Research Article

Increased Sensory Inputs Through Productive Learning Tasks To Enhance The Short-Term Memory Capacity: An Alternative To Nootropics

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Abstract: Nootropics are drugs that have been used as cognitive enhancers that many take to improve memory and mental alertness. However, taking any type of drug is likely to be associated with some risk either physiologically or psychologically. This study offers an alternative approach to this excess reliance on medication, that is the use of increased sensory inputs through productive skills to enhance the short-term memory capacity. There are times when a short attention span and an ineffective retention ability are caused by unengaging instructional approaches, not physiological factors.An experimental study was conducted among 50 high school students whose ability to remember a set of 10 distinct numbers was tested in two different settings: receptive learning through auditory and visual stimuli and productive learning through auditory and kinesthetic stimuli. The results showed that by incorporating the productive skills (i.e., speaking and writing), students' short-term memory of the numeric informationwas improved significantly at the statistical level of 95%. It therefore suggests that before deciding to take any medication, the first attempt to be made to help students concentrate more on learning and enhance their memory capacity is to intensify sensory inputs through the productive skills, rather than leaving them exposed only to the receptive tasks.

Keywords: short-term memory, productive skills, nootropics, kinesthetic learning, cognitive information processing

1. Introduction

Cognitive enhancers under the pharmaceutical title of nootropics are taken by some people to enhance their memory capacity, mental alertness and concentration (De Jongh et al., 2008). Despite the fact that this type of drugs has been used to treat conditions such as attention disorders and/or narcolepsy, many use nootropics to improve their cognitive performance (Dave & Cabrera, 2020). However, here comes a great concern as evidence showing that nootropics can help improve cognitive processes and performance is weak, while their side effects posing health risks seem apparent (Hall & Lucke, 2010). De Jongh et al. (2008) suggest that nootropics can help lessen psychological fatigue and boredom, but do not enhance the level of intelligence. In addition, the positive effects only last for a short period of time as long as the drug remains circulating in the body (De Jongh et al., 2008). In addition, some of these drugs may be harmful to teenagers as their neurological development is ongoing (Zaami et al., 2020).

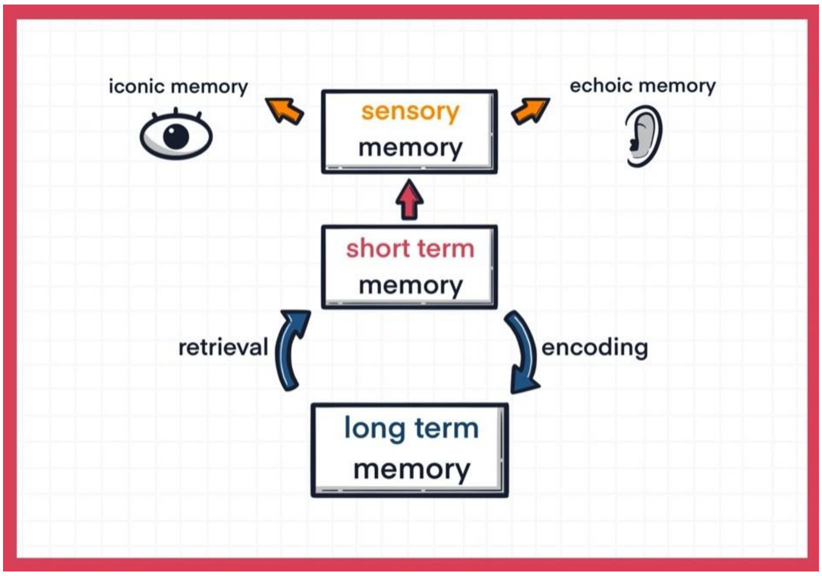
This study therefore turns to an alternative approach that is believed to help enhance cognitive performance without depending on medication. However, it is important to note here that we have no objections to using nootropics for those suffering from medical conditions as long as they are ethically prescribed with care by doctors. Our mere intention is to propose instructional strategies that are capable of catching students' attention and enhancing their memory capacity, especially the process of retaining short-term memory. A variety of educational frameworks focused on psychology of learning have been proposed to explain instructional approaches to enhance students' learning, mainly aiming to enhance cognitive skills. Among many others, this article focuses primarily on the model of cognitive information processing, VARK learning model, and productive skills in learning. These frameworks help teachers understand how students learn from both cognitive and pragmatic perspectives where cognitive information processing, learning styles based on preference to retrieve information, and ways to enhance students' attention and learning are considered in conjunction to form a coherent theoretical framework.

