Malaysian Journal of Social Sciences and Humanities (MJSSH) (e-ISSN : 2504-8562)
2023, Volume 8, Issue 7, e002424
DOI: https://doi.org/10.47405/mjssh.v8i7.2424

Reviewing How Individual Differences in Working Memory Capacity Affect the Ability in Following Instructions

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

[1]Faculty of Cognitive Sciences and Human Development, Universiti Malaysia Sarawak, Jalan Datuk Mohammad Musa, 94300 Kota Samarahan, Sarawak, Malaysia.
Email: abmazhari@unimas.my
[2]Faculty of Cognitive Sciences and Human Development, Universiti Malaysia Sarawak, Jalan Datuk Mohammad Musa, 94300 Kota Samarahan, Sarawak, Malaysia.
Email: gkartini@unimas.my
[3]Faculty of Cognitive Sciences and Human Development, Universiti Malaysia Sarawak, Jalan Datuk Mohammad Musa, 94300 Kota Samarahan, Sarawak, Malaysia.
Email: znorehan@unimas.my

CORRESPONDING AUTHOR (*):
Mohamad Azhari Bin Abu Bakar (abmazhari@unimas.my)

KEYWORDS:
Individual differences
Working memory capacity
Following instructions

CITATION:
Mohamad Azhari Abu Bakar, Kartini Abd Ghani, & Norehan Zulkiply. (2023). Reviewing How Individual Differences in Working Memory Capacity Affect the Ability in Following Instructions. *Malaysian Journal of Social Sciences and Humanities (MJSSH), 8*(7), e002424. https://doi.org/10.47405/mjssh.v8i7.2424

ABSTRACT

This literature review aims to analyze the role of individual differences in working memory capacity in following instructions based on theoretical perspectives and empirical evidence. Individual differences in working memory capacity have an impact on the encoding, and retrieval stage. In general, the output from the review stated that the performance difference between individuals relates to the experimental design and treatment, which include delivery of the instructions, presentation of objects, the length of instructions, involvement of dual tasks, and retrieval methods. In addition, the contents of instructions can be transferred into working memory space if the individuals can give a high level of attention and control the attention to suppress the distractors. Therefore, the ability to follow instructions depends on the individual's understanding of the instructions' meaning and matching them with the available space of their working memory (capacity). This review also adds value and suggestions to the need to conduct more research on the role of working memory capacity in following instructions.

Contribution/Originality: This study is one of the very few studies that have reviewed the role of working memory capacity in following instructions based on individual differences, by referring to the theoretical perspectives and empirical studies. The review also contributes to the need of conducting more studies in this area.

1. Introduction

Baddeley and Hitch (1974) defined working memory as a storage system with a limited capacity to manipulate information. The model consists of executive attention, a phonological loop, a visuospatial sketchpad, and an episodic buffer (Baddeley, 2000). Executive attention plays the role of monitoring, selecting, and controlling attention from

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

distractors. The phonological loop processes verbal information, while the visuospatial sketchpad handles visual and spatial information. Finally, the episodic buffer combines verbal and visuospatial information and links them with information in long-term memory (Baddeley, Allen & Hitch, 2011). Each component of working memory has limited capacity and temporarily stores information (Alloway, Gathercole, & Pickering, 2006). Therefore, individuals must pay great attention to discriminating against distractors to allow information processing in the working memory space.

Cognitive psychology research highlights that working memory works within its limited capacity system. There are individual differences between high and low working memory capacity in processing information (Cantor & Engle, 1993). The research addresses individuals' information processing from attention to retrieval based on task completion, correct and incorrect recalls, and reaction times (Carpenter, 1992; Baddeley, 2010). However, there is a limitation in keeping and attending to all information at one time (Cowan, 2005). Individuals typically are limited in remembering seven items with plus and minus two, and this is labeled as working memory capacity limits (Miller, 1956). Later Cowan (2005) suggested that the capacity limit declined to four items.

Working memory also can be described based on time, space, and energy perspectives. Those elements reflect individual differences in working memory capacity (Cowan, 2005). Cowan (2008) points out an analogy that working memory representations could fade quickly because of limited time. It also has a space limit, which can fit a few items if no appropriate chunking techniques are applied. The energy limit is a resource limit whereby every representation in working memory requires energy and competition between various representations. The one with reliable power will be processed and attended to.

