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The Comparison of Chunking Method to Enhance the Cognitive Capacity of Short-term Memory to Retain Textual Information among High School Students

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Abstract

Our short-term memory has a limited capacity of taking in information and retaining it the memory storage. However, this can be enhanced by various memory techniques especially dividing the information into smaller chunks. To investigate this memory enhancement strategy, this study compared the effectiveness of three chunking methods, namely One-Chunk, Two-Chunk, and Three-Chunk, to enhance the capacity to retain information in the forms of letters and numbers in the short- term storage. Participants in this study were 50 high school students who took part in an online short- term memory assessment experimental design. The results revealed that the ability to remember ten distinct alphabets and ten distinct digits statistically varied, depending on how the information was chunked. To be more precise, the student participants could memorize the information when divided into 2 or 3 chunks more effectively than one full set of the data (1 chunk) as the mean scores gained in the two chunking methods were statistically greater than that of the One-Chunk delivered information. However, the findings only relied on single types of information so that further research could be done to explore this with more complicated information. Educational implications can be drawn from this present study. To assist students in memorizing and retaining learning materials more effectively, it is essential to help classify them into 2-3 groups of information. This could be done through the use of tree thinking, binary thinking, and computational thinking.

Keywords: Cognitive Information Processing, Short-term Memory, Chunking, Textual Information

INTRODUCTION

Whether there is an effective way to assist people's memorization is an issue of interest. Interestingly, various people's daily life activities, including memorizing 10-digit phone numbers, adopting three-point sermon in preaching, and selecting two to three words to define themselves, are found to utilize a cognitive strategy called "chunking." Moreover, it is also evident that numerous famous brands merely choose two simple but unique words as their slogans to hook people's attention to their product. Regarding these facts, an assumption could be made that chunking information could increase its effectiveness of being processed into short-term memory and eventually long-term memory. Therefore, this study focuses on determining the effectiveness of each chunking method in retaining textual information. It is believed that the study would provide a clearer understanding of how different forms of information should be chunked to maximize people's memorization and could be implicated in educational fields.

LITERATURE REVIEW

Cognitive Information Processing (CIP) Theory is a well-renowned theory in cognitive psychology that has been constantly being applied to illustrate the human memory system (see Figure 1). By adopting the multi-store model from Shiffrin & Atkinson (1969), in which a computer metaphor is

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used with its inputs and outputs to locate sensory memory, short-term memory (STM), and long-term memory (LTM) to convey how information is processed from sensory inputs to cognitive storage. Sensory memory holds information associated with senses such as visual and auditory for a short period of time (in seconds) before the information is processed further. Short-term memory functions or working memory further processes the carried information, and with regular rehearsal, it is ready for long-term storage or for a response. The information in humans' long-term memory is permanent and capable of retaining information in numerous ways (Schunk, 1996).

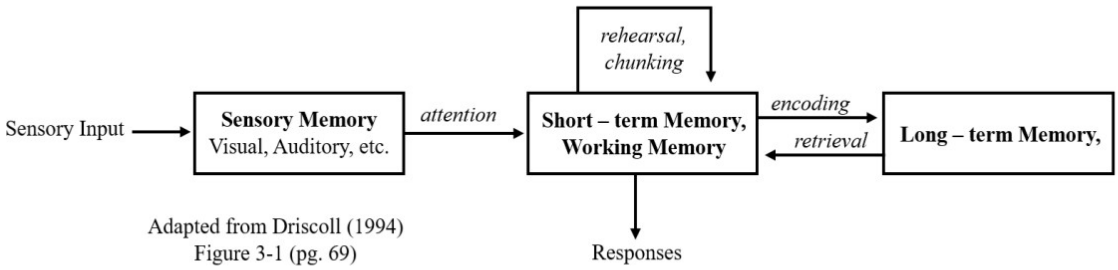

Figure 1 - Multi-store Model according to CIP Theory

A later study points out that short-term memory and long-term memory differ in various aspects, especially duration and capacity to retain information. It is believed that an item told in the same time interval with others is more difficult to recall because it shares its temporal cues to retrieval (Cowan, 2008). Thus, when the list of subjects is told, short-term memory would most likely to remember the most distinct one more temporally. Also, Vogel & Luck (2006) reports in the same way that the limit of the focus of attention for the number of items in each chunk was between three and four items.