2. Cognitive Information Processing (CIP)

Cognitive Information Processing (CIP) is used to describe perspectives of learning that focus on how our cognitive processes such as attention, perception, encoding, storage, and retrieval of knowledge (see Figure 1). The theory is based on the analogy that our brain is like a computer where short-term memory is the processor and the long-term memory is the hard drive. *Short-term memory* is something that humans are aware of in a short period of time, for example, remembering seven digits. To be more precise, short term memory is limited in both duration and capacity.In terms of the duration, research suggests thatit works effectively in between 15 to 30 seconds, while its capacity can retrieve 5 to 9 items or a mean of 7 at a time (Gathercole & Baddeley, 2014).On the other hand, *long-term memory* holds a greater amount of information being stored for a much longer period of time. The process of taking a memory from our short-term memory and storing it into our long-term memory is called *encoding*. The process of taking old memory from our long-term memory and bringing it to our consciousness or our awareness or your short-term memory is called *retrieval*(Suppawittaya&Yasri, 2021).

However, for environmental stimuli to be taken to our short-term memory, they have to be detected by our senses, for which is called *sensory memory*. Sensory for visual information is called iconic memory, while auditory information is called echoic memory (Koshy et al., 2012). Since the capacity of short-term memory is limited, it can get overwhelmed when it experiences lots of sensory information all at once. The process of filtering out excess information and allowing important information to get in our short-term memory is called *selective attention*(Dayan et al., 2000). It is important to note that those with the attention deficit hyperactivity disorder (ADHD) often have trouble with this selective attention process which makes it difficult for them to concentrate and finish tasks. Therefore, some have to rely on medication to help improve the efficiency of this selective process (Booth et al., 2005).

Figure 1. Cognitive Information Processing (CIP)



Research suggests that humans have capacity limits to take multiple auditory inputs at the same time (Dayan et al., 2000). It is likely that even though we can hear different sources of information simultaneously, we tend to more effectively receive information from only one source, compared to the others. However, we can do visual and auditory tasks at the same time without a problem such as driving a car (visual) and listening to music (auditory). This led researchers to come up with a different conceptualisation of short-term memory called *working memory* components. It is commonly agreed among researchers to refer to working memory as the processes that are used to temporarily store, organise, and manipulate information; whereas, short-term memory refers only to the temporary storage of information in memory. In addition, working memory can be determined by forgetting causes postulated e.g., limited activation resources, time-based decay, interference due to confusion between items and preventative measures or mechanisms that improve capacity e.g., articulatory rehearsal, attention-based refreshing, and linkage to related information in long term memory(Gathercole & Baddeley, 2014).

3. VARK learning model

Stojanova, et. al. (2017) explain that the process of learning and understanding can be different for each person. The teaching methods are especially important for students to learn the curriculum, because not every student can learn the teaching material in the same way. Some students can learn better if they listen to the information, others use videos, presentations or graphs for better understanding and there are also some students who prefer to learn through practical examples. Chief among many learning theories is the VARK model which suggests that there are four main types of learners: visual, auditory, reading, and kinaesthetic. Although one may have a preferred mode of learning, it is possible that learners can be categorised as unimodal, bimodal, trimodal, or quad/multimodal (Mirza, et. al. 2020). This model has been extensively applied in various educational settings to help students learn more effectively (Stojanova, et. al. 2017). Also, when applied appropriately, this learning model can help improve students' learning performance (Goldschmidt & Smolkov, 2006).

An environmental stimulus stimulates our senses to create a perception which is the ability to see, hear, or become aware of something, in this case according to VARK theory. After we receive a variety of inputs through our senses, each of these is held in their own register, but only for micro seconds and then only some inputs are transferred to the short-term memory. Importantly each sensory registrar works in parallel and does not interfere with each other. Sanchez et. al. (2019) also add the same idea of a cognitive information processing system. A cognitive inference and learning system worked together to receive data from many sources, they provide cognitively processed insights, the cognitive inference and learning system further comprising performing a learning operation to repeatedly improve the cognitively processed insights over time.