Despite various applications of working memory in different modalities, an important gap in this growing body of research is the limited understanding of the individual differences between high and low working memory capacity in following instructions. Hence, this paper reviews theoretical perspectives and empirical evidence on working memory capacity and following instructions.

2. Theoretical Perspectives

This section focuses on reviewing theoretical perspectives underpinning the role of working memory capacity in following instructions. The theories are related to attention, attentional control, cognitive load theory, and following instructions.

2.1. Attention

Activation of working memory depends on the individual's ability to give attention. In this context, attention refers to the amount and intensity given to select the information from the sensory stimulus and further be processed in the working memory storage (Fougnie, 2008). Miyake and Shah (1999), mentioned that the relationship between working memory and attention should be referred in the form of systematic mapping. There are differences in attention's taxonomy, such as alerting, orienting, and executive attention. In the alerting state, individuals responded to sensory resources such as what they see and hear. In the orienting state, the information from the perceptual stimulus is transformed into filtering procedures through noise reduction and suppression (Slotnick, Schwarzbach, &Yantis, 2003). In the final state, the executive attention reacts to allow the selected information from the orientation state to get into a limited capacity system which

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

is working memory space (Eriksen & Eriksen, 1974). Therefore, it is regarded that working memory activation requires attention, which also makes individuals differ in their working memory capacity.

Suppose an individual fails to give appropriate attention to a particular stimulus; the possibility for information to be registered in working memory is low. Extraneous stimuli will diminish one's ability to store important information. Hence, a person must engage in selected information with a high state of consciousness and attention. The ability to repress the noises in the environment allows an individual to pay great attention and encode the selected information (Chun, Golomb, & Turk-Browne, 2011).

Another theoretical orientation related to attention is by Kahneman (1973). He suggested that the intensity of attention depends on the arousal level which depends on the contents of the stimulus, which stimulates the arousal of attention energy. For example, the novelty and complexity or low familiarity with a stimulus will arouse more attentional capacity and gauge the high level of control in discriminating the interference factors (Berlyne, 1970). Kahneman's (1973) theory emphasizes the presence of effort as a mechanism for attentional capacity. It has to deal with voluntary and involuntary selection. With the expansion of the limited capacity of the resource, individuals might be able to access the contents of the stimulus. It has to be blended with an effort to make the process meaningful. For example, suppose we do not try to understand a new subject matter. In that case, we will not be able to allow the presented information to be selected. Kahneman (1973) emphasized that attention is mental effort and regarded attention as central to the mental capacity and energy to draw a pool of situational attentional demands in task processing. His theory addressed that the difficulty of the tasks requires increased mental effort.

The attentional effort is enhanced when the presented stimulus requires activation of motivation and focus on exploring the needs and sorting the stimulus's contents. For example, abnormal difficulties, high-risk tasks, changing to new methods, presentation of distractors, and stressful situations appear. The absence of attentional effort affects the decline of information processing performance. With the increase of attentional effort, the activation of individual neural circuits also increases in detecting an error, changes, manipulating, selecting, deleting, decoding, and encoding (Sarter, Gehring, & Kozak, 2006).

In conclusion, successful information processing depends on meaningful structures, which depend on the role of the filtering system: energy, effort, and capacity. The amount of attention to be executed at any time is also limited based on limited attentional capacity. Therefore, the presented stimulus must compete for the limited space. At the same time, the stimulus must not overload the available amount, leading to individual differences in working memory capacity (Cowan, 2001).

2.2. Attentional Control

Unsworth and Engle (2005) suggest that working memory capacity is vital in processing information that requires attention control. Activities with automatic processing do not require much attention control. Therefore, explicit, and intentional learning is essential to working memory capacity and attention control. Working memory assesses purposeful learning and skill acquisition based on verbal, visual, and sensing information. Working memory capacity defines individual differences between high and low span, and the

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

manifestation of cognitive processing in terms of ability, comprehension, skills, and achievement.

Conway, Cowan, and Bunting (2001) also suggested that individual differences in working memory capacity are based on attentional control. There are no differences between low and high-span individuals regarding automatic processing because it does not require much attention control. The function of attention control in the working memory span will be decreased when a person achieves automaticity. The reason is due to the practice and rehearsal effect. Working memory capacity works best when the situation requires high attentional control.

