, 2013; Fanuel, Portrat, Tillmann, & Plancher, 2018 for similar methods).

Experiment 1

Participants

Eighty undergraduate students (59 females, $M_{age} = 21.5$) from the University of Lyon 2 were recruited. All participants gave their informed consent before beginning the study. Each of them was tested individually and was randomly assigned to one of the four conditions (20 participants per condition).

Design

Two independent variables were manipulated: (1) the type of encoding: Verbal Task (VT) vs. Self-Performed Task (SPT) as a within-subjects variable; and (2) the type of concurrent task: no concurrent task, low cognitive load motor task, high cognitive load motor task and verbal task as a between-subjects variable.

Material

Actions storage

Participants were required to memorise action sentences. The sentences were active voice sentences containing three words, like *peel a banana* and *drink a coffee*. A trial was composed of five sentences. Each participant performed 12 trials, six trials in a row in VT and six trials in a row in SPT. Two different lists were constructed, each composed of 30 action sentences in order to have each sentence combined with each type of encoding (VT/SPT), given 60 sentences in total. The type of encoding was blocked and their order was counterbalanced between participants.

Processing

Between each pair of sentences, the participants performed a computer-paced concurrent task. The low cognitive load motor task required participants to draw in the air with their hands the digit "two" presented on the screen, three times. In the high cognitive load motor task, participants had to draw in the air with their hands three different digits randomly presented on the screen (1–9). No repetition of the same digit could occur between two sentences. The verbal task required participants to read the digit "two" presented on screen, six times.

To ensure that the differences between the low cognitive load motor task and verbal task conditions arise from the nature of the task and not from its cognitive load, we matched the cognitive load in both conditions. The Cognitive Load (CL) can be computed using the formula given by the TBRS model (Barrouillet & Camos, 2015): $CL = t_a/T$ where t_a is the time during which attention is occupied and T is the total time allowed to perform the task. The processing time for reading the digit "two" was estimated around 300 ms (t_a), whereas the processing time for drawing the digit "two" around 600 ms (t_a). In order to respect a relatively low CL of 0.3 in both conditions, we presented three and six digits in the same action condition and verbal repetition conditions respectively for a total time of 6,000 ms.

Procedure

A trial began with an asterisk centrally displayed for 500 ms, followed by a 100 ms delay and then a series of five sentences successively displayed on the screen at a rate of 4,000 ms per sentence (see Figure 1). In SPT, participants had to perform the action and to memorise it simultaneously; whereas they were asked to silently read the action sentences and to memorise them in VT (cf. Engelkamp & Seiler, 2003; Zimmer, Helstrup, & Engelkamp, 2000 for similar methods). Once

