Following instructions in working memory: do older adults show the enactment advantage?

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Abstract

Objectives: In young adults, the ability to verbally recall instructions in working memory is enhanced if the sequences are physically enacted by the participant (self-enactment) or the experimenter (demonstration) during encoding. Here we examine the effects of self-enactment and demonstration at encoding on working memory performance in older and younger adults.

Method: 50 young (18-23 years) and 40 older (60-89 years) adults listened to sequences of novel action-object pairs before verbally recalling them in the correct order. There were three different encoding conditions: spoken only, spoken + demonstration, spoken + self-enactment. We included two different levels of difficulty to investigate whether task complexity moderated the effect of encoding condition and whether this differed between age groups.

Results: Relative to the spoken only condition, demonstration significantly improved young and older adults' serial recall performance, but self-enactment only enhanced performance in the young adults, and this boost was smaller than the one gained through demonstration.

Discussion: Our findings suggest that additional spatial-motoric information is beneficial for older adults when the actions are demonstrated to them, but not when the individual must enact the instructions themselves.

Keywords: self-enactment, demonstration, recall

Verbal recall of instructions in working memory: do older adults show the enactment advantage?

The ability to successfully follow instructions is imperative across the lifespan. Learning to use new technology, following a recipe without having to look back at every step, learning a new routine in an exercise class, and taking medication in a particular order all require the ability to follow, encode, retain and implement instructions using working memory. Working memory is defined as a limited capacity system responsible for temporarily storing and manipulating information (Baddeley, 2012; Cowan, 2012; Logie, 2011). Despite the importance of working memory for older adults, not least because research points to a decline in working memory with healthy aging (Johnson et al., 2010; Park et al., 2002), little work has explored how memory for instructional sequences can be improved for this age group using strategies at encoding. To this end we designed the current study, in which participants were required to perform instructions (self-enactment) or watch the experimenter demonstrate them (demonstration) to examine how manipulating enactment at encoding might impact older adults' performance on a following instructions task within a working memory paradigm.

Within the working memory domain, and in line with long-term memory research (e.g. Cohen, 1981; Engelkamp & Zimmer, 1997) young adults' verbal recall of spoken instructions is improved when instruction sequences are self-enacted or demonstrated at encoding, or self-enacted at recall (Allen & Waterman, 2015; Yang et al., 2015). These benefits are attributed at least in part to the additional visual and motoric codes made available at encoding creating a richer multi-modal representation (Allen & Waterman, 2015; Jaroslawska et al., 2015; Waterman et al., 2017).

Acknowledging the literature on working memory performance in children may well be prudent for the current study, as parallels can be drawn between children's developing working memory capacities (which are still limited) and older adults' generally considered declining performance. Children's memory for instruction sequences is also enhanced following demonstration at encoding (Waterman et al., 2017; Yang et al., 2017). However, results in relation to self-enactment at encoding are mixed, with some evidence for it improving recall for real-world objects (Jaroslawska et al., 2015), and some that the beneficial effect of self-enactment on children's recall is only present when the task was simplified (Waterman et al., 2017). Demonstration rather than self-enactment might therefore be a more reliable method for improving performance, an idea supported by Allen et al. (2020) who found superior performance following demonstration compared to self-enactment in young adults. This was attributed to self-enactment being a more active, attentionally demanding way of obtaining the additional visuo-motoric code, compared with passive observation of the experimenter during demonstration. In other words, the benefits provided by self-enactment may be reduced by the costs of self-generating visuo-spatial motoric information; a cost more easily overcome if it is 'paid' by the experimenter in the case of demonstration (Allen et al., 2020).

Despite the importance of working memory for following instructions, and the fact that there is some evidence that working memory capacity declines with age (Johnson et al., 2010; Park et al., 2002), research investigating the effects of enactment on the working memory performance of older adults in a following instructions task is very limited. To our knowledge only one, small-scale study has used an older adult population within this paradigm, and the authors report superior recall following self-enactment at encoding compared to verbal encoding (Charlesworth et al., 2014). However, this exploratory study did not feature a young adult group as a comparison, so it does not tell us whether the magnitude of the self-enactment effect changes with age. In addition, serial order recall was not explicitly required, and action-object pair responses were scored as correct regardless of the order in which they were recalled in the sequence (free recall). In line with the LTM literature (Engelkamp & Dehn, 2000; Schult et al., 2014; Steffens, 2007), it is possible that, for older adults at least, self-enactment improves memory for items generally, but not for remembering those items in a particular order; an ability that declines with age (Golomb et al., 2008; Maylor et al., 1999; Old & Naveh-Benjamin, 2008). Finally, this experiment did not feature a demonstration condition, so there is no existing research on how this form of presentation might impact on older adults' working memory performance.