Furthermore, high spans individuals can focus better on the attended message and block all unattended messages (distractors). Low working memory capacity individuals usually perform poorly on the test requiring attentional control and execution than those with high working memory capacity. Therefore, high and low working memory capacities significantly differ in their alerting and attentional control performances (Conway, Cowan, & Bunting, 2001).

Eysenck et al. (2007) also emphasized that attentional control plays a role in controlling anxiety that can impair the individual performance of the central executive to manipulate the information in the working memory space. The theory also counts on the bases of two aspects which are a goal-directed attentional system and a stimulus-driven attentional system. The goal-directed attentional system depends on individual expectations, available knowledge, and present goal. In contrast, the stimulus-driven attentional system depends on the presented stimulus, which grabs individual attention. Therefore, it is essential to provide a stimulus that can capture individual attention and, at the same time, link with the individual goal. Individuals also need to inhibit distractors by minimizing anxiety and interference of irrelevant stimuli to allow high engagement in stimulus-driven attentional control. Therefore, the goal-directed system will be able to suppress the distractor and focus on the main goal of completing the task.

To conclude, individual performance in following instructions and completing other tasks depends on the individual's ability to control attention. The ability of individuals is different, and they must gain control in suppressing the distractors and lower their anxiety level to retain their attention longer.

2.3. Cognitive Load Theory

This theory is essential in studying the human learning system and instructional design approach. From this theory, the researcher can understand the cognitive architecture of human ability in information processing, which is in line with their different capacities. The core belief of this theory highlights that individuals' capacity for working memory is different, and it depends on their ability to assess and process information. Therefore, clear instruction will allow more information to be processed in the working memory (Tindall-Ford & Sweller, 2006). When the information exceeds the limits of the capacity, then the performance declines. This explanation refers to designing and processing instructions related to novel tasks and requires a high level of attentional control to acquire them (De Jong, 2010; Sweller, 2004). Therefore, it is important to focus on individual ability and background knowledge in designing instruction to ensure the smoothness of information processing and following instructions (Sweller, 2004). Consequently, the distribution of attentional focus and working memory resources will

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

vary across individuals and tasks, depending on the nature of the specific task being performed; the neurological, developmental, and experiential abilities of the individual; and the current availability of internal and external cognitive resources (Sepp, Howard, Tindall-Ford, Agostinho, & Pass, 2019).

This theory consists of three types of loads. The first type is the intrinsic load, defined as the number of items to be manipulated and processed. The processing criteria are determined by the complexity of learning contents and materials and could be beyond the control of course instructors. The second type is an extraneous load which focuses on the unnecessary content presentation that disturbs the individual ability to focus on the intended information. For example, the instructions consist of redundant information that possesses the same meaning and requires the same demonstration of action. Therefore, extraneous cognitive load is induced by individual cognitive load. The third type is the germane cognitive load which focuses on the organization of newly acquired information with the assimilation and accommodation of existing knowledge stored in long-term memory (Mayer & Moreno, 2010; Moreno & Park, 2010). It also requires a high level of active cognitive processing in organizing, retrieving, and updating information.

In conclusion, combining three cognitive loads produces the total consumption of working memory resources. The remaining unused cognitive resources are considered free space and must be benefited by increasing the germane load (Sweller, Van Merriënboer, & Paas, 1998). Therefore, the instructional designer must design content that can direct individual focus to the relevant information with low extraneous cognitive load because a load of instructions significantly affects individual performance due to the limited working memory capacity.

2.4. Following Instructions

The ability to follow instructions significantly impacts academic achievement, skills proficiency, and ability to perform specific actions or learned behaviors. All the behavioral and skills execution will be successfully performed according to the given instructions when individuals can merge the collaborative interactions of perceptions, attention, and long-term memory retrieval, which are catered by a working memory storage system (Baddeley, 2010; Cowan, 2014). Suppose the individuals can capture the narration of the instructions. In that case, they should be able to manipulate their working memory space and recall the instruction in verbal or action form (Barrett, Tugade, & Engle, 2004).

