INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 15, Issue 8, (2025) E-ISSN: 2222-6990

# The Effects of Working Memory Capacity, Types of Instructions, and Recall on Following Instructions Performance

Mohamad Azhari Bin Abu Bakar[1*], Kartini Binti Abd Ghani[2], & Norehan Binti Zulkiply[3]

[1,2,3]Faculty of Cognitive Sciences and Human Development, Universiti Malaysia Sarawak

Email: [1]abmazhari@unimas.my, [2]gkartini@unimas.my, & [3]znorehan@unimas.my

Corresponding Author Email[1*]: abmazhari@unimas.my

**DOI Link:** http://dx.doi.org/10.6007/IJARBSS/v15-i8/26093

***Published Date:*** 13 August 2025

**Abstract**

Many past studies showed that participants performed well during spoken instructions task with action recall. The discussion was directed to understand the functional role of working memory components. However, less studies investigated the role of Working Memory Capacity (WMC) in following instructions. Therefore, this study aimed to investigate the effect of WMC, types of instructions, and recall in following instructions based on the total correct recall. We recruited 52 participants (26 with high WMC and 26 with low WMC) who completed spoken and written instruction tasks, followed by verbal and action recall. This quasi-experimental design used three-way mixed factorial design (2x2x2), and all data were analysed by using three-way factorial ANOVA. Findings of this study suggested that there is a significant effect of WMC, types of instructions, and types of recall on following instructions performance. The results also reveal that there is a significant interaction between WMC and types of instructions, and between types of instructions and types of recall. One of the main results suggests that both groups (WMC) performed better during action recall compared to verbal recall in both types of instructions.

**Keywords:** Working Memory Capacity, Following Instructions

**Introduction**

Working memory is a temporary storage system with limited capacity that is responsible in manipulating and storing information (Baddeley, 2007; Unsworth & Engle, 2007; Cowan, 2008). Working memory plays a crucial role in determining how much information an individual can hold and use when engaging in a task. For example, a child who wants to learn how to cook might repeatedly ask his parents for instructions or continually refer to a YouTube video to follow the sequence of steps in preparing a dish. This activity requires active mental engagement, as the child must remember the ingredients and the specific actions associated with each one. If a step is missed, the final dish may not turn out as expected. Therefore, the child must pay close attention to each step and remember what needs to be done next throughout the cooking process. These demands involve the coordination of multiple components of working memory, including the ability to maintain, update, and manipulate information in real time (Baddeley, 2007).

Working memory utilised its limited capacity to support the process of encoding, rehearsal, retention, retrieval, and execution (Baddeley, 2000; Cowan, 2010; Engle et al., 1992). The Baddeley and Hitch (1974) multicomponent model of working memory consists of the phonological loop, visuospatial sketchpad, and central executive that provides a framework for understanding how different components of working memory contribute to information processing. The phonological loop is responsible for processing verbal information, such as what we read and listen to, while the visuospatial sketchpad processes visual and spatial stimuli, such as images, photos, and spaces. While central executive works to determine and decide what information needs to be processed, retained, recalled, and executed. Baddeley (2000) added the episodic buffer to the existing model, and it works to combine information from different sources to make meaningful episodes and bindings. Based on General Capacity Theory (Engle et al., 1992), individual differences in encoding and retaining the stimulus from the sensory storage to the working memory space depend on the availability of Working Memory Capacity (WMC) and the ability to control attention. If a person fails to control attention and inhibit the distractors, the performance of working memory will weaken, and that has an impact on the available capacity to process information as mentioned by Control Attentional Theory Engle (2001). This point addresses that differences in WMC are reflected in the ability to make the information stored in working memory highly active (Cowan, 2008). This limited capacity system has a significant role in handling a complex task such as following instructions.

The ability to follow and execute instructions is crucial for learning new skills, particularly when the task involves a high level of complexity (Buszard et al., 2017). In daily life, many of the activities we engage in require following instructions. Some of these tasks demand a high level of attention (e.g., conducting medical surgeries; combining different parts of a furniture), while others are performed more automatically due to repeated practice (e.g., preparing a familiar dish). Activities that require greater attentional control are closely linked to the activation of working memory functions (Cowan, 2010). Individual differences in working memory capacity (WMC) may influence how effectively one can retain and execute instructions, both verbally and through action, especially when instructions are presented in different formats, such as spoken or written.