With regards to how both self-enactment and demonstration will affect older adults in comparison to younger adults, it is possible that the proposed increase in demands on attentional control elicited by self-enactment during working memory encoding (Allen et al., 2020; Waterman et al., 2017) might particularly impact on older adults' performance. This would mean that they are not then able to show the same benefits from this manipulation as young adults. This would fit with observations that older adults show larger negative effects of dual-task manipulations applied during encoding (Logie et al., 2007; Rhodes et al., 2019). In that regard, demonstration might prove to be a more suitable encoding condition to boost older adults' working memory for instruction, in that it may offer additional forms of representation without placing the same dual-task cost. However, it is also possible that older adults will show a reduced benefit from demonstration as well as self-enactment compared to younger adults. Visuo-spatial working memory has been observed to show larger declines with healthy aging, relative to verbal working memory (Jenkins et al., 2000; Johnson et al., 2010), so older adults could struggle to benefit from the visuo-spatial codes provided.

The present study was designed to investigate the effect of demonstration and self-enactment at encoding on young and older adults' ability to immediately verbally recall short instruction sequences in the correct order. We examined older and younger adults' verbal recall of instruction sequences across three encoding conditions: spoken only, spoken + demonstration, and spoken + self-enactment, and two levels of difficulty (achieved by varying the number of possible actions). For young adults, it was hypothesised that self-enactment and demonstration at encoding would result in higher recall compared to spoken-only encoding. It was also hypothesised (based on Allen et al., 2020) that demonstration would lead to better recall than self-enactment for younger adults. For older adults, the work of Charlesworth et al. (2014) suggests that self-enactment will aid recall. However, if it holds true that the attentional costs of self-generating action counteract the benefits of self-enactment when the task is difficult, it is possible that self-enactment benefits will only be evident when task difficulty is low. Finally, while demonstration might provide relatively more reliable performance benefits for older adults across the two experiments (compared to self-enactment), these might be reduced in magnitude relative to the young adult group.

Methods

Participants. Fifty young adults (mean age = 19.42, SD = 1.33, range = 18-23 years, undergraduate students from the University of Leeds) and Forty older adults (mean age = 70.88, SD = 5.15, range = 61-89 years, recruited through the School of Psychology Successful Aging Research Panel, or via word of mouth) participated on a voluntary basis or for course credit. Participants were excluded if they had any musculoskeletal or neurological condition that affects movement of the upper limbs. Based on previous work in young adults using a similar methodology (Allen et al., 2020; Allen & Waterman, 2015), we predicted a large effect of demonstration (*Cohen's d* = .8), and a medium effect of self-enactment (*d* = .5). G*Power (Faul et al., 2009) indicated a minimum sample size of 15 and 34 to detect each of these effects respectively (with alpha = .05 and power at 80%).

The Spot-the-Word Test Version B (a reliable and valid measure of premorbid intelligence (Baddeley et al., 1993)) was used to screen for intelligence in all participants, and the Mini-Mental State Examination (MMSE) was employed to screen for signs of cognitive impairment/dementia in older adults (Folstein et al., 1975; Tombaugh & McIntyre, 1992). The maximum score which could be obtained for each was 60 and 30 respectively. The usual cut-off established for the MMSE defines 'normal' cognitive function as ≥ 24 (Creavin et al., 2016). Scores below 23 would have led to exclusion (n=0). There was a significant difference between the groups in terms of number of years in education (older adults = 17 years, younger adults = 16 years), $t\,(88) = -2.52$, $p < .05$, d = -.54, $BF_{10} = 3.46$, presumably due to a number of older adults being educated to degree level. Older adults' mean scaled Spot-the-Word Test score (13.6) was significantly higher than young adults' mean scaled Spot-the-Word Test score (9.3), $t\,(88) = -12.76$, $p < .001$, d = -2.70, $BF_{10} > 10{,}000$. Written consent was obtained from all participants and ethical approval was granted from the University of Leeds Research Ethics Committee (Ethics Reference Number PSC-142).