In order to improve our short-term memory capacity, a strategy called *chunking* which is a process of grouping the presented information to effectively compress the context (Schneider et al., 2001), is considered one of the best-known methods (Lane et al., 2001). Chunking could occur in two different ways: either through strategic reorganization based on familiarity or prior knowledge (often used in letters and numbers) or through grouping based on perceptual characteristics (often used in visuals) (Gobet, 2005). Miller (1956) points out that information could be categorized in meaningful units, namely chunks, which could increase the amount of recalled information and immediate memory span. Attempts have been put by researchers to enhance the validity of chunking. Tulving & Patkau (1962) suggest that this chunking method could be even more effective when it is applied to relatable or familiar information. However, unfamiliar data, as well as complicated information, may be less effective to be retained even though the information is properly chunked. In addition, each chunk must be limited to an appropriate number of items in order to maintain its effectiveness. Otherwise, it would be similar to simply not undergoing chunking as most people are likely to remember the information at the beginning and at the end (Lorenz & Tizón-Couto, 2019). Vogel & Luck (2006) also reports that the limit of the focus of attention for the number of items in each chunk was between three and four items. It is further suggested that behavioral and neuropsychological, and modeling methods must be integrated to further improve methods of chunking in order to maximize human's memorizing potential (Gilchrist. 2015).

Therefore, it is evident that although extensive research studies have attempted to portray the full picture of the human memory system, the experiments and explanations about chunking patterns and the comparison between the effectiveness of the human's memory to memorize letters, numbers and a combination of these two aforementioned types are still limited. Hence, this research is set to compare the effectiveness of working memory when retrieving textual information in different chunking methods.

METHODOLOGY

The data collection was divided into two main parts depending on the types of textual information used: 10 randomly selected distinct alphabets ranging from A to Z, and 10 randomly selected distinct numbers ranging from 0 to 9. The participants in this study were 50 high school students in Bangkok. Each was asked to work on five trails which all undergo different chunking methods: *One-Chunk* where each set of textual information was told continually without any spacing, *Two-Chunk* where the textual information was split into the first 5 alphabets or digits and the other half, and *Three-Chunk* where the textual information was divided in 3 different ways, consisting of 4-3-3, 3-4-3, and 3-3-4 (see Appendix). However, in this present study, the differences among these three chunking patterns are not emphasized. Instead, they were all combined together as a result of the *Three-Chunk* method. After the results of 50 participants were collected, they were brought to perform T-tests using IBM SPSS Statistics 24 to find whether each value was significantly different from one another or not.

It is important to note that the participants were informed about the research purpose. They voluntarily decided to take part in this process of data collection. Due to the pandemic of COVID-19, this was conducted only. However, the audio was delivered with clarity which did not interfere with the ability to listen to the given information. In addition, the participants were aware of their right to withdraw their participation at any time that they felt they would like to. All the information of the participants was kept confidential. Only the researchers could gain access to the data. No personal identification can be found in this study because only numerical data is presented.

RESULT AND DISCUSSION

According to Table 1, the results showed that students could retain the information in the form of letters most effectively when it was delivered to them in 3 chunks. However, different patterns of chunks yielded different results. Although it is not the focus of this study to scrutinize the pattern of chunking here, it is interesting to point out that chunking the information into the patterns of 4 3 3 and 3 3 4 such as 0916 789 879 or 091 678 9879 were found to be more effective than the other forms of chunking (one chunk, two chunks, and even three chunks in the pattern of 3 4 3). More evidently, when the textual information in the form of alphabets was chunked into 3 groups, the results revealed that students were more precise in memorizing the given information, compared to the information being divided into one or two chunks. The following sections do not focus on the patterns of three chunks, but the mean scores of the three patterns were calculated to make sense of the statistical findings.