Past studies (Conway et al., 2005; Engle, 2001; Unsworth et al., 2013) reported that individuals with high WMC performed better than the low WMC group due to their attentional control ability in suppressing the distractors and allowing a high level of attention to process the information. This advantage enabled them to complete a task with fewer errors and faster (Kane & Engle, 2000). In the last 15 years (Yang, 2011; Yang et al., 2014; Yang et al., 2015, Yang et al., 2022; Yang et al., 2024) there has been an increasing interest in investigating the role of working memory in following instructions to understand the role of each component of working memory in responding to the different treatments of instructions based on the types of instructions and recall. If an individual failed to follow instructions, they would fail to execute the task and commit more errors (Dunham et al., 2020). On top of that, the ability to follow instructions also depended on the individual's ability to understand the meaning of the instructions, which added criteria to the attentional control and working memory capacity (Yang et al., 2016; Dunham et al., 2020).

Past studies reported that types of instructions also play a significant role in influencing the ability to follow instructions, where participants performed better in demonstration-type instructions as compared to spoken or written instructions (Yang et al., 2014). Yang et al. (2016) showed that participants recalled spoken instructions better when they were able to see the objects presented while listening to the instructions, especially for the task with action recall. During the spoken instructions task, participants did not burden themselves to articulate the sequence of instructions because they just listened to the instructions compared to the written instructions (Kalyuga,2012). However, this advantage also depends on the types of recall as well. Individuals perform better when they recall in the form of action compared to verbal recall (Jaroslawska et al., 2016; Yang, 2011). It is now well established that working memory has a significant role in following instructions performance when there is collaborative effort between the different components of working memory (verbal processing, visuospatial coding, and executive function).

In contrast to the role of working memory in following instructions, there is much less information on the role of WMC (the differences between high and low WMC) in following instructions. Although theories suggest that high WMC performed better than low WMC in most of the tasks, there is room for further investigation in following instructions. Less studies emphasised the assignment of both types of instructions (spoken and written) in each participant group, including both types of recall. Therefore, this theoretical gap and methodological gap give a clear direction to continue investigation on the effect of working memory capacity, types of instructions, and types of recall on following instructions performance based on the total correct recall of the instructions. The following research hypotheses were used as the main guideline to answer the main study objective:

H1-There is no main effect of WMC (high vs low WMC) on following instructions performance based on the total correct recall of the instructions.
H2- There is no main effect of types of instructions on following instructions performance based on the total correct recall of the instructions.
H3- There is no main effect of types of recall on following instructions performance based on the total correct recall of the instructions.
H4-There is no interaction effect between WMC and types of instructions on following instructions performance based on the total correct recall of the instructions.
H5-There is no interaction effect between WMC and types of recall on following instructions performance based on the total correct recall of the instructions.
H6- There is no interaction effect between types of instructions and types of recall on following instructions performance based on the total correct recall of the instructions.
H7- There is no interaction effect between WMC, types of instructions, and types of recall on following instructions performance based on the total correct recall of the instructions.

This study enhances our understanding of how differences in working memory capacity (WMC) influence performance and interact with various types of instructions and recall. The findings provide valuable insights for the design of learning environments, particularly within the education system. By examining how different instruction formats and recall types affect learners with varying WMC levels, this research challenges the tendency to underestimate the potential of individuals with lower WMC. Results suggest that, when instructions are tailored to learners' cognitive capacities, even those with lower WMC can achieve meaningful learning outcomes. For educators, this underscores the importance of designing curricula and modules that prioritise optimising the learning process over simply completing a syllabus. Overemphasis on syllabus coverage often overwhelms students, leading to cognitive overload and reduced engagement, especially when tasks rely heavily on verbal retrieval rather than practical demonstration. Stakeholders who may benefit from these findings include curriculum developers, instructional designers, teachers, and policymakers seeking to foster more inclusive and effective learning environments that accommodate diverse cognitive capacities.

**Literature Review**

This section reviewed the past literature that is reflected to the main variables of this study. Individuals with high WMC can control attention to inhibit distractors during encoding (Engle, 2001). Past studies (Yang et al., 2015; Yang et al., 2016) reported that participants performed better during the recall stage when the instructions were presented with the demonstration as compared to the verbal or written instructions only. On the aspect of types of recall, participants performed better during action recall as compared to verbal recall due to less focus on articulating the list of instructions in a proper sequence. They just focused on the main keys of movement patterns (Yang, 2011; Yang et al., 2015; Yang et al., 2016). From this review, the findings are mostly narrated based on the working memory as a storage system in responding to the different types of instruction modalities and recall types, with less emphasis on the WMC.