Materials. The materials used were similar to those used by Allen and Waterman (2015). Six actions (push, tap, lift, shake, flip and spin) and six shapes (circle, square, triangle, moon, cross and star) were used to create action-object pairs. The action "*tap*" involved tapping the shape once, "*push*" involved pushing the shape forward a few centimetres and back to its original position, "*shake*" involved moving the shape side to side on the table, "*lift*" involved lifting the shape up a few centimetres and placing it back down, "*spin*" involved rotating the shape whilst on the table and "*flip*" involved flipping the shape over and then back again to its original position on the table. The shapes had a black outline and were printed on white laminated paper measuring 5 x 5 cm and mounted on cardboard. Using shapes as objects meant it was unlikely that there were any pre-existing associations between actions and objects in LTM, therefore ensuring recall of action-object pairs relied on working memory (Allen et al., 2020; Allen & Waterman, 2015; Waterman et al., 2017).

The instructional sequences were composed of three, four, or five action-object pairs (e.g. a three pair sequence was: *push the cross, flip the square, shake the moon)*. We also included two levels of difficulty: simple (younger adults n = 26, older adults n = 21) and complex (younger adults n = 24, older adults n = 19), with participants randomly assigned to one condition. In the complex condition, actions and shapes were repeatedly recombined to produce novel combinations for each sequence, with the constraint that each action and each shape did not appear more than once within the same sequence. In the simple condition only two actions were used; “push” and “lift”, so there was some replication of action within a sequence. These were the same actions used in the more simplified version of the task in Waterman et al. (2017). There were 15 sequences in each of the three encoding conditions (generating a total of 45 sequences), with five trials per sequence length. Two practice trials of sequence length three preceded testing trials. For each encoding condition, the maximum number of action-object pairs that could be recalled was 60.

Procedure. The participant sat at a table opposite the experimenter and standardised instructions were read out loud by the experimenter (see supplementary materials). All participants completed the Spot-the-Word Test Version B and older adults also completed the MMSE. The experimenter placed the six shapes in a pseudorandom configuration on the table within comfortable reach in front of the participant. Shapes remained in view of the participant, in the same pseudorandom configuration, throughout testing. The experimenter named all of the shapes and demonstrated the actions, ensuring participants were familiar with them. Participants were informed of the type of encoding required before each condition and were reminded to verbally recall the action-object pairs in exactly the same order they were presented (serial recall). Participants were made aware that recalling the sequences may be a difficult task and were encouraged to guess if unsure of an action-object pair.

For each encoding condition, two practice trials of sequence length three preceded the 15 test trials (five trials per sequence length). Sequences started at length three and increased to length four, then five. Participants completed all sequences regardless of correct or incorrect responses. Sequences were read out loud by the experimenter one at a time, at a steady rate, with a delay of approximately three seconds after each action-object pair (see Figure 1 for a depiction of all three encoding conditions). In the spoken-only encoding condition, neither the experimenter nor the participant touched the shapes in the three-second delay, and participants simply listened to the instruction sequences. In the spoken + demonstration encoding condition, participants observed the experimenter demonstrate the actions with the shapes in the three-second delay. In the spoken + self-enactment encoding condition, participants performed the actions with the shapes in the three second delay. After the final action-object pair and either a further three-second delay, demonstration or self-enactment (depending on the condition), participants verbally recalled the full instruction sequence in the correct order. A co-experimenter sat at a table behind the participant recording participants' responses. The experimental session took no longer than 40 minutes to complete.

[Figure 1 about here]

Design. The study employed a 2 (age group: young, older; between-subject) x 2 (difficulty: simple, complex; between-subjects) x 3 (encoding condition: spoken only, spoken + demonstration, spoken + self-enactment; within-subject) mixed design. For ease, the spoken + demonstration and spoken + self-enactment conditions are hereafter referred to as demonstration and self-enactment respectively. The dependent variable was the proportion of correct action-object pairs recalled in the correct order (serial recall), in line with previous research (Allen & Waterman, 2015; Waterman et al., 2017). Encoding condition was counterbalanced across participants to control for order effects.