Individuals learned to solve new problems with difficulties although they had experienced solving previous problems. They also find difficulties and challenges in solving a new problem when the instructions are too general and applied to many different scenarios. Therefore, it is suggested to design instructions based on specific cases with an appropriate flow that can be followed and imitated (Catrambone, 1990). The ability to follow instructions allows the individual to complete presented or attempted tasks in appropriate ways. It also depends on the ability to encode, retain, rehearse, and retrieve the sequence of verbal or action recall instructions. Therefore, completing these processes requires activating working memory (Gathercole, Lamont, & Alloway, 2006).

Different types of users prefer different ways of instruction delivery. Some preferences are based on declarative information or procedural information. Individuals that prefer the declarative style of information will take longer to process information and experience a low confidence level to learn new things without declarative information

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

(Karreman, 2004). They spent a lot of time reading the instructions. Contrary to individuals with a procedural style, they preferred to explore the functions without having an appropriate manual of the tools. They were also more confident and able to access information faster. They used them easily due to less focus on the instruction manual. They regarded the learning process as less burden and easy to acquire (Karreman, Ummelen, & Steehouder, 2005). Their actions require less function of working memory activation compared to the individual with a declarative learning style.

In conclusion, the ability to learn knowledge also depends on imparting the essence of instructions which requires remembering a series of instructions in the appropriate sequence. Therefore, active working memory is needed to process the sequence of required instructions (Yang, 2011).

3. Empirical Evidence: Individual Differences in Working Memory Capacity and Following Instructions.

This section focuses on past studies on the role of working memory and working memory capacity in following instructions. The reviews are also based on various experimental designs and treatments, including delivery of the instructions, presentation of objects, the length (numbers) of instructions, involvement of dual tasks, and retrieval methods.

Working memory plays a significant role in helping children to follow instructions for their daily activities. To justify this benefit, Jaroslawska et al. (2016a) investigated the role of working memory processes and subcomponents in following instructions using the 3D task dimension. The study involved 42 students, and they were tested using Automated Working Memory Assessment and real-world following instructions tasks. The researchers used lists of instructions that can be applied to daily interaction (e.g., touch the red pencil). The number of instructions increased gradually to see their working memory capacity in following instructions. The findings of the study suggested that the children with a higher verbal memory span performed better in recalling longer sequences of instructions. However, children with low verbal working memory span struggled to follow the instructions related to the everyday classroom learning environment. In this context, the nature of following instructions tasks is also influential based on the types of participant groups. Therefore, it is important to design instructions tailored to the children's capacity, which is more towards paper-pencil tasks, completing action tasks, and playing around with the objects presented in front of them through manipulation.

Regarding better performance at action recall than verbal recall, Jaroslawska et al. (2016b) wanted to study further the connection between the performance during encoding and retrieval and the differences between motor recall and verbal recall. The researcher wanted to see the linkage between the encoding and the retrieval stage of the instructions among children aged 7-9 years. Another objective of their study was to see the enactment advantage by comparing the enactment and verbal recall performance. The study also wanted to identify whether the spatiomotoric actions play a role in enactment rather than any other motoric movement.

Experiment 1 involved 60 children (37 boys); the participants were required to recall instructions that were started with one action and up to six actions in one trial. The example of instruction was "touch the red ruler" (require one action). The trials were terminated when the participants did more than three incorrect trials. The findings from

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

experiment 1 stated that participants performed well during the encoding and retrieval stage. The performance during the initial stage (encoding) has an advantage compared to the retrieval stage because of a common mechanism, spatiomotoric memory, which controls both.

In another experiment, they explored the role of non-motoric involvement during the presentation. The study methodology involved a condition in which children (52 children, with 33 boys) were required to repeat the presented instructions as they heard them. During the encoding stage, the instructions sequences were presented either in the form of;1-spoken by the experimenter (no enactment), 2-spoken by the experimenter and followed by verbal repetition by the participant immediately (shadowing), and 3-spoken by the experimenter and enactment recall by the participant. An example of shadowing was when the experimenter presented verbally; (pick up the red box), and the participant needed to repeat the same instructions aloud. In conclusion, the findings suggested that the role of motor storage during the presentation of instructions (encoding) and recall (retrieval) existed to maintain the temporal, spatial, and motoric properties of instructions requiring action planning or execution. Therefore, from this study, we can understand the importance of different types of instruction delivery.