Previous studies (Yang et al., 2014; Yang et al., 2016; Jaroslawska et al., 2021) designed the experiment with a combination of three elements (movement, objects, and colours- e.g., spin the red pencil). Each instruction (trial) must consist of all three elements, and the length was five actions with the linking word "and" (e.g., "spin the red pencil, and touch the yellow ruler, and push the blue ruler, and pick up green eraser, then put into the green folder"). The findings demonstrated that participants outperformed in action recall as compared to verbal recall because of two main advantages: 1-they observed the objects during encoding, and 2-no requirement to articulate the sentence sequence during recall, which contributed to more available space to process information. It has been reported that enactment rehearsal during encoding supported the action recall performance (Allen & Waterman, 2015). Participants learned a series of instruction sequences such as "touch the circle, spin the cross...", and recalled them through verbal or action. In addition to that, participants also perform better for verbal recall when they went through enactment rehearsal during encoding, as compared to the no-rehearsal condition. These study findings provide suggestions for improvement in learning by adding the element of action rehearsal to practice, which leads to later improvement in memory retention. So, the element of spatial and motoric encoding during rehearsal boosts performance and is more impactful than verbal rehearsal alone. Jaroslawska et al. (2016) also supported the essential role of action rehearsal during encoding, boosting the performance of action recall for verbal instruction among children aged 7-9 years old, emphasising the importance of visuospatial and verbal working memory resources in task execution. This evidence led to an understanding of the contribution of working memory components, especially the visuospatial sketchpad and episodic buffer, to form the clear connection and meaning between the presented spoken instructions and enactment rehearsal (Baddeley, 2007). These findings established the understanding of following instructions depends on the types of instructions with encoding support. Thus, our study applied the object presentations throughout the experiment during spoken and written instructions tasks. However, they were not allowed to point with a finger at the objects while listening to the spoken instructions.

Older adults with low WMC showed low performance in following instructions performance based on the accuracy, as compared to the younger group (Yang et al., 2022). Older participants performed better during action-based processing with demonstrations benefiting during instruction delivery. In this context, they were scaffolded with the observation stimulus to support encoding. Action-based processing enhances recall, particularly with demonstrated instructions. In addition, they benefited from the dual modalities (spoken instructions with simultaneous demonstration) method to support verbal recall performance (Yang et al., 2022). Yang et al. (2024) investigated the effect of encoding strategies on spoken instructions performance through verbal rehearsal, motor imagery, action observation, and self-enactment (doing). The findings from the two experiments found that the action-based encoding approach (motor imagery, observation, and self-enactment) has better recall than verbal rehearsal, regardless of different types of recall (verbal or action). These findings suggested the importance of physical engagement support or mental simulation of actions to enhance working memory performance through sensorimotor activation. Similarly, Waterman et al. (2017) found that children (6-10 years old) benefited from the action recall through the enactment rehearsal. The benefit of action recall also happened in older adults (60–89 yrs), which gives clear support that action recall persists across different age groups (Coats et al.,2021). However, these research findings did not provide a clear notion of the WMC effect. Thus, this current research is directed to investigate how the WMC groups process the properties of the spoken and written instructions through verbal and action recall.

To date, only a several studies have shown a clear emphasis on the role of WMC (between high and low WMC) in following instructions. Buszard et al. (2017) investigated the effect of WMC on motor learning performance when there were multiple instructions imposed on the kids aged 8-10 (24 high WMC and 24 low WMC). They practiced 240 trials of basketball shooting (within 20 blocks) and received the specific five multiple instructions before starting the trials in each block. The performance was assessed during pre-, post-, and retention-stages of the intervention. The findings showed that individuals with high WMC outperformed in all three stages of assessment, as compared to low WMC. Explicit instructions had a positive impact on the high WMC but not on the low WMC. In this context, multiple instructions overloaded the available capacity of the low WMC group, leading to impaired performance during motor instructions recall. Ahmadian (2020) conducted a study with three different groups of 78 Iranian EFL learners: group one received explicit instruction (direct explanation and corrective feedback), group two received implicit instruction (provided indirect input for enhancement), and group three received no instruction (control group). Findings indicated that group one (explicit instructions) achieved better performance of the learning objectives with consistence improvement as compared to the other two groups. Besides that, the performance of high WMC in the implicit instructions group showed good performance compared to low WMC. The performance of high WMC showed no difference from low WMC in the following explicit instructions task. Therefore, explicit instruction promotes positive learning and impact regardless of different WMC groups.

Another study by Kok et al (2021) investigated the effect of explicit and implicit instruction for motor learning, including feedback, on 9-13-year-old students was correlated with the verbal and visuospatial WMC. Both high and low WMC demonstrated significant improvement in balancing and perceived competency during pre- and post-test. High verbal WMC interacted well with explicit instructions, as compared to low verbal WMC, which benefited more from the implicit instructions. The finding also did not show a significant interaction between visuospatial WMC and types of instructions. Therefore, it is essential to align the instructional types to the participants' verbal WMC to enhance motor learning performance. Aldugom et al. (2020) investigated the effect of hand gestures in learning mathematics for students with higher verbal working memory and visuospatial working memory. The findings showed that individuals with high visuospatial working memory performed better when the teacher used hand gestures during instruction delivery. The higher verbal WMC performed better when no gesture was presented. To conclude, although these past studies talked about WMC contributions in following instructions (motor learning, multiple instructions, explicit, and implicit instructions), there is still room for the continuous investigation on the effect of WMC, types of instruction, and types of recall in following instructions performance.