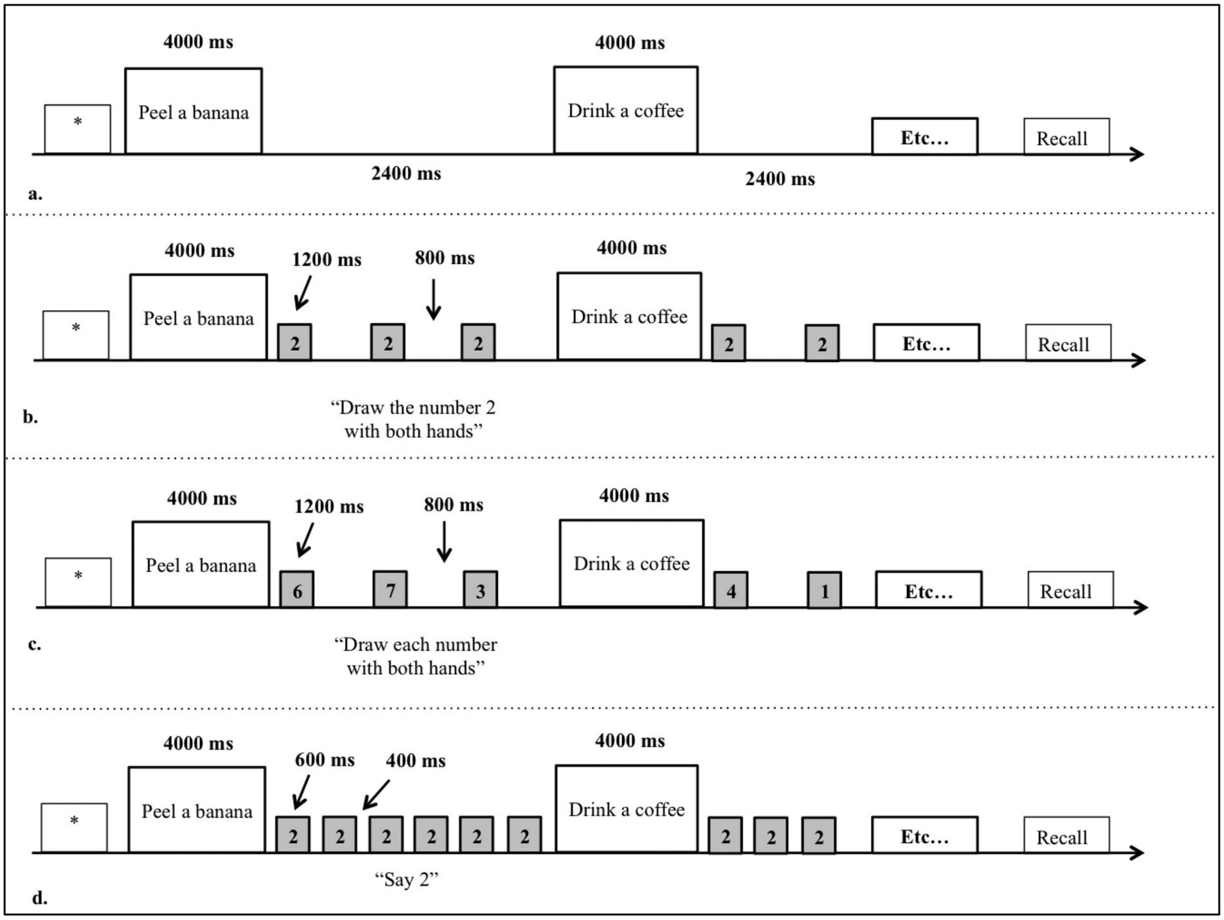

Figure 1. Illustration of the design of Experiment 1. Participants were presented with sentences to-be-remembered through a verbal task (VT) or a self-performed task (SPT). Depending on the condition, each sentence was followed or not by a series of digits to-be-processed.

the last sentence presented, participants performed a verbal immediate serial recall. In the *no-concurrent task condition,* an empty delay of 2,400 ms separated each sentence. Between two sentences, in the *low CL motor condition*, participants had to draw with both hands the digit "two" in the air every time it appeared on the screen (three times). Each digit was presented during 1,200 ms and was followed by a blank of 800 ms. In the *high CL motor condition*, participants performed the same task except that they had to draw three different numbers in the air. In the *verbal condition*, participants read aloud the digit "two" every time it appeared on screen (six times). Each digit was presented during 600 ms followed by a 400 ms delay. In the control condition, we chose an interval of 2,400 ms between pairs of sentences because a greater interval might decrease the arousal of the participants and led to poorer performance. Also, contrary to the control condition, the three experimental conditions required task switching, which is known to place additional demands on WM in complex span tasks (Liefooghe, Barrouillet, Vandierendonck, & Camos, 2008); as such, the cognitive load should be greater in the experimental conditions compared to the control condition.

Before the experimental trials, participants were invited to perform two practice trials, one in each encoding condition (VT and SPT). For the participants who performed the motor actions, they were first trained to draw digits in the air (the digit "two" or digits 1 to 9 respectively). Recall performance was scored by calculating the mean number of sentences that were recalled in the correct position in each condition. Both the action and object have to be correct to score a point.