Data analysis. A mixed ANOVA was conducted to investigate the effects of age group, difficulty and encoding condition on serial recall performance. Interactions were further investigated using t-tests to compare groups at each level of encoding condition and repeated measures ANOVAs to investigate each group separately across encoding conditions. Pairwise comparisons with Bonferroni Holm corrections were used to interpret significant main effects. The data were analysed using traditional frequentist analysis in JASP (JASP Team, 2019). However, as frequentist tests rely on null hypothesis significance testing, they cannot provide evidence of no effect or no difference between groups (Barchard, 2015). Bayes Factor (BF) analysis was therefore also conducted in JASP. This assesses the strength of evidence for the alternative hypothesis compared to the null hypothesis, and also provides a test of equivalence between groups and/or conditions (Mulder & Wagenmakers, 2016). In each case, $BF_{10} < 1$ indicates support for the null hypothesis, and $BF_{10} > 1$ support for the alternative hypothesis. While Bayes Factors should be interpreted as a continuous outcome, we refer to the classification scheme in which BF 1-3 equates to weak or anecdotal evidence of an effect, BF 3-10 as moderate evidence, and BF > 10 as strong evidence. Similarly, BF 0.33-1 equates to weak evidence of no effect, BF 0.1-0.33 as moderate evidence, and BF < 0.11 as strong evidence (Jeffreys, 1961; Lee & Wagenmakers, 2014; van Doorn et al., 2019).

Results

Figure 2 shows the mean number of correct pairs recalled in the correct order (serial recall) across all trials for both groups across encoding conditions. A 2 x 2 x 3 mixed ANOVA was conducted to investigate the effects of age group, difficulty and encoding condition on serial recall performance.

Young adults recalled more action-object pairs than older adults, $F(1, 86) = 6.25$, $p = .014$, $\eta_p^2 = .07$, $BF_{10} = 3.41$ and performance was better in the simple condition compared to the complex one, $F(1, 86) = 210.37$, $p = .001$, $\eta_p^2 = .71$, $BF_{10} > 10{,}000$. There was a significant main effect of encoding condition, $F(2, 172) = 51.85$, $p < .001$, $\eta_p^2 = .38$, $BF_{10} > 10{,}000$. Participants recalled significantly more correct action-object pairs following demonstration at encoding compared to both self-enactment, $p <.001$, *Cohen's d* = .77, $BF_{10} > 10{,}000$, and spoken-only encoding, $p <. 001$, $d = 1.03$, $BF_{10} > 10{,}000$ which also differed from each other, $p =.02$, $d = 0.26$, $BF_{10} = 2.21$, with participants recalling more pairs in the self-enactment condition. There was a significant interaction between encoding condition and group, $F(2, 172) = 4.67$, $p = .01$, $\eta_p^2 = .05$, $BF_{10} = 3.96$. The BF analysis indicated strongest support for the model containing main effects of group, difficulty and encoding condition and the encoding condition x group interaction, $BF_{10} > 10{,}000$ compared to the null model including participant only, and 2.60 times more likely than the next best model containing group, difficulty, encoding condition, and the encoding condition x group and group x difficulty interactions. No further interactions emerged: encoding condition x difficulty $F(2, 172) = 0.89$; $p = 0.41$, $\eta_p^2 = .01$, $BF_{10} = 0.12$; group x difficulty $F(1, 86) = 0.24$; $p = 0.63$, $\eta_p^2 = .003$, $BF_{10} = 0.31$; encoding condition x group x difficulty $F(2, 172) = 1.91$; $p = 0.15$, $\eta_p^2 = .02$, $BF_{10} = 0.49$.

[Figure 2 about here]