Table 1 Mean of correct answers in the Letters part, Number's part, and Combined part (N = 50)

	Mean	SD
Letter_OneChunk	5.02	2.24
Letter_TwoChunks	5.82	2.45
Letter_4_3_3	6.08	1.99
Letter_3_4_3	5.80	2.09

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Letter_3_3_4	6.52	2.19
Number_OneChunk	5.66	2.50
Number_TwoChunks	5.64	2.41
Number_4_3_3	6.74	2.31
Number_3_4_3	6.14	2.42
Number_3_3_4	6.72	2.28

The paired T-test revealed that the mean scores of correct answers based on student memorization of the textual information in the form of alphabets (10 randomly selected distinct alphabets) of the Two-Chunk ($\bar{x}$ = 5.82) and Three-Chunk ($\bar{x}$ = 6.13) chunking methods were significantly greater than that of the One-Chunk ($\bar{x}$ = 5.02) chunking method as shown in Table 2.

Table 2 T-test of the average number of correct answers in the part of the alphabet

	Mean	SD	t	df	Sig. 2-tailed
OneChunk - TwoChunks	-0.80	2.89	-1.96	49	.05
OneChunk - ThreeChunks	-1.11	2.51	-3.14	49	.00
TwoChunks - ThreeChunks	-0.31	2.06	-1.08	49	.28

The paired T-test revealed that the mean scores of correct answers based on student memorization of the textual information in the form of numbers (10 randomly selected distinct digits) of Three-Chunk method ($\bar{x}$ = 6.53) was statistically greater than that of the Two-Chunk method ($\bar{x}$ = 5.64) and that of the One-Chunk method ($\bar{x}$ = 5.66). However, no statistical difference was found between the mean scores gained from the Two-Chunk and One-Chunk method as shown in Table 3.

Table 3. T-test of the average number of correct answers in the numbers part

	Mean	SD	t	df	Sig. 2-tailed
OneChunk - TwoChunks	0.02	2.76	0.05	49	.95
OneChunk - ThreeChunks	-0.87	2.57	-2.40	49	.02
TwoChunks - ThreeChunks	-0.90	2.30	-2.75	49	.00

This study empirically portrays evidence to support that dividing textual information into different chunks can help improve the short-term memory capacity of learners. Apart from this theoretical contribution, the findings from this study can also be implicated in education to make instructors perceive the effectiveness of chunking information to facilitate students' memorization and maximize their learning potentials. When instructors were designing their teaching materials, such as preparing lecture slides or making video lessons, they should keep in mind that despite the length and depth of the lesson, they ought to categorize the large chunk of information into two or three smaller chunks. Nevertheless, they should also not put an excessive amount of information in a category as it might decrease the supposed effectiveness of chunking.

Additionally, the results would indicate that more learning techniques should be implemented to build these cognitive skills for learners. Various instructional approaches are believed to help students develop chunking skills by themselves, such as conceptual classification, tree-thinking, computational thinking, and binary thinking. It is likely that conceptual classification through thematic analysis and phenomenographic analysis can help students systematically organize ideas into categorical relationship where 2-3 chunks are divided, in which contain additional 2-3 sub-chunks (Yasri et al., 2013; Yasri & Mancy, 2014; Yasri & Mancy, 2016; Praputpittaya & Yasri 2020; Praputpittaya et al., 2020). Despite the fact that tree thinking is a crucial ability for scientists that could enhance in biology and another general public, it is still not being used enough in education (Novick & Catley, 2018) Recent researchers argue that by adopting the tree thinking method to help learners learn biology more effectively, their memorization outcomes substantially increase. (Mutiara, et al., 2020; Julaeha, et al., 2020). Moreover, the significance of computational thinking education in the twenty-first century must not be overlooked, as digital computing technologies had emerged into practically all human activities (Threekunprapam & Yasir, 2020a). In fact, the method has gradually been adopted to improve students' understanding of certain topics (Yadav, et al., 2017). To be more precise, many regions of the world put great attempts to implement this method into students' courses, including in the United States, Europe, and Asia (Threekunprapam & Yasir, 2020b). In addition, while binary thinking is mainly used in computer mechanisms (Gatenby, 2017), this tradition of binary thinking is also considered a foundation for the numerous forms of structuralism including education (Chalmeau, et al., 2019). Thus, regarding the result of this study, teachers are advised to use the strategy to facilitate students' understanding, hence, improving their ability to memorize new knowledge.