Allen and Waterman (2015) also addressed the connection between the spatial motoric coding in working memory and the performance during encoding and retrieval of physical performance. The findings of this study indicated that the performance of verbal and enactment recall was based on the encoding stage in which participants needed to plan motor spatial representation in working memory. The study also used the simple combination of action and object in the instructions (e.g., touch the circle, spin the cross…) and involved adult participants (28), which required them to perform verbal and enactment recall. The presentation of instructions was based on no enactment and enactment. Therefore, the encoding of the instructions was much emphasized for the task requiring participants to perform verbal recall compared to enactment recall.

Allen et al. (2022), in current reviews on the practices related to the studies of working memory and following instructions, addressed the dynamic of the experimental tasks and approaches to assess the manipulations of information by working memory. Based on the reviews, there are different ways of presentation of the instructions and required retrieval activities after the presentation. The presentations of instructions include the demonstration style of presentation, which require participants to perform the tasks with the presentation of the items in front of them. The other studies asked participants to view and enact the object. Some presented the stimulus through verbal instructions and asked participants to listen only. The involvement of the participants was also not centered on the typical but also atypical, including males and females as well as age groups. The findings of the studies generated different conclusions and suggestions stating the involvement of working memory processes, an underlying mechanism such as observed, encode, retrieval, imagination, rehearsal, and individual differences.

The current study by Coats et al. (2021) on the role of working memory in following instructions involved early adults (18-23 years) and late adults (60-89 years). The experimenters wanted to investigate the effects of demonstration and self-enactment at the encoding stage on verbal working memory performance among younger and older people. The experiment design involved the action-object combination's three conditions (1-spoken only,2-spoken with demonstration, and 3-spoken with self-enactment). Trials of the experiment involved two levels of complexity to identify whether the complexity

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

affects the encoding condition and impacts both groups' performance during the retrieval stage. The experiment's findings suggested that the spoken-only and demonstration condition improved the recall performance of both groups. However, self-enactment at encoding impaired performance in older adults compared to younger adults who showed better performance. Both groups' performances may suggest that working memory span plays a role in their performance. The involvement of demonstration at the encoding stage with spatial motoric information is highly recommended to enhance the performance in older adults.

As informed in other studies, working memory plays an essential role in processing information related to instructions, allowing us to perform the instructions through verbal and action recall. Yang et al. (2015) wanted to empower the previous findings on the role of working memory in following instructions by implementing various input and output modalities to assess individual performances. In experiment 1, the participants listened, read, and observed the demonstration of the action sequence based on the instructions, later followed by the verbal or action recall performance. The findings indicated that the recall performance for the demonstration condition at encoding outperformed the other conditions. In the second experiment, the participants were presented with instructions in two modalities:1- spoken and demonstration, and 2-spoken. Participants showed better performance in dual modalities than in spoken instruction presentations. Compared to the first experiment, the presentation of dual modalities at encoding did not bring many advantages compared to the demonstration condition of the instructions. The findings from these two experiments suggest the different impacts of encoding—retrieval approaches and input-output modalities in following instructions and working memory performance. Therefore, different styles of instruction presentation also may suggest different performance outcomes.

Buszard et al. (2017) investigated individual differences in working memory capacity (high and low) in following multiple instructions between 24 children with high working memory capacity and another 24 children with low capacity. The experimenter used five explicit instructions that required motor learning acquisition (basketball shooting). Every participant was needed to demonstrate the motor learning performance after 1 week. The study revealed that individuals with higher working memory capacity demonstrated improvement in motor performance (i.e., shooting performance) throughout the phases. The individuals with low working memory capacity demonstrated the opposite side of performance. This finding is based on the demands given on working memory capacity and explicit multiple instructions. It does state clearly that low working memory individuals have difficulties performing new motor skills when there are multiple instructions given. In this context, individuals with high working memory capacity can utilize the multiple instructions as meaningful chunks and execute them in different ways based on their large WMC.