Results and discussion

An ANOVA with the type of encoding as a within-subjects factor and the type of concurrent task as a between-subjects factor was performed. While no effect of type of encoding ($F < 1$), and concurrent task ($F(3, 76) = 1.58$; n.s.) reached significance, the two-way interaction was significant, $F(3, 76) = 5.90$, $p < .01$; $\eta_p^2 = .19$. Planned comparisons revealed an enactment effect in the *no-concurrent task condition,* better performance was observed for the SPT ($M =$ 3.71; SD = 0.43) than the VT ($M = 3.34$; SD = 0.41) condition, $p < .01$; Cohen's $d = 0.88$ (see Figure 2). The enactment effect was yet reversed in the *low CL motor condition* with better performance in VT ($M = 3.87$; SD = 0.88) than in SPT ($M = 3.55$; SD = 0.70), $p < .05$, Cohen's $d = 0.40$. The SPT traces were not significantly affected by the concurrent motor task ($p = .52$), while a benefit in favour of the motor condition appeared ($M = 3.87$; SD = 0.88; control condition $M = 3.34$; SD = 0.41) for the VT traces, $p < .05$. In addition, the enactment effect was also reversed in the *high CL motor condition* with better performance in VT ($M = 3.34$; SD = 1.07) than in SPT ($M = 3.02$; SD = 0.78), $p < .05$. The SPT and the VT conditions showed lower performance when different motor actions were performed compare to when the same motor action was made ($p < .05$ and $p = .07$ for SPT and VT respectively) and compare to when no motor action was produced, but only for SPT ($p < .01$). Finally, the enactment effect was not significant in the *verbal* condition ($p = .67$); each trace did not significantly differ from the control condition (for SPT: $p = .23$, for VT: $p = .95$).

To have a different view of how the enactment effect is influenced by each condition, we performed an additional ANOVA on the enactment effect (computed with the difference between SPT and VT) with the concurrent task as a between subject factor. In accordance with the interaction observed in the previous ANOVA, we observed a significant effect of the concurrent task, $F(3, 76) = 5.90$; $p < .01$, on the enactment effect. Post-hoc comparisons using Newman–Keuls procedure indicated that significant differences appeared between the *no-concurrent task condition* ($M = 0.37$; SD = 0.42) and the *low CL motor condition* ($M = -0.32$; SD = 0.58), $p < .01$, and between the *no-concurrent task condition* and the *high CL motor condition* ($M = -0.33$; SD = 0.66), $p < .01$, see Figure 3. No difference was observed between the *no-concurrent task condition* and the *verbal condition* ($p = .11$).

Experiment 1 revealed different findings. First, we replicated the enactment effect in WM with higher memory performance when the sentences were encoded by enactment rather than by reading. Second, performance after a verbal concurrent task did not significantly differ from the control condition, suggesting no involvement of verbal rehearsal in VT (at least during periods of maintenance of memory traces, because rehearse may also occur during encoding). Third, surprisingly performing the same action after reading a sentence describing an action (VT) improved memory performance, and showed no influence when the sentences were enacted (SPT). Fourth, performing different actions, which increases the cognitive load, significantly decreased the performance of SPT compared to performing the same action (for VT only a tendency was observed), suggesting that SPT traces are maintained through attentional refreshing. These results remained to be validated using within-subjects designs. Next, we tried to replicate: (1) the decrease of SPT (and marginally VT) with an increase of the cognitive load (Experiment 2a), and (2) the improvement of memory performance in VT when participants produced a concurrent motor task (Experiment 2b).

Experiment 2a

Participant and design

Thirty-two participants (26 females, $M_{age} = 20.8$) from the University of Lyon 2 were included in the experiment. All participants gave their informed consent. None of them took part in Experiment 1. Two independent variables were manipulated as within-subjects variables: (1) the type of encoding: Verbal Task (VT) vs. Self-Performed Task (SPT) and (2) The type of concurrent task: *low CL motor condition* vs. *high CL motor condition*.

Material and procedure

Material and procedure were similar to the conditions *low CL motor condition* and *high CL motor condition* used in Experiment 1. The participants performed 24 trials, 12 trials performing with the *low CL motor condition* (six trials in VT and six trials in SPT) and 12 trials performing with the *high CL motor condition* (six trials in VT and six trials in SPT).

Results

An ANOVA with the type of encoding and the type of concurrent task as within-subjects factors was conducted. We replicated the findings of Experiment 1, the type of encoding was significant, $F(1, 31) = 5.06$, $p < .05$; $\eta_p^2 = .14$, confirming better performance for the VT sentences ($M = 3.45$; SD = 0.74) than the SPT sentences ($M = 3.20$; SD = 0.82) when participants performed a motor concurrent task. We also observed a significant effect of the type of concurrent task, $F(1, 31) = 8.59$; $p < .05$; $\eta_p^2 = .22$, with lower performance in the different actions condition ($M = 3.19$; SD = 0.77) compared to the same action condition ($M = 3.45$; SD = 0.79), but no interaction between the two factors, $F < 1$ ($M = 3.59$; SD = 0.74 for *VT same action* condition; $M = 3.32$; SD = 0.82 for *SPT same action* condition; $M = 3.31$; SD = 0.77 for *VT different actions* condition; $M = 3.08$; SD = 0.69 for *SPT different actions* condition).