## Method

*Design*

In a 2x2x2 mixed design, WMC was a between-subjects design (high vs low WMC), while instruction types (spoken and written) and recall types (verbal and action) were the within-subject design.

*Participants*

Fifty-two participants participated in this study (26 high WMC; 26 low WMC), aged between 18-26 years, and most of them are undergraduate university students. Convenience sampling was employed in this study, and all participants must fulfil the stated criteria to become participants (proficiency in Bahasa Melayu; writing, speaking, and reading, an age range of 18 to 26, and no history of hearing issues, blindsight, neurological problems, or psychiatric disorders). All participants in this study received an honorarium of RM40.

*Materials*

This experiment employed working memory tasks to assess the working memory capacity, and following instruction tasks to assess the total correct recall of the spoken and written instructions. The following are the details of each task employed in the experiment:

*1-Working memory task (Reading Span Task)*

The task was designed to assess the verbal working memory capacity, and it was adapted based on the framework of Engle et al. (1999) and Kane et al. (2004). The task consisted of four blocks, and in each block, there were three trials, and in each block, the number of words to be recalled differed, ranging from 2-5 words. The total of the real trials is 12 trials. Before starting the real trials, the participants were given two practice trials to ensure they understood the nature and flow of the task. During each trial, participants were instructed to read each sentence aloud and determine whether it was logical or not. At the same time, they had to silently memorise a word presented under each sentence. After completing each trial, they were asked to write down the words they had remembered using the form provided.

*2-Working memory task (Rotation Span Task)*
This task was adapted from the Rotation Span Test (Visuospatial Working Memory Task) developed by Shah and Miyake (1996) and later refined by Kane et al. (2004). It was designed to measure visuospatial working memory capacity and consisted of four blocks; each block consisted of three trials. Each block required participants to remember a different number of arrow directions, ranging from two to five. The total of the real trials is 12 trials. Before starting the real trials, the participants were given two practice trials to ensure they understood the nature and flow of the task. Participants were shown arrows in two colours: blue and red. When a blue arrow appeared, they identified its shape by saying either “tepat” (right) or “condong” (deviating). Immediately after responding, they pressed a key, prompting the red arrow to appear. After completing each trial, they were asked to write down the degree of the red arrows that they had remembered using the form provided.

*3-Following instructions task (spoken instructions)*
This task employed three main elements in the task design involving six different objects, different colours, and different movements. Two different tasks were created with different arrangement sequences in each block of the task. Each task consists of four blocks, and each block consists of three trials. Different blocks contain different numbers of instructions, ranging from two to five lists of instructions in each trial. The total of the real trials is 12 trials. Before starting the real trials, the participants were given two practice trials to ensure they understood the nature and flow of the task. In this task, participants were required to recall spoken instructions through verbal recall, and another through action recall. Both instructions were recorded and played through computer speakers. All the instructions were recorded by the experimenter to ensure voice consistency and minimise error.

The following are the details of the elements in the following instructions task.
1-Objects: pen, pensil, pinggan, sudu, penyepit, dan kain (pen, pencil, plate, spoon, clip, and cloth)
2-Colours: jingga, kuning, hijau, hitam, merah, dan biru (orange, yellow, green, black, red, and blue)
3-Movements: tolak,tarik, sentuh, ketuk, pusing, dan angkat (push, pull, touch, knock, rotate, and lift)

The full combination of the objects and colours are as follow:

- Pen merah, pen hitam
- Pensil hitam, pensil hijau
- Pinggan kuning, pinggan jingga
- Sudu biru,sudu merah
- Penyepit hijau, penyepit kuning
- Kain jingga, kain biru

The structure of each instruction consists of the three elements (movement, object, and colour). For example: Sentuh (movement) sudu (object) merah (colour);

*4-Following instructions task (written instructions)*
This task consists of two different tasks of the written instructions, which were arranged in different sequences. The total of the real trials is 12 trials. Before starting the real trials, the participants were given two practice trials to ensure they understood the nature and flow of the task. All the contents were the same as in the spoken instructions' tasks. One task required participants to recall the instructions through verbal, and another task through action recall. The participants had to read the presented instructions on the computer screen.

All the objects for the following instructions task (both spoken and written tasks) were laid on the table. Presentation of the objects remained the same throughout the experiment, including the setting of the experiment. Overall, the design of these tasks (both spoken and written instructions) was adapted based on the framework by Yang (2011), Yang et al., (2014), and Yang et al. (2016).