To unpack the group x encoding condition interaction we carried out repeated measures ANOVAs on each group separately (collapsed across difficulty). Main effects of encoding condition were found for both the young, $F(2, 98) = 47.86$, $p < .001$, $\eta_p^2 = 0.49$, $BF_{10} > 10{,}000$, and older, $F(2, 78) = 13.37$, $p < .001$, $\eta_p^2 = 0.26$, $BF_{10} = 1797.91$, groups. Pairwise comparisons with Bonferroni Holm corrections showed that these were driven by significant differences between demonstration and spoken-only (young $p < .001$, $d = 1.37$, $BF_{10} > 10{,}000$; older $p < .001$, $d = .71$, $BF_{10} = 389.69$) and demonstration and self-enactment (young $p < .001$, $d = .84$, $BF_{10} > 10{,}000$, older $p < .001$, $d = .70$, $BF_{10} = 2195.93$) for both groups. For the young adults the self-enactment advantage over spoken-only encoding was significant, $p < 0.01$, $d =.53$, $BF_{10} = 30.50$. In contrast, the older adults showed no advantage with the Bayes Factor analysis in favour of no effect, $p = .94$, $d = .01$, $BF_{10} = 0.17$. We also compared the younger with the older adults at each encoding condition. We found no significant group difference at spoken-only, $t(88) = 0.17$, $p = 0.87$, $d = .04$, $BF_{10} = 0.23$, or at self-enactment, $t(88) = 1.54$, $p = 0.13$, $d = .33$, $BF_{10} = 0.62$, but younger adults were significantly better than older adults at demonstration, $t(88) = 2.00$, $p < 0.05$, $d = .42$, though this was not well supported by Bayesian analysis, $BF_{10} = 1.26$.

Discussion

The present study aimed to investigate the effects of self-enactment and demonstration at encoding on young and older adults' verbal recall of instruction sequences in working memory. In line with existing working memory research (Johnson et al., 2010; Park et al., 2002), young adults were better than older adults overall, although this effect was moderated by encoding condition. As predicted, demonstration of instructions at encoding significantly improved young adults' recall of instruction sequences compared to spoken-only encoding, and this was also the case for the older adults. However, self-enactment at encoding only significantly improved young adults' recall of instruction sequences; there was no such advantage for older adults. Analyses indicated that for the younger adults the enactment advantage (improvement in performance over spoken-only encoding) was much larger following demonstration than self-enactment. In addition, it seems that younger adults got a larger boost from demonstration over spoken-only encoding than did older adults.

The positive effect of demonstration on younger and older adults' recall is consistent with previous research and adds to findings that demonstration is a more effective way to boost verbal recall within a working memory paradigm (Allen et al., 2020; Waterman et al., 2017; Yang et al., 2017). However, it also appears that the magnitude of the demonstration advantage changes with age, with older adults showing a reduced benefit, relative to the younger group. There are several, currently speculative, reasons why this might be the case. One possibility relates to the observation that healthy aging appears to particularly impact on visuo-spatial rather than verbal working memory (e.g. Jenkins et al., 2000; Johnson et al., 2010). As the demonstration advantage is assumed to at least partly reflect the processing and storage of visuospatial information in working memory, any age-related difficulty in this set of abilities would be expected to impact on the magnitude of the demonstration advantage that older adults are able to exhibit. In addition, visually encoding and maintaining demonstrated actions alongside spoken instructions might still come with something of a processing cost, albeit reduced compared to self-enactment (e.g. Craik, 1994). This processing cost might reduce, but not completely abolish, the demonstration effect observed in older adults.

The finding that older adults showed no self-enactment advantage is in direct contrast to Charlesworth et al. (2014) who found that older adults did get a self-enactment boost.

However, the nature of their task was different, using real instead of simple geometric objects, deemphasising serial order of responses, and therefore analysing free recall performance in line with what participants were instructed to do. Our finding is in line with that of Experiment 1 from Waterman et al. (2017), where children gained no benefit from self-enactment, but in contrast with their second experiment, where a reduction in task complexity led to a boost in children's recall from self-enactment. Whilst we found a main effect of task difficulty with all participants recalling more action-object pairs when the task was simple (using only two possible actions, rather than six) we found no interactions between age and difficulty, so it was not differentially affecting each group. It is possible that task difficulty could moderate the effect of self-enactment at encoding on older adults' performance in some contexts (as has been seen in children, e.g. Jaroslawska et al., 2015; Waterman et al., 2017) and further research could explore that possibility.