Experiment 2b

Participants and design

The experiment was conducted on 24 students of the University Lyon 2 (14 female, $M_{age} = 19.70$). All participants gave their informed consent. None of them took part in previous experiments. The type of concurrent task was manipulated as within-subjects variable.

Material and procedure

They were similar to the conditions *low CL motor condition* and *no concurrent task* used in Experiment 1. The encoding was made only through VT. The participants performed 24

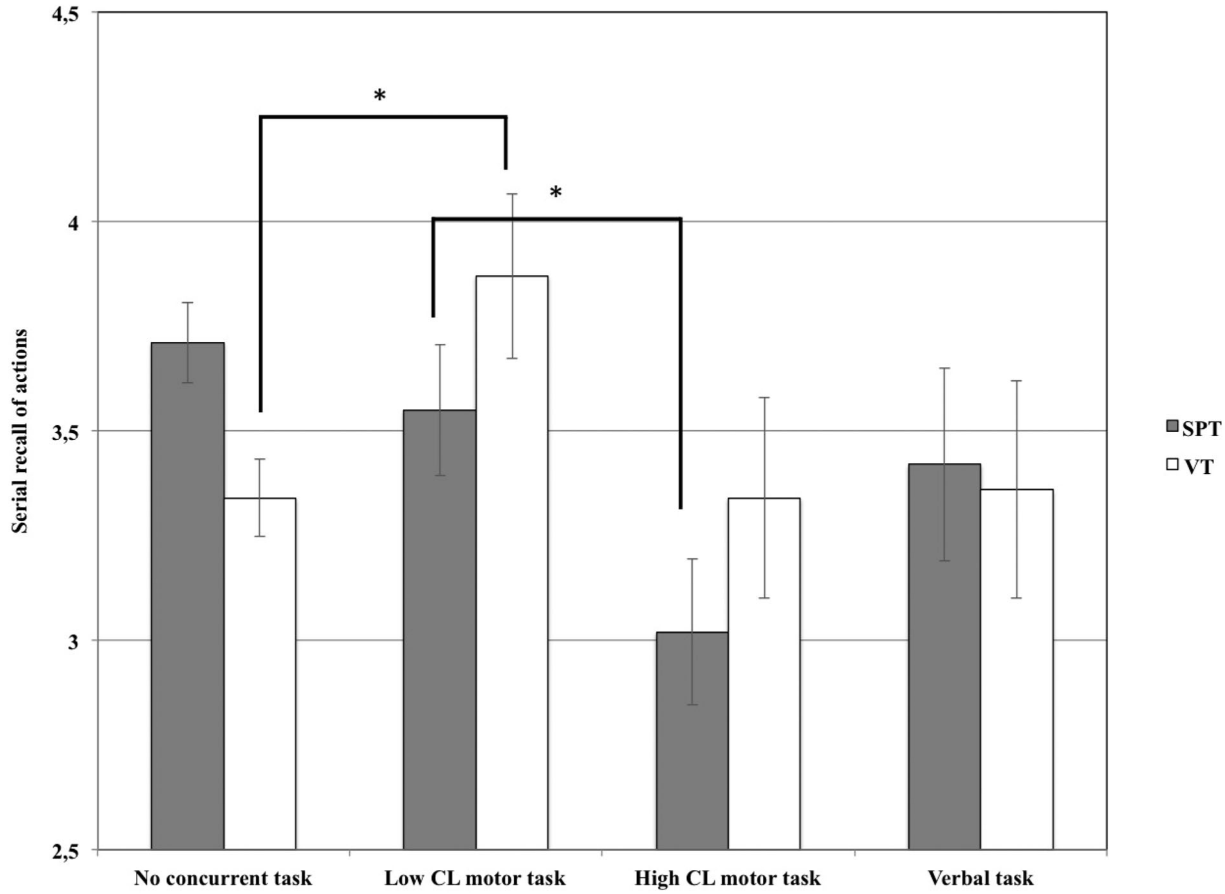

Figure 2. Mean recall performance (with standard errors) as a function of the type of encoding and the concurrent task in Experiment 1. SPT: Self-Performed Task; VT: Verbal Task.

trials, 12 trials with no concurrent task and 12 trials with the concurrent motor task.