Of course, the intention of this suggestion is not for promoting memorization as an effective mode of learning. It is fully acknowledged that this is rather a lower-order thinking skill. However, it is undeniable that our daily life activities involve a certain degree of memorization, and this is the area that we would like to encourage instructors to adopt. Once students can be more effective in memorizing information, this would ease their learning skills in other advanced aspects such as understanding and application of content knowledge. In addition, our mere intention is to explain the phenomena in which we face on a daily basis when encountering textual information that is presented into 3 chunks such as advertisements, slogans, and 3-point sermons. Moreover, it is essential somehow for people to memorize things such as phone numbers of important people and/or places. Also, many students are required to learn to memorize something related to their learning materials, thus this could be an alternative strategy for them to adopt in time of need.

Furthermore, researchers interested in this strand of research in cognitive psychology may wish to extend the current study to explore the effect of other chunking methods such as 4 chunks or more. This can help advance our current understanding towards the maximum number of chunks that learners can retain within a short period of time. In addition, this study only focuses on a single type of textual information, either alphabets or numbers. It is also interesting to see in what ways learners' cognitive capacity would differ if the information is more complicated such as the combination of alphabets and numbers. This latter suggestion would be more practical in daily life as we do not always encounter single types of information. In addition, as indicated above, this present study only focuses on the effectiveness of short-term memory as a result of receiving textual information in the three different chunking methods. However, the descriptive statistics showed that the student participants could memorize the information both in the forms of distinct alphabets and distinct letters when they were delivered into 3 chunks. It is interesting to further investigate why the different patterns of the three-chucks yield different cognitive capacity. Also, it would be also interesting to see how participants with different age groups would perform in this

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process of experimentation. The cognitive capacity of younger students as well as older ones can be studied to compare against the results presented in this study.

Last but not least, it would be interesting to see how this chunking concept can be applied to actual instructional approaches, such as how to divide lesson plans into flows (chunks). For example, instead of delivering the whole content all at once, teachers could divide their lessons into three parts: the introduction, the body, and the conclusion. If they have topics to cover in the body part, they could also chuck them into 2-3 groups to help ease students to take in the information. Trails could be done with various learning settings such as game-based learning (Piyawattanaviroj et al., 2019; Meekaew & Yasri, 2020), blended learning (Seangdeang and Yasri, 2019; Maleesut et al., 2019; Ingkavara & Yasri, 2019), and hands-on learning activities (Changtong et al., 2020). This would provide greater insight into how to apply the chunking method to learning and teaching. Also, this could extend our current understanding of how chunking could yield some benefits to long-term memory.

CONCLUSION

Our short-term memory has a limited capacity of taking in information and retaining in the memory storage. However, this can be enhanced by various memory techniques, especially dividing the information into smaller chunks (not exceeding four chunks for a maximized ability). In addition, it was evident that for the information to reach the short-term memory, it must be unique and straightforward (single types of information rather than combined). However, to allow the information to be retrieved and retained more effectively, it is supposed to be delivered into different chunks. This study experiments that chunking textual information in the forms of 10 distinct alphabets and 10 distinct digits that are randomly selected into two and three chunks can help improve the cognitive capacity of the student participants (N = 50) to memorize the given information more effectively than the information that is delivered all at once. Based on the findings mentioned above, it could also be implicated in education to depict how chunking methods maximize students' learning potentials and short-term memory capacity. This study also suggests possible options for future research that can help advance our current understanding of the cognitive processing information, in particular the enhancement of our ability to retain information in our short-term memory.

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Appendix: Evaluation Form Key

Experiments			Digits									
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Letters	One-Chunk (10)		3	7	9	6	8	2	5	4	1	0
	Two-Chunk (5-5)		8	5	7	3	1	4	6	2	0	9
	Three-Chunk	4-3-3	2	6	9	5	8	0	4	7	1	3
		3-4-3	9	6	2	1	4	7	5	3	0	8
		3-3-4	5	1	8	4	7	9	0	2	6	3
Numbers	One-Chunk (10)		G	H	S	A	C	L	B	O	Q	D
	Two-Chunk (5-5)		H	M	A	L	C	Q	J	W	F	X
	Three-Chunk	4-3-3	I	M	G	Y	J	V	C	L	S	A
		3-4-3	P	L	G	O	D	H	V	U	B	I
		3-3-4	B	Y	I	V	W	C	H	D	K	M

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