Alternatively, perhaps the additional attentional and cognitive demands required to self-generate and maintain visuo-spatial motoric representations are sufficiently large for older adults, regardless of task difficulty, that self-enactment provides no benefit. This may reflect age-related difficulties with dual tasking during encoding (Logie et al., 2007; Rhodes et al., 2019) and/or reproducing temporal or serial order (Golomb et al., 2008; Maylor et al., 1999; Old & Naveh-Benjamin, 2008). However, the argument that self-enactment brings about dual-task costs that interfere with encoding operations would appear to apply equally well to encoding in long-term memory, and within the long-term memory literature robust self-enactment benefits have been found for both young and older adults (e.g. Cohen, 1981; Engelkamp & Zimmer, 1997). Again there may be methodological differences between working memory and long-term memory research underlying these contradictory findings, such as a wider variety of objects and actions, logical rather than arbitrary pairings between objects and actions, the relative time available to process each item at encoding, and the use of free recall rather than serial recall as the outcome measure (Bäckman & Nilsson, 1984; Kormi Nouri, 1995; Steffens et al., 2015).

As well as difficulties associated with dual tasking (balancing simultaneous storage and processing demands), or problems related to reproducing serial order information, it is possible that the lack of self-enactment advantage in the older population might also be driven my motoric differences between older and younger adults. With advancing age comes decline in motor function, including increased variability of movement, slowing, difficulties with gait and balance, and reduced manual dexterity, force control and coordination (Cole, 1991; Contreras-Vidal et al., 1998; Seidler et al., 2002, 2010; Shkuratova et al., 2004). Declining motor skills might interfere with the ability to form a motoric representation; thus no additional recall benefit is gained by performing an action. In addition, it is possible that older adults took marginally longer to complete the self-enactment tasks than the younger adults (given motoric differences), thereby experiencing additional time between instruction and recall, which could have led to poorer performance. Reaction time data would be needed to investigate this proposal, which we did not collect in the present study. However, the cardboard backing and lamination meant the shapes were easy to pick up, and we piloted using the shapes with a number of individuals from both age groups and experimenters noticed no age differences then, nor during data collection.

For both younger and older adults, it seems that demonstration rather than self-enactment might be a more reliable method for improving performance. This finding with regards to older adults is novel, and in line with working memory research using similar paradigms in other age groups (Allen et al., 2020; Waterman et al., 2017) and some LTM literature (Schult et al., 2014; Steffens, 2007). While we have yet to clearly establish the mechanisms underlying the demonstration advantage, it is likely that observing the performance of an action sequence provides additional visuo-spatial and motor coding and thus a richer working memory representation. This may emerge without further substantial active processing costs beyond those involved in encoding and maintaining spoken sequences, hence why both children and older adults are able to reliably benefit across different task contexts.

Given the fact that age differences in most verbal working memory tasks (and cognitive tasks more generally) are relatively robust (e.g. Johnson et al., 2010; Park et al., 2002), it is perhaps surprising that young and older adults did not differ in performance in spoken only trials, either in the simple or the complex condition. This might be due to the recruitment of different neural circuitry by older adults that can allow them to perform at similar or equivalent levels to their younger counterparts (Cabeza, 2002; Park & Reuter-Lorenz, 2009). On the other hand, it is possible that we had a high performing older adult group. The older participants were largely healthy and active, and often take part in studies within the School, whereas the younger adult group might be more representative of their age group (or at least more similar to younger adults tested in previous research). Our primary interest in this research was the comparison of the different encoding conditions within each age group rather than the main effect of age, and we found that the older adults responded in a different way to demonstrated and self-enacted encoding conditions compared with our younger adult sample. However, future work might consider using a more representative older adult sample to promote generalizability of our results to the broader population.

In conclusion, it is clear that demonstrating instruction sequences leads to improved memory performance in older adults, and so from a practical perspective this appears to be an optimal presentation method. In the future it would be useful to systematically explore the possible cognitive and neural processes underlying the self-enactment and demonstration effects that emerge in working memory, both from a theoretical perspective and to better understand which population groups would be most likely to benefit from these methods in an applied context.

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Figure Captions

Figure 1. Schematic diagram of an instruction sequence of length three, under all three encoding conditions: spoken-only (a) spoken + demonstration (b) and spoken + self-enactment (c).

Figure 2. Mean number of correct action-object pairs recalled in the correct position in the sequence (serial recall), across all encoding conditions (spoken only, spoken + demonstration, spoken + self-enactment) for young and older adults at both levels of difficulty (simple and complex). Error bars represent standard error of the mean.