Dual-task studies can enhance understanding of the role of working memory components in following instructions. The previous findings also highlighted the great performance of enactment recall as compared to verbal recall. However, due to the lack of evidence regarding the multicomponent model of working memory, Jaroslawska et al. (2018) continued to search for additional information by applying motor suppression tasks in three experiments. The rationales of their study were to see the impact of motor suppression as interference that may impair the encoding of motor representation at encoding and retrieval. The conditions for the motor suppression required participants to do repetitive sequences of fine motor gestures (in experiment 1) or more basic gestures

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

(in experiments 2 and 3). Findings from the experiments revealed that the action recall performance was affected by the motoric suppression imposed by dual tasks, which suggests the competing modalities between the instruction properties and the motoric suppression activity. Therefore, the working memory capacity limit has impacted retrieval performance, especially action performance.

As previous studies mentioned the advantages of the self-enactment and observing other enactment actions (through demonstration) in following instructions, Allen et al. (2020) continued to explore the effects of demonstration and self-enactment among young adults in retrieving the sequence of instructions that consisted of object-action combination (e.g.: spin the circle) (first experiment-48 participants). Based on the findings, the participants performed better in the retrieval stage with prior demonstration as encoding, as compared to self-enactment as encoding. However, both showed positive performance. In another experiment (24 participants), they wanted to explore the effects of 1-no presence of objects during the encoding stage, 2-with the presence of partial demonstration (either with action or object only), and 3-with full or no demonstration. The findings from this experiment found that the performance at the retrieval stage was better with the full of demonstration, and the half demonstration only gave an advantage for the retrieval of the demonstrated items (object or action) only during the encoding stage. Overall, the findings from both experiments allow understanding that additional supporting mechanisms during the encoding stage (visuomotor combination) can enhance verbal working memory performance.

The latest study by Yang et al. (2022) continued to explore the function of working memory in following instructions with the application of different approaches for the presentation of instructions during the encoding stage. As we know, the age influences the performance of working memory especially in older adults. Therefore, Yang et al. (2022) compared the effect of spoken condition and demonstrated instructions (in silence mode) through verbal and action recall performance. Older participants obtained fewer numbers of correct recalls for both conditions but showed better performance in recalling the demonstrated instruction for verbal recall as compared to the action recall. For the next study (experiment 2), the participants were presented with other comparative conditions; 1-spoken instruction with simultaneous demonstration, and 2-spoken instruction or silent demonstration. The performance for both groups (older and younger adults) in the dual conditions (spoken + direct demonstration) outperformed the performance of the spoken instructions for the verbal recall performance. Therefore, the functional role of working memory can be improved with the presence of effective approaches in delivering instructions regardless of age categories.

4. Discussion

Working memory is activated when the individual starts to pay attention to the sensory resources presented. On top of that, individual differences in working memory capacity are also regarded with the individual ability to perform attentional control. If individuals failed to downgrade the influence of distractors, then they will have difficulties processing the upcoming information in their working memory space. Attention control also functions when we must do tasks that are outside of the routine, novel tasks, and low in terms of automaticity.

Theories also mentioned the differences between high and low-span individuals are defined based on the ability to block unattended messages (distractors). Usually, low

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

working memory capacity individuals perform poorly as compared to those with a high working memory capacity. Therefore, individual differences in high and low working memory capacities showed significant differences in terms of alerting and attentional control ability.

With regards to individual differences in processing information, then it is suggested to prepare instructions that are tailored to the capacity of the individuals. Because the cognitive load is believed to be the main influence in the performance and retrieval of instructions. It is good, if we know that the group of individuals is having difficulties grabbing many lines of instructions at once, then we can make it into small chunks to avoid cognitive overload.

Reflecting on the previous empirical studies shared earlier, we can see that most studies pointed out the role of working memory, but still, there are lacking in terms of emphasizing the individual differences between high and low working memory capacity. Thus, we want to research more about how individual differences in working memory capacity take place in processing instructions with the limited available resources.

Previous studies also shared various methods in the delivery of instructions as the medium of the experiment. We can adapt and adopt the methods to search for more evidence on the role of working memory capacity in the following instructions. Although past studies mentioned the general role of working memory, then future studies can have more focus on dividing participants between high and low spans at the beginning by using the working memory assessments before embarking with following instructions tasks.