Results

An ANOVA with the type of concurrent task as within-subjects factor was performed. The effect of the type of concurrent task was replicated, $F(1, 24) = 4.74$, $p < .05$; $\eta_p{}^2 = .17$, signing better performance for the concurrent motor task ($M = 3.34$; SD = 0.74) compared to the baseline condition ($M = 3.09$; SD = 0.75).

General discussion

In our study, we examined how the memory traces resulting from SPT and VT are maintained in WM. Several results were observed. First, based on the results of Experiment 1 and 2a, it appears that neither SPT nor VT are maintained through motor or verbal representations since motor and verbal suppression did not decrease the memory performance. This is surprising because, using the Following Instruction paradigm, Yang et al. (2014) observed a negative impact of articulatory suppression on memory traces to be verbally recalled (or enacted). Also, Jaroslawska and colleagues (2018) measured a detrimental effect of motor suppression also on both kinds of memory traces. However, first in Yang et al.'s study, participants were required to articulate from the very beginning of the trial (including during encoding) and thus verbal representations were afforded little opportunity to survive. In our study, participants articulated only in between the memoranda and were not required to read the sentences out loud. In the future, it would be important to test the impact of continuous articulatory suppression on VT. In addition, in Jaroslawska et al. (2018)'s study where enactment operated at recall, participants needed to maintain motor representations because an action has to be planned. In our case, the recall was verbal and it appeared less important for participants to use motor representations.

Second, we observed that an increase in cognitive load resulted in lower WM performance of SPT and VT. This result suggests that memory traces created through enactment or verbal repetition are maintained through attentional refreshing. This mechanism is presented as a domain-general reliance on attention to keep multimodal representations active (Camos et al., 2018). The present findings suggest that representations of actions can also benefit from attentional refreshing and confirm the domain-general nature of refreshing.