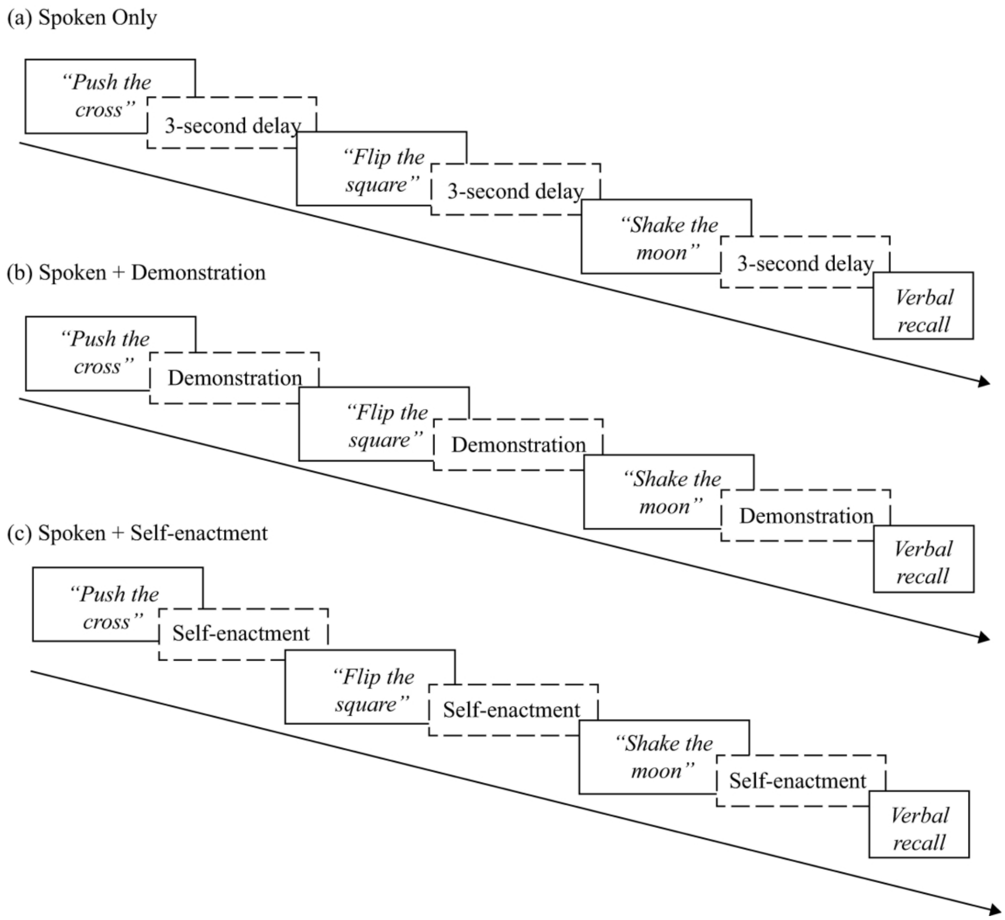
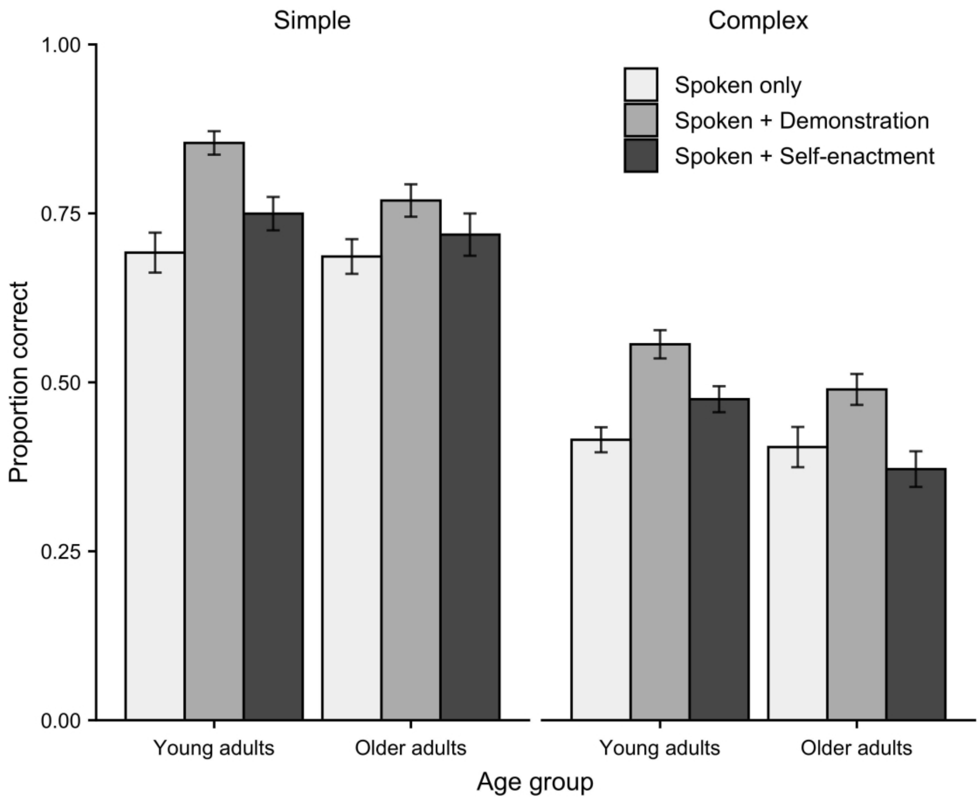