4. Kinesthetic learning

Kinesthetic learning, also known as tactile learning, is a learning style that allows students to carry out physical activities, rather than passively listening lectures and/or watching demonstrations. Depending on levels of education and learning contexts, kinesthetic learning can appear in the forms ranging from whole-body movement suitable for younger learners, and hands-on activities for STEM activities (Changtong et al., 2020), to the incorporation of productive skills i.e., writing and speaking suitable for language acquisition as well as active mental engagement (Treerattanaphan, 2021). Research suggests that this form of learning can help improve students conceptual understanding, motivation to study, self-efficacy in learning (Threekunprapa&Yasri, 2020a, 2020b). In addition, it has been proven effective among slow learners (Seangdeang&Yasri, 2019; Ingkavara&Yasri, 2019). Last but not least, a great deal of empirical evidence shows that it can effectively engage students to learning through the use of game-based learning (Piyawattanaviroj et al., 2019; Meekaew&Yasri, 2020), which students themselves find it useful and would be willing to participate in hands-on activities(Maleesut et al., 2019). However, little has been shown how students' short-term memory capacity can be benefited from kinaesthetic learning, despite knowing the fact that students perceive that it can help them retain their knowledge for a longer period time, i.e., long-term memory (Maneejak&Yasri, 2020).

5. Research objectives

This study aimed to examine how various environmental stimuli (visual, auditory, and kinesthetic) which are delivered in the forms of receptive and productive learning impact on students' short-term memory capacity to retain numeric information (10 distinct numbers). The visual stimulus was given by showing the 10 distinct numbers. The auditory stimulus was given by a voice record of the numeric information. The kinesthetic stimuli were given into two different tasks: writing and speaking. It was hypothesized here that learning with the productive modes (kinesthetic learning) allows students to better retain the given information compared to the receptive modes, based on statistical validation.

6. Methodology

The participants in this study were 50 high school students in Bangkok. Prior to the process of data collection, the participants were informed about research objectives and procedures. Once they agreed to participate in this, all participants received an answer sheet where they wrote down the numbers that they could remember from the test. Each participant was assigned to work on 4 different tasks (Table 1), each of which with 3 repetitions. An example of the answer sheet containing the tasks given to a particular participant is proved in the Appendix. The first task was for them to listen to a set of 10 distinct numbers using a pre-recorded audio which was played once only, and to write down those in the answer sheet immediately (only auditory stimuli). The second task was for them to listen to another set of 10 distinct numbers and to see those numbers at the same time, and write down also in the answer sheet (auditory and visual stimuli). The third task was for them to listen to another set of 10 distinct numbers and to write down the numbers in another blank paper, before writing down the numbers once again in the answer sheet (auditory and kinesthetic stimuli). The fourth task was for them to listen to another set of 10 distinct numbers and repeat the number out loud by themselves, before writing down the numbers in the answer sheet(auditory and kinesthetic stimuli).

The intention of this experimental design is to determine how different stimuli of the same type of retrieved information (10 distinct numbers) can impact on students' short-term memory capacity. Tasks 1 and 2 are considered learning with receptive skills, composing of listening and reading, as tasks involve receiving information. On the other hand, tasks 3 and 4 are considered productive skills as they both require some form of language output, i.e., writing and speaking.

Table 1. Four tasks with different stimuli

Task	Stimuli	Learning skill
1	Auditory only	Receptive
2	Auditory and visual	Receptive
3	Auditory and kinaesthetic (writing)	Productive
4	Auditory and kinaesthetic (speaking)	Productive

Thedata analysis adopted both descriptive and inferential statistics. The mean scores the student participants gained from each of the tasks were calculated. Then, a paired t-test was performed to determine whether there was statistical evidence that the mean difference between two sets of observations on a particular outcome was significantly different. To elaborate more, a paired t-test or dependent sample t-test is used when we are interested in the difference between two or more variables for the same subject, in this case 4 different tasks were done by the same participants.

7. Results

According to Tables 2 and 3, the highest mean score at the significance level of 95% was shown in Task 4 where the student participants were exposed to the productive learning receiving the information (10 distinct numbers) via auditory stimulus and producing the outcome via speaking ($\bar{x}$ = 9.90). Coming the second was the mean score gained in the other form of productive learning (Task 3), receiving the information via auditory stimulus and producing the outcome via writing ($\bar{x}$ = 9.63). It is important to note that both exhibited relatively low standard deviation indicating that the scores tended to be very close to the mean.

Table 2. Mean scores gained by students participating in the four tasks

Task	Min	Mean	Max	S.D.
1	6	8.98	10	0.74
2	6	8.88	10	0.85
3	8	9.63	10	0.36
4	8	9.90	10	0.15

Table 3. P-values based on the paired t-test analysis

Pair	P-value
Tasks 1 and 2	0.56
Tasks 1 and 3	0.00
Tasks 1 and 4	0.00
Tasks 2 and 3	0.00
Tasks 2 and 4	0.00
Tasks 3 and 4	0.00

Interestingly, the mean scores exhibitedwhen participating in the receptive learning in Task 1 receiving auditory stimulus only ($\bar{x}$ = 8.98) and Task 2 receiving auditory and visual stimuli ($\bar{x}$ = 8.88) did not differ significantly, yet both were statistically lower than the two means from the productive learning at the significance level of 95%. On top of this, their relatively high standard deviations indicated that the data points were spread out over a large range of values.