*Procedure*
All participants in this study received the consent form and were informed that all of them understood and were willing to participate in this research. The procedure began with working memory tasks, consisting of a reading span task and a rotation span task to assess the working memory capacity, which was later used to classify between high and low WMC. During this phase, the participants sat at the desk, facing the computer screen. For the reading span task, participants were asked to read aloud each sentence presented on the computer screen and determine whether the sentence was logical or not. While doing this, they also had to remember a word displayed below each sentence. At the end of each trial, participants were required to recall and write down the words they remembered.

Next, participants completed the rotation span task. In this task, they were shown arrows on the computer screen and asked to remember the orientation of the red coloured arrows. The task included two colours of arrows: blue and red. When a blue arrow appeared, participants were only asked to identify whether the arrow was facing to the right or deviating. When a red arrow appeared, participants were required to focus on remembering the direction of the arrow without commenting on its orientation (tepat "right" or condong "deviating"). After completing each trial, they recorded the degree of the red arrows they had remembered.

Following the completion of the working memory tasks, participants moved on to the instruction-following tasks. The experimenter introduced all the movements, objects and colours prior to the experimental task. All participants completed the task conditions and counterbalance in order. The first two trials in each of the tasks were practice trials to ensure the smoothness of the experiment flow. During the spoken instructions task (for verbal recall), the participants listened to the recorded instructions, and when the instruction "SILA ULANG" was played, they immediately recalled the instructions verbally. During this task, the objects were displayed on the table, and they could see them while listening to the instructions and were not allowed to touch the objects or do any rehearsal (verbal or movement). In the spoken instructions task for action recall, they executed the instructions in the form of action recall when the instruction "SILA ULANG" was played.

Next, for the written instructions task with verbal recall, they were asked to read the presented instructions on the computer screen in a clear voice and could not repeat them. After each trial, the instruction "SILA ULANG" appeared on the computer screen, and they immediately recalled the instruction verbally. After that, the participants continued with the written instructions' tasks with action recall, where they recalled the instructions in the form of action when the instruction "SILA ULANG" appeared on the computer screen. The researcher scored all the responses from the participants in all four different task conditions (spoken instructions (verbal recall), spoken instructions (action recall), written instructions (verbal recall), written instructions (action recall). Data of this study were analysed using the three-way factorial ANOVA in SPSS version 29.0.
This study received ethical approval from the University Ethics Committee: HREC(NM)/2023 (2)/56

**Results**
*Descriptive findings*
Data from the reading span task and rotation span task were analysed using a median split to classify participants into high and low WMC groups. The total WMC score was obtained by summing the scores from both tasks. Participants with scores equal to or above 12.405 were classified as having high WMC, while those with scores below 12.405 were classified as having low WMC. Based on this criterion, 26 participants were classified as high WMC and the remaining 26 as low WMC.

The descriptive findings in Table 1 show that the high WMC group performed better in all instruction types and recall types in comparison to the low WMC group. To be specific, the high WMC recalled well in spoken instructions with verbal recall (M=23.81, SD=7.00) and spoken instructions with action recall (M=25.96, SD=5.66) as compared to the low WMC group for both tasks (M=18.12, SD=5.19; M=22.38, SD=4.62). On the other hand, the recall performance in both groups (high vs low WMC) was increased when they performed action recall for the spoken instructions compared to the verbal recall for the spoken instructions. Both groups obtained lower scores for the verbal and action recall tasks of the written instructions. There is a slight difference in the memory performance between both groups in the spoken instruction task with verbal recall, where the high WMC group obtained (M=18.10, SD=3.84) and the low WMC group obtained (M=17.38, SD=2.95). For action recall performance of the written instructions task, both groups showed slightly higher points (high WMC: M=18.23, SD=4.61; low WMC: M=17.62, SD=3.26) than the performances in the verbal recall of written instructions.

Table 1
*Mean and standard deviation of the high and low WMC performance for each type of instruction and recall.*

| **Instructions Type (Recall Type)** | **High WMC (N=26)** | **Low WMC (N=26)** |
|---|---|---|
| Spoken Instructions (Verbal Recall) | 23.81 (7.00) | 18.12 (5.19) |
| Spoken Instructions (Action Recall) | 25.96 (5.66) | 22.38(4.62) |
| Written Instructions (Verbal Recall) | 18.10 (3.84) | 17.38 (2.95) |
| Written Instructions (Action Recall) | 18.23 (4.61) | 17.62 (3.26) |

*Inferential findings*

The analysis of the three-way ANOVA showed a significant main effect of WMC, $F$ (1, 50) = 8.70, p = .005, partial $\eta^2$ = .148. This finding suggests that, regardless of different types of instructions and types of recall, the performance in the high and low WMC groups showed a significant difference in the total correct recall of the instructions. Therefore, Hypothesis 1 is rejected. The finding also showed that there is a significant main effect of instruction type, $F$ (1, 50) = 53.86, p < .001, partial $\eta^2$ = .519. It indicates that regardless of different types of recall, and WMC groups, the performance was better in spoken instructions as compared to written instructions. Therefore, Hypothesis 2 is rejected. Next, the result of Hypothesis 3 revealed a significant main effect of recall type, $F$ (1, 50) = 12.21, $p$ =<.001, partial η2 = .196, which indicates if we ignore the presence of WMC and types of instructions, there is still a difference in recall types. This result also rejects the null hypothesis.