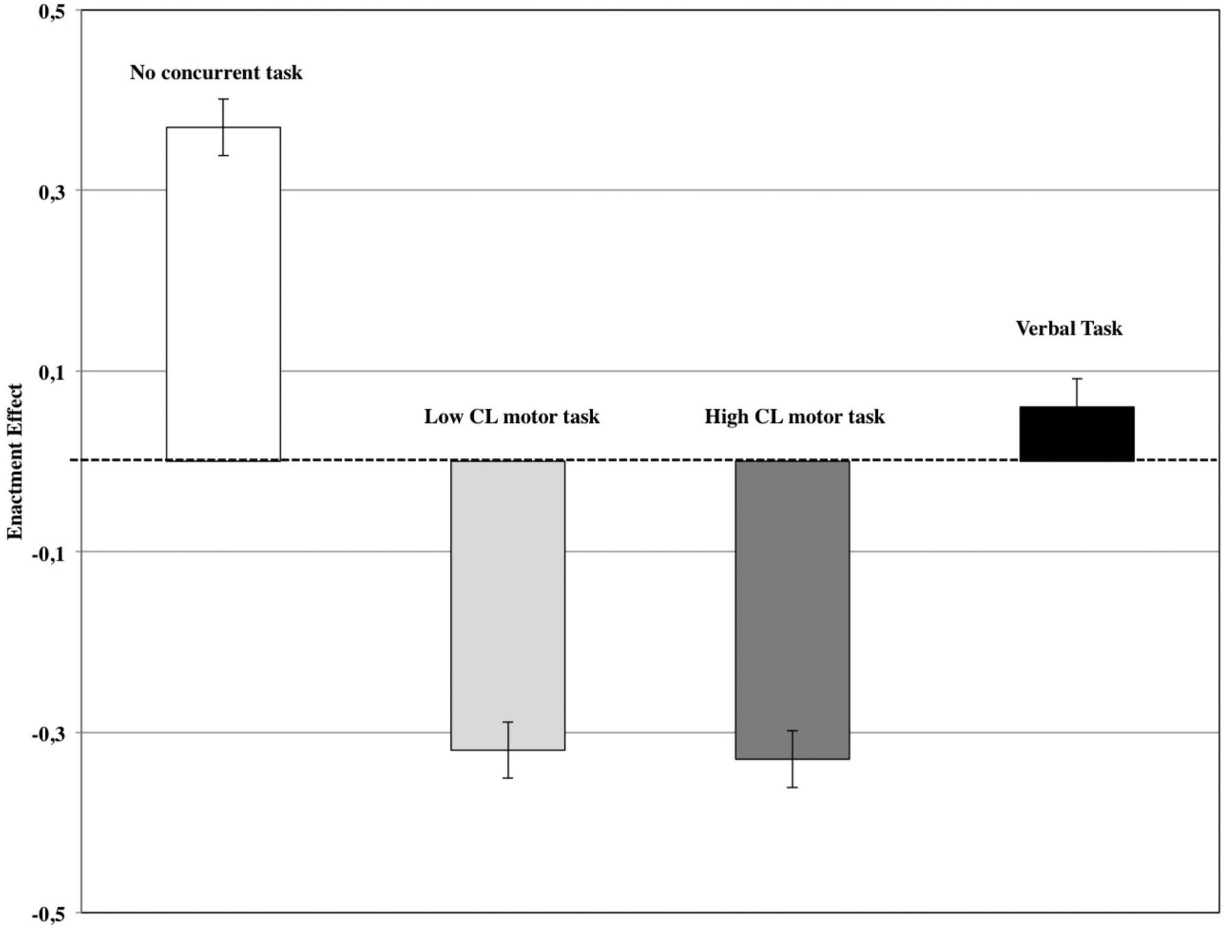

Figure 3. The enactment effect according to the concurrent task (mean and standard errors) in Experiment 1.

Third, we observed a surprising result: in VT, repeating the same motor action between to-be-remembered sentences increased memory performance. We replicated this effect in a third experiment. Although there is no obvious explanation for this improvement, one possible reason may involve the rhythmic nature of the task. One might imagine a beneficial role for temporal regularities on cognitive processes, in the spirit of dynamic attending theory. This theory assumes that motor activity helps to synchronise temporal fluctuations of attention with the timing of events facilitating the processing (Large & Jones, 1999). According to this theory, attention would not be equally and continuously distributed over time, but rather develops in attentional cycles. The external regularities would provoke internal oscillators that guide attention over time and induce temporal expectations about future events, thus facilitating event processing. For instance, it was observed that a rhythmic motor routine enables sharpened sensory representations (Morillon, Schroeder, & Wyart, 2014). In the present study, it may be that producing regular gestures boosts maintenance mechanisms in WM. We consistently observed that the appearance of temporal regularities, supplied by an isochronous auditory rhythm, during the maintenance interval increased WM performance (Fanuel et al., 2018; Plancher, Lévêque, Fanuel, Piquandet, & Tillmann, 2018). It is plausible that an isochronous motor rhythm would produce the same effect. This should be further investigated in the future. However, one may wonder why repeating the same action gesture did not help SPT traces. It is plausible that SPT traces also benefit from these regularities, but because performing an incongruent action impaired memory performance compared to a congruent action (Lagacé & Guérard, 2015), the repetition of the incongruent gesture may partially interfere with the SPT traces.

Finally, we replicated the enactment effect in short-term memory. However, this effect was influenced by WM constraints, as it was reversed and eliminated when respectively motor and verbal concurrent tasks were required. However, as noted earlier, this pattern of results was rather explained by an increase of VT performance than a decrease of SPT performance. Even if we cannot provide an explanation for the enactment effect in WM, it seems that this effect does not rely on different maintenance mechanisms for VT and SPT. Consistent with Yang et al. (2014), who observed that the enactment effect was unaffected by a concurrent task requiring the central executive, attentional refreshing does not appear to be the source of the enactment advantage. Our finding provided supplementary evidence that the benefit of enactment does not cost additional WM resources.

In conclusion, the enactment effect in WM would not rely on different maintenance mechanisms for VT and SPT, as both memory traces could be maintained through attentional refreshing. Surprisingly, memory performance is boosted when participants performed gestures between sentences memorised through VT. This finding should be investigated in the future. Better understanding of the motor aspects in WM tasks appears essential, in particular because common persistent neural activity has been observed in the prefrontal cortex during WM maintenance and during motor tasks (Curtis & D'Esposito, 2003).

Note

1. It is worth noting that in the majority of the studies using the Following Paradigm, the enactment was produced at recall and not at encoding (as traditionally occurred in the SPT paradigm).