Figure 1. Schematic diagram of an instruction sequence of length three, under all three encoding conditions: spoken-only (a) spoken + demonstration (b) and spoken + self-enactment (c).

186x169mm (300 x 300 DPI)



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1270x1058mm (72 x 72 DPI)

Following instructions in working memory:
Experimenter script/participant instructions

Good morning/ afternoon, thank you for participating in this study.

Information Sheet and Consent Form followed by Spot the Word and MMSE (for older adults).

The aim of this experiment is to investigate the ability to recall instructions in working memory. You will hear a series of instructions, and your job is to repeat those instructions back to me in the correct order.

The instructions consist of an action and shape. The shapes are a square, a star, a triangle, a cross, a circle and a moon *(point at each shape as you say it).* Now I'd like you to name the shapes *(get participant to name the shapes. If they make any errors, correct them).*

The actions I will be instructing you to do are spin, push, flip, lift, shake and tap *(as you say each action, perform the action on one of the shapes).* Now I'd like you to practise those actions *(say each action and get the participant to perform the action. If they make any errors, correct them).*

The instructions will consist of sequences of action-object pairs, for example, "tap the circle", "spin the star", "shake the moon". Each sequence will contain 3 action-object pairs to start with, but sequences will increase in length over time. This means the experiment will get more difficult as the number of instructions in the sequence increases. Don't worry if you find it hard; just try to do your best and guess if you have to.

You will complete three different conditions:

1) I will say the instructions to you, and you repeat them back
2) I will demonstrate the instructions to you after I have said them and you then repeat them back
3) You will act out the instructions after I have said them and you then repeat them back.

In each case you will be verbally recalling the instructions back to me. You must try to recall the sequences as accurately as possible in the same order in which I present them. I will tell you in advance which condition you are doing, and you will get practise trials at the start of each condition.

Ok, now we are going to begin the first condition *(remember this is counterbalanced)*.

<u>Condition: Spoken-only</u>

I am going to read out a series of instructions e.g. "flip the circle", "spin the triangle", "push the square". I will leave a few seconds pause in between each instruction. When I have finished reading all of them, I would like you to verbally repeat them back to me, as accurately as you can, in the same order. We'll do a couple of practise trials first.

(Do the practise trials at sequence length 3. Correct any errors in understanding the instructions)

OK, now we are going to do the test.

<u>Condition: Demonstration</u>

I am going to read out a series of instructions e.g. "flip the circle" , "spin the triangle", "push the square". I will demonstrate each instruction after I say it. When I have finished all of them, I would like you to verbally repeat them back to me, as accurately as you can, in the same order. We'll do a couple of practise trials first.

(Do the practise trials at length 3. Correct any errors in understanding the instructions)

Ok, now we are going to do the test.

<u>Condition: Self-enactment</u>

I am going to read out a series of instructions e.g. "flip the circle" , "spin the triangle", "push the square". I would like you to act out each instruction after I say it. When I have finished all of them, I would like you to verbally repeat them back to me, as accurately as you can, in the same order. We'll do a couple of practise trials first.

Do the practise trials at length 3. Correct any errors in understanding the instructions)

Ok, now we are going to do the test.