Finding of the Hypothesis 4 showed a significant interaction between instruction types and participants' WMC, $F$ (1, 50) = 9.50, p = .003, partial $\eta^2$ = .160. This significant interaction suggested that the effect of instruction types on following instructions performance, based on the total correct recall of instructions, differed between high and low WMC groups. Spoken instructions have a stronger interaction with the high WMC group than with the low WMC group. This result rejects Hypothesis 4. However, the result of Hypothesis 5 indicated no significant interaction between the recall types and WMC, $F$ (1, 50) = 1.27, $p$ =.266, partial η2 = .025. This interaction suggests that the total correct recall of the instructions in the high and low WMC groups was not affected by the types of recall assigned to them. Therefore, this finding supports Hypothesis 5. Hypothesis 6's finding showed a significant interaction between the instruction types and recall types assigned, $F$ (1, 50) = 7.19, $p$ =.010, partial η2 = .126. This interaction suggests to us that the effect of instruction types was stronger for one of the instructions (spoken instructions) than another (written instructions) for both recall types. Therefore, the null Hypothesis 6 is rejected. Finally, the analysis indicated that there is no significant interaction between the type of instruction employed, how they were asked to recall, and whether the participants were the high or low WMC group, $F$ (1, 50) =.82, $p$ =.370, partial η2 = .016. This finding accepts the null Hypothesis 7.

**Discussion**

The current finding found that the apparent difference is centred on instructions' performance of spoken instructions for verbal and action recall between high and low WMC. Both groups performed better in spoken instruction tasks with verbal and action recall than in verbal and action recall of written instruction tasks. The differences might be due to the treatment difference imposed to the participants during spoken instructions tasks (for both recall types). During spoken instruction tasks, participants can see the presented items on the table while listening to the spoken instructions played via computer speakers. This situation scaffolded the process of encoding and enhanced performance during recall. Regardless of high and low WMC groups, both groups benefitted from the presentation of objects on the table. This finding also aligned with Ahmadian (2020) on the impact of explicit instructions. The best performance was championed in the spoken instruction with the action recall and this result is in line with what been stated by Yang (2011), Yang et al. (2016), and Allen and Waterman (2015). Another explanation to this result may be due to the ability of participants in both groups to form mental imagery of the object movement by tailoring to what they see and what they were hearing from the instructions (Yang, 2011). This result also is supporting the role of phonological loop to process the verbal stimulus, and the role of visuospatial sketchpad in capturing the correct movement of the object displayed on the table. Combination of two different storage system, and low competing of the same resources support the recall performance (Baddeley, 2000; Baddeley and Hitch, 1974).

In this study, WMC were found to cause different score performance in following instructions tasks. A possible explanation of this result is connected to the Control Attentional Theory (Engle, 2002) with the emphasis that high WMC group can control attention and lead to better performance compared to low WMC group. This finding also is aligned with the General Capacity Theory by Engle et al. (1992), where the performance differences between these two groups are due to ability to manage their attention and put consistent effort to process the information, and not depends on the available space of their working memory (Buszard et al., 2017). Participants in both groups showed that the types of instructions played a significant factor in following instructions performance. They performed better in spoken instructions because of the support from the other modality which is the visual stimulus from the presented object. This finding is aligned with what been suggested in Yang et al. (2014) and Jaroslawska et al. (2016). Participants performed better in the action recall task than the verbal recall task, as notified in the past study by Jaroslawska et al. (2016). Action recall was easily executed because less burden on the processing the verbal rehearsal and more on the mapping the objects movement with the observation, and this process is processed effectively by the central executive of the working memory system (Baddeley, 2000).

The positive interaction between the WMC and types of instructions may be explained by the fact that spoken and written instructions are from the same group which is verbal element. However, spoken instructions depend much on the processing of the word in phonological loop with the support of the visuospatial sketchpad due to the object presentation (Baddeley, 2000). So, it becomes the extra benefit to the spoken instructions. On the other hand, the written instruction gave much burden to the phonological loop to articulate the words and with no additional support during encoding. Therefore, the results showed the impact of interaction between WMC and types of instructions especially the spoken instructions. This result aligned with Baddeley & Hitch (1974) on the role of the central executive in regulating the two subsystems, and the role of episodic buffer (Baddeley, 2000) that integrate the elements (movement, objects, and colours) in each trial of instruction as a meaningful instruction and allows execution.