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Disclosure statement

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References

Allen, R. J., & Waterman, A. H. (2015). How does enactment affect the ability to follow instructions in working memory? *Memory & Cognition*, *43*, 555–561.

Barrouillet, P., & Camos, V. (2015). *Working memory: Loss and reconstruction*. Hove, UK: Psychology Press.

Barrouillet, P., Plancher, G., Guida, A., & Camos, V. (2013). Forgetting at short term: When do event-based interference and temporal factors have an effect? *Acta Psychologica*, *142*, 155–167.

Barrouillet, P., Portrat, S., & Camos, V. (2011). On the law relating processing and storage in working memory. *Psychological Review*, *118*, 175–192.

Camos, V., Johnson, M., Loaïza, V., Portrat, S., Souza, A., & Vergauwe, E. (2018). What is attentional refreshing in working memory? *Annals of the New York Academy of Science*, *1424*, 19–32.

Camos, V., Lagner, P., & Barrouillet, P. (2009). Two maintenance mechanisms of verbal information in working memory. *Journal of Memory and Language*, *61* (3), 457–469.

Curtis, C. E., & D'Esposito, M. (2003). Persistent activity in the prefrontal cortex during working memory. *Trends in Cognitive Sciences*, *7*, 415–423.

Engelkamp, J., & Seiler, K. H. (2003). Gains and losses in action memory. *The Quarterly Journal of Experimental Psychology. A, Human Experimental Psychology*, *56*, 829–848.

Fanuel, L., Portrat, S., Tillmann, B., & Plancher, G. (2018). Temporal regularities allow saving time for maintenance in working memory. *Annals of the New York Academy of Sciences*, *1424*, 202–211.

Jaroslawska, A. J., Gathercole, S. E., Allen, R. J., & Holmes, J. (2016). Following instructions from working memory: Why does action at encoding and recall help? *Memory & Cognition*, *44*, 1183–1191.

Jaroslawska, G., Gathercole, S. E., & Holmes, J. (2018). Following instructions in a dual-task paradigm: Evidence for a temporary motor store in working memory. *Quarterly Journal of Experimental Psychology*, *71*, 2439–2449.

Lagacé, S., & Guérard, K. (2015). When motor congruency modulates immediate memory for objects. *Acta Psychologica*, *157*, 65–73.

Large, E. W., & Jones, M. R. (1999). The dynamics of attending: How people track time-varying events. *Psychological Review*, *106*, 119–159.

Liefooghe, B., Barrouillet, P., Vandierendonck, A., & Camos, V. (2008). Working memory costs of task switching. *Journal of Experimental Psychology: Learning Memory and Cognition*, *34*, 478–494.

Morillon, B., Schroeder, C. E., & Wyart, V. (2014). Motor contributions to the temporal precision of auditory attention. *Nature Communications*, *5*(5255). doi:10.1038/ncomms6255

Plancher, G., & Barrouillet, P. (2013). Forgetting from working memory: Does novelty encoding matter? *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *39*, 110–125.

Plancher, G., Lévêque, Y., Fanuel, L., Piquandet, G., & Tillmann, B. (2018). Boosting maintenance in working memory with temporal regularities. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *44*, 812–818.

Vandierendonck, A. (2016). A working memory system with distributed executive control. *Perspectives on Psychological Science*, *11*, 74–100.

Waterman, A. H., Atkinson, A. L., Aslam, S. S., Holmes, J., Jaroslawska, A., & Allen, R. J. (2017). Do actions speak louder than words? Examining children's ability to follow instructions. *Memory and Cognition*, *45*, 877–890.

Yang, T., Allen, R. J., & Gathercole, S. E. (2016). Examining the role of working memory resources in following spoken instructions. *Journal of Cognitive Psychology*, *5911*, 1–13.

Yang, T., Gathercole, S. E., & Allen, R. J. (2014). Benefit of enactment over oral repetition of verbal instruction does not require additional working memory during encoding. *Psychonomic Bulletin & Review*, *21*(1), 186–192.

Zimmer, H. D., Cohen, R. L., Guynn, M. J., Engelkamp, J., Kormi-Nouri, R., & Ann Foley, M. (2001). *Memory for action*. New York: Oxford University Press.

Zimmer, H. D., Helstrup, T., & Engelkamp, J. (2000). Pop-Out into memory : A retrieval mechanism that Is enhanced With the recall of subject-performed tasks. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *26*(3), 658–670.