As mentioned earlier, working memory space has limited capacity, and it must be controlled to minimize the interference of the distractors. When the instructions loaded too much on the limited capacity, it led to information decay. Therefore, it is vital to look at the length of the instructions as well as the audience who received the instructions. If the length of instruction is too long, it might become a cognitive burden for the individual with low working memory capacity.

5. Conclusion

In conclusion. the successful application of the following instructions also must be tallied with the cognitive architecture of the information processing. One of them is the working memory capacity. Using insight gained from previous studies, several new strategies are proposed to leverage the pool of studies on working memory capacity and following instructions. Firstly, more studies need to be conducted in the Malaysian context because through literature search most studies centered in Western countries. The researchers also found out that working memory studies in the Malaysian context also is lacking in the working memory niche area. Secondly, the studies must apply different methods of delivery and employ diverse groups of participants which can help the researchers to map the working memory capacities between different age groups and developmental stages. Thirdly, the researchers also aim to continually investigate the contributions of working memory capacity in following instructions in the Malaysian context by implementing the Malay language as a medium of instruction because most previous studies used English as a medium of instruction. So, it is good if the instructions are tailored to the national language used in the Malaysian context. Hypothetically, the results might give new inputs on the performance of working memory capacities and the ability to follow instructions. Finally, the implementation of the instruction delivery in a real context (such as classroom

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

teaching and learning environment) is much encouraged to be based on the previous studies' findings and suggestions. As a result, we can exercise a more evidence-based approach in our educational setting, and other activities.

Acknowledgement

Part of this article was extracted from the ongoing doctoral research project of the main author.

Funding

This study received no funding.

Conflict of Interest

The authors reported no conflicts of interest for this work and declare that there is no potential conflict of interest with respect to the research, authorship, or publication of this article.

References

Allen, R. J., Hill, L. J., Eddy, L. H., & Waterman, A. H. (2020). Exploring the effects of demonstration and enactment in facilitating recall of instructions in working memory. *Memory & cognition*, *48*(3), 400-410.

Allen, R.J., Waterman, A.H., Yang, T., & Jaroslawska, A.J. (2022). Working memory in action: Remembering and following instructions. In R.H. Logie, Z. Wen, S.E. Gathercole, N. Cowan, & R.W. Engle (Eds.) *Memory in science for society: There is nothing as practical as a good theory*: Oxford University Press.

Allen, R. J., & Waterman, A. H. (2015). How does enactment affect the ability to follow instructions in working memory?. *Memory & Cognition*, *43*(3), 555-561.

Alloway, T. P., Gathercole, S. E., & Pickering, S. J. (2006). Verbal and visuospatial short-term and working memory in children: Are they separable?. *Child development*, *77*(6), 1698-1716.

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. A. Bower (Ed.), *Recent advances in learning and motivation* (Vol. 8, pp. 47–90). New York: Academic Press.

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

Baddeley, A. (2010). Working memory. *Current biology*, *20*(4), R136-R140.

Baddeley, A. D., Allen, R. J., & Hitch, G. J. (2011). Binding in visual working memory: The role of the episodic buffer. *Neuropsychologia*, *49*(6), 1393-1400.

Barrett, L. F., Tugade, M. M., & Engle, R. W. (2004). Individual differences in working memory capacity and dual-process theories of the mind. *Psychological bulletin*, *130*(4), 553.

Berlyne, D. E. (1970). Novelty, complexity, and hedonic value. *Perception & psychophysics*, *8*(5), 279-286.

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.

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

Cantor, J., & Engle, R. W. (1993). Working-memory capacity as long-term memory activation: An individual-differences approach. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(5), 1101.

Carpenter, P. A. (1992). A capacity theory of comprehension: individual differences in working memory. *Psychological review*, *99*(1), 122.-387.

Catrambone, R. (1990). Specific versus general procedures in instructions. *Human-Computer Interaction*, *5*(1), 49-93.

Chun, M. M., Golomb, J. D., & Turk-Browne, N. B. (2011). A taxonomy of external and internal attention. *Annual review of psychology*, *62*, 73-101.

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., Cowan, N., & Bunting, M. F. (2001). The cocktail party phenomenon revisited: The importance of working memory capacity. *Psychonomic bulletin & review*, *8*(2), 331-335.

Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and brain sciences*, *24*(1), 87-114.

Cowan, N. (2005). Essays in cognitive psychology. Working memory capacity. New York, NY, US.

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

Cowan, N. (2014). Working memory underpins cognitive development, learning, and education. *Educational psychology review*, *26*(2), 197-223.

De Jong, T. (2010). Cognitive load theory, educational research, and instructional design: Some food for thought. *Instructional science*, *38*(2), 105-134.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & psychophysics*, *16*(1), 143-149.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion*, *7*(2), 336.

Fougnie, D. (2008). The relationship between attention and working memory. *New research on short-term memory*, *1*, 45.

Gathercole, S. E., Lamont, E. M. I. L. Y., & Alloway, T. P. (2006). Working memory in the classroom. In *Working memory and education* (pp. 219-240). Academic Press.

Jaroslawska, A. J., Gathercole, S. E., Logie, M. R., & Holmes, J. (2016a). Following instructions in a virtual school: Does working memory play a role? *Memory & Cognition*, *44*(4), 580-589.

Jaroslawska, A. J., Gathercole, S. E., Allen, R. J., & Holmes, J. (2016b). Following instructions from working memory: Why does action at encoding and recall help? *Memory & Cognition*, *44*(8), 1183-1191.

Jaroslawska, A. J., 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*(11), 2439-2449.

Kahneman, D. (1973). *Attention and effort* (Vol. 1063). Englewood Cliffs, NJ: Prentice-Hall.

Karreman, J. (2004). *Use and effect of declarative information in user instructions* (Vol. 18). Rodopi.

Karreman, J., Ummelen, N., & Steehouder, M. (2005, July). Procedural and declarative information in user instructions: What we do and don't know about these information types. In *IPCC 2005. Proceedings. International Professional Communication Conference, 2005.* (pp. 328-333). IEEE.

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

Mayer, R. E., & Moreno, R. (2010). Techniques that reduce extraneous cognitive load and manage intrinsic cognitive load during multimedia learning. In Plass J. L., Moreno R., Brünken R. (Eds.), *Cognitive load theory* (pp. 131–152). Cambridge University Press.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological review*, *63*(2), 81.

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

Moreno, R., & Park, B. (2010). Cognitive load theory: historical development and relation to other theories. In J.L. Plass, R. Moreno, & R. Brünken (Eds.), *Cognitive load theory* (pp.9-28). Cambridge University Press.

Sarter, M., Gehring, W. J., & Kozak, R. (2006). More attention must be paid: the neurobiology of attentional effort. *Brain research reviews*, *51*(2), 145-160.

Sepp, S., Howard, S. J., Tindall-Ford, S., Agostinho, S., & Paas, F. (2019). Cognitive load theory and human movement: Towards an integrated model of working memory. *Educational Psychology Review*, 1-25.

Slotnick, S. D., Schwarzbach, J., & Yantis, S. (2003). Attentional inhibition of visual processing in human striate and extrastriate cortex. *Neuroimage*, *19*(4), 1602-1611.

Sweller, J. (2004). Instructional design consequences of an analogy between evolution by natural selection and human cognitive architecture. *Instructional science*, *32*(1-2), 9-31.

Sweller, J., Van Merrienboer, J. J., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational psychology review*, *10*(3), 251-296.

Tindall-Ford, S., & Sweller, J. (2006). Altering the modality of instructions to facilitate imagination: Interactions between the modality and imagination effects. *Instructional science*, *34*(4), 343-365.

Unsworth, N., & Engle, R. W. (2005). Working memory capacity and fluid abilities: Examining the correlation between Operation Span and Raven. *Intelligence*, *33*(1), 67-81.

Yang, T. (2011). *The role of working memory in following instructions*. (Doctoral dissertation), University of York.

Yang, T.-X., Allen, R. J., Yu, Q., & Chan, R. C. K. (2015). The influence of input and output modality on following instructions in working memory. *Scientific Reports, 5*(17657), 1–8. doi:10.1038/srep17657

Yang, T. X., Su, X. M., Allen, R. J., Ye, Z., & Jia, L. X. (2022). Improving older adults' ability to follow instructions: benefits of actions at encoding and retrieval in working memory. *Memory*, 1-11.

© 2023 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).