Unexpected finding of this study revealed that no interaction between WMC and types of recall in following instructions performance. This finding suggests that WMC is not a main resource to determine the difference performance during action and verbal recall. This result may be explained with the requirement of both tasks that still asked the participants to pay attention, and due to the performance indicator, that showed the performance were due to the types of instructions. This result is supported by Miyake and Shah (1999) on understanding the relationship between working memory and attention. The obvious significant interaction was between the instruction types and recall types where the performance was differed with increased and decreased score due to these two variables. Participants in regardless of WMC scored well during action recall of both types of instructions. Low WMC group scored better during action recall of spoken instructions task as compared to the written instructions. This result tells that the design of the instructions and recall approach has huge impact on individual performance although the person is considered as low WMC. This finding is consistent with the past studies by Yang (2011), Yang et al. (2014), and Jaroslawska et al. (2016). Finally, the results show no significant interactions among the three variables (WMC, types of instructions, and types of recall). This may be explained by the limited additional resources provided for the written instructions task compared to the spoken instructions task. These findings highlight the importance of incorporating visual elements across all conditions to prevent advantages from being limited to only one type of instruction design or presentation. This perspective offers a valuable direction for future experimental research.

These study findings contribute significantly to the knowledge and scientific research of cognitive psychology especially in the studies of working memory and following instructions. Moreover, the findings support the theories of Multicomponent Model by Baddeley (2000), General Capacity Theory by Engle et al. (1992), and Control Attentional Theory by Engle (2001). The attentional control expressed by the participants was considered higher when there was no distractor imposed. However, the attentional control was affected when dealing with written instructions that must manage resources loaded between to understand what is written and articulate verbally, and or demonstrate in action. In terms of the practical implication, this study findings provides a clear understanding on how to design and plan appropriate strategies that help to minimise the cognitive load in instructions delivery for different groups of WMC. Besides that, we can make use different types of instructions to boost performance because individual's brain has ability to be utilised in adapting and learning to different stimulus. Individuals with low WMC can do more hands-on activities and involved with psychomotor approach rather than rely on the cognitive domain only. This research design contributes on the novelty of the study in terms of the methods utilised and design. Overall, all the tasks were designed by using Malay language as Malaysian national language.

This study has its limitations. First, this study did not impose the element of dual task as interference which cannot draw the how the scores will be differed between baseline and dual task interference. However, the design of this study is meaningful due the complexity of presentation of the tasks as within group where participants in both groups received all the four tasks and completed all the required recall types. This method contributed to the wealth of data that can compare how high and low WMC responded to both types of instructions and recall types. Second, the presentation of objects on the table during both types of instructions were mostly benefitted by the spoken instruction tasks only, because during written instructions tasks all participants have to focus on reading the instructions on the computer screen and no chance to see the objects directly unless during the recall time. However, this design was considered meaningful and ecologically valid, as it reflected real life situations in which our attention is typically divided between reading instructions and simultaneously assembling objects.

Based on the limitations stated, future research may include the element of dual task interference in one study, as a direct approach to compare the performance between high and low WMC for both written and spoken instructions with dual task interference, and baseline. Next, future research can utilise the design where participants will read the written instructions on a computer screen and at the same screen the objects also appear on the screen. For example, the text was on the top of the slides, and at the bottom of the slides will appear the objects that are the same arrangement with what presented on the table throughout the experiment. Finally, more studies on the effect of WMC in following different types of instruction presentation and stimulus are much warranted.

**Conclusion**

In conclusion, this experimental study provides a novel paradigm with which to investigate the individual differences in WMC by connecting with the theoretical paradigm of working memory as storage system, individual capacity, and ability to control attention. This results also has is not conclusive to all context but do give a meaningful finding that low WMC group also have their strengths when we were able to provide appropriate stimulus for them to execute. Working memory capacity (WMC), whether high or low, contributes to task completion, but it is not the sole determinant of successful recall. Consistently providing additional stimuli that scaffold learning can enhance recall by engaging multiple storage systems within working memory to process the encoded information. When information is distributed across more than one storage system, it has a greater positive impact during retrieval.

**Acknowledgment**

We sincerely thank all participants involved in this study for their valuable contributions.

**References**

Ahmadian, M. J. (2020). Explicit and implicit instruction of refusal strategies: Does working memory capacity play a role?. *Language Teaching Research*, *24*(2), 163-188.

Aldugom, M., Fenn, K., & Cook, S. W. (2020). Gesture during math instruction specifically benefits learners with high visuospatial working memory capacity. *Cognitive Research: Principles and Implications*, *5*(1), 27.

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

Baddeley, A. (2000). The episodic buffer: a new component of working memory?. *Trends in cognitive sciences*, *4*(11), 417-423.

Baddeley, A. D. (2007). *Working memory, thought, and action* (Vol. 8). Oxford University Press.

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* Vol. 8 (pp. 47–89). New York: Academic Press.

Buszard, T., Farrow, D., Verswijveren, S. J., Reid, M., Williams, J., Polman, R., ... & Masters, R. S. (2017). Working memory capacity limits motor learning when implementing multiple instructions. *Frontiers in psychology*, *8*, 1350.

Coats, R. O., Waterman, A. H., Ryder, F., Atkinson, A. L., & Allen, R. J. (2021). Following instructions in working memory: do older adults show the enactment advantage?. *The Journals of Gerontology: Series B*, *76*(4), 703-710.

Conway, A. R., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic bulletin & review*, *12*(5), 769-786.

Cowan, N. (2008). What are the differences between long-term, short-term, and working memory?. *Progress in brain research*, *169*, 323-338.

Cowan, N. (2010). The magical mystery four: How is working memory capacity limited, and why?. *Current directions in psychological science*, *19*(1), 51-57.

Dunham, S., Lee, E., & Persky, A. M. (2020). The psychology of following instructions and its implications. *American Journal of Pharmaceutical Education*, *84*(8), ajpe7779.

Engle, R. W., Cantor, J., & Carullo, J. J. (1992). Individual differences in working memory and comprehension: a test of four hypotheses. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *18*(5), 972.

Engle, R. W., Tuholski, S. W., Laughlin, J. E., & Conway, A. R. (1999). Working memory, short-term memory, and general fluid intelligence: a latent-variable approach. *Journal of experimental psychology: General*, *128*(3), 309.

Engle, R. W. (2001). What is working memory capacity? In H. L. Roediger III, J. S. Nairne, I. Neath, & A. M. Surprenant (Eds.), *The nature of remembering: Essays in honor of Robert G. Crowder* (pp. 297–314). American Psychological Association. https://doi.org/10.1037/10394-016

Jaroslawska, A. J., Bartup, G., Forsberg, A., & Holmes, J. (2021). Age-related differences in adults' ability to follow spoken instructions. *Memory*, *29*(1), 117-128.

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.

Kalyuga, S. (2012). Instructional benefits of spoken words: A review of cognitive load factors. *Educational Research Review*, *7*(2), 145-159.

Kane, M. J., & Engle, R. W. (2000). Working-memory capacity, proactive interference, and divided attention: limits on long-term memory retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*(2), 336.

Kane, M. J., Hambrick, D. Z., Tuholski, S. W., Wilhelm, O., Payne, T. W., & Engle, R. W. (2004). The generality of working memory capacity: a latent-variable approach to verbal and visuospatial memory span and reasoning. *Journal of experimental psychology: General*, *133*(2), 189.

Kok, M., Kal, E., van Doodewaard, C., Savelsbergh, G., & van der Kamp, J. (2021). Tailoring explicit and implicit instruction methods to the verbal working memory capacity of students with special needs can benefit motor learning outcomes in physical education. *Learning and Individual Differences*, *89*, 102019.

Shah, P., & Miyake, A. (1996). The separability of working memory resources for spatial thinking and language processing: an individual differences approach. *Journal of experimental psychology: General*, *125*(1), 4.

Miyake, A., & Shah, P. (Eds.). (1999). *Models of working memory: Mechanisms of active maintenance and executive control.* Cambridge University Press.

Unsworth, N., & Engle, R. W. (2007). The nature of individual differences in working memory capacity: active maintenance in primary memory and controlled search from secondary memory. *Psychological review*, *114*(1), 104.

Unsworth, N., Brewer, G. A., & Spillers, G. J. (2013). Working memory capacity and retrieval from long-term memory: The role of controlled search. *Memory & cognition*, *41*, 242-254.

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 & Cognition*, *45*, 877-890.

Yang, T. (2011). The role of working memory in following instructions. York, UK: University of York.

Yang, T. X., Allen, R. J., & Gathercole, S. E. (2016). Examining the role of working memory resources in following spoken instructions. *Journal of Cognitive Psychology*, *28*(2), 186-198.

Yang, T. X., Allen, R. J., Waterman, A. H., Graham, A. J., Su, X. M., & Gao, Y. (2024). Exploring techniques for encoding spoken instructions in working memory: a comparison of verbal rehearsal, motor imagery, self-enactment and action observation. *Memory*, *32*(1), 41-54.

Yang, T. X., Allen, R. J., Yu, Q. J., & Chan, R. C. (2015). The influence of input and output modality on following instructions in working memory. *Scientific reports*, *5*(1), 17657.

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.

Yang, T., Su, X., Allen, R. J., Ye, Z., & Jia, L. (2022). Improving older adults' ability to follow instructions: benefits of actions at encoding and retrieval in working memory. *Memory, 30*(5), 610–620. https://doi.org/10.1080/09658211.2022.2035768