8. Discussion

To begin with, the hypothesis being tested in this research was found to be accurate. The same group of participants when being exposed to Tasks 3 and 4 where they exercised the productive skills in the forms of writing and speaking could gain a statistically higher mean compared to their own ability when being immersed in Tasks 1 and 2 where the receptive skills were emphasized. From an educational perspective, this can be explained that the students were more active mentally and physically in the two productive tasks, making them attend to the given information more carefully so they could retain the information more precisely. From the cognitive processing information theory, this could be explained in the light that the students in these learning modes were given stronger sensory inputs which allow them to retrieve the information in their short-term memory storage more precisely. To be more precise, when participating in Task 1, the only sensory input that existed was the auditory stimulus from hearing the numeric information from the pre-recorded voice. In Task 2, in addition to the auditory input, the participants were given an extra stimulus which was a visual input through see the 10 distinct numbers simultaneously. However, these two forms of sensory inputs did not show their effectiveness to enhance short-term memory capacity of the participants compared to the other two productive tasks. This is perhaps because the increased the sensory inputs, the better the short-term memory capacity. In Task 3 where the participants listened to the numeric information and subsequently noted it down, before filling in the answer sheet in the end. Their first sensory input was the auditory stimuli. When noting the numbers down, they receive two additional stimuli including kinesthetic stimulus while writing and visual stimulus while seeing what they noted. This cognitive process is believed to contribute to the greater outcomes gained in this certain task. Likewise, in Task 4 where the participants received the auditory stimuli at first and then produced their speaking task which was basically reciting the number out loud, they also tended to receive at least three sensory inputs, starting from the auditory input, followed by a kinesthetic stimulus when they began to speak, then their own voice returned to their auditory sensory, receiving another auditory input, before producing the final answer. Therefore, to conclude this, in the productive tasks, the student participants received increased sensory inputs both from the given information and from their own kinesthetic responses. This is believed to be the explanation for their high scores gained in this learning simulation.

Admittedly, the findings discussed above require further studies to validate, especially from the lens of neuroscience. Nonetheless, if this is the case, educational implications can be suggested from these results. First, the comparison between the means of Tasks 1 and 2 suggest that regardless of the number of sensory inputs the students receive, as long as it is a receptive mode of learning, the learning outcome is unsatisfactory. It can be picturized that in Task 1, students keep listening to the lecture without any physical or mental activeness, and in Task 2, they listen to the lecture and see the slides being shown by the teacher. These two learning environments would yield no different outcomes. In contrast, when they are allowed to do some kinesthetic tasks, either writing (taking note) or speaking (discussion), they can effectively enhance their level of mental capacity. It can be assumed that as the participants could enhance their short-term memory capacity in this study, the retained information if further rehearsed, it can sufficiently proceed with the long-term memory storage which is the most beneficial for learning. Second, although subtle, it is promising that speaking would be more effective in learning compared to writing, as evidenced in the comparison between the results from Tasks 3 and 4. Having said that educational implications would be made in the integration of both productive tasks together to maximize the benefits for students.

Returning to the title of this article, it aims to offer kinesthetic learning as an alternative for using medication through nootropics. Although the participants in this research do not have any disorder related to cognitive information processing, thus no medication is required, their performance gives us some suggestions that teachers may wish to try this alternative approach first. This would involve no alteration of brain chemistry and produce little harm to students themselves and their learning. However, if this does not work, the medication process can be further proceeded with care under the supervision of experienced doctors. A case can be given by the study of Ingkavara & Yasri (2019) whose results revealed that once being taught properly through attention and care, students with learning disabilities could enjoy their mathematics lessons more, stay with given tasks much longer, and perform better in the end, without having to take medication. Also, Trout et al. (2007) provide an intensive review for non-medication treatments for attention-deficit/hyperactivity disorder (ADHD) learners, claiming that it is still possible to enhance their academic performance when instructional approaches are adopted appropriately. Among many other instructional approaches, the COPE learning model is suggested to help students engage with multiple sensory tasks according to the VARK model and to develop their social skills when working with peers (Praputpittaya & Yasri, 2020). This learning model does not only concern multiple stimuli, but also various responsible tasks for students to learn which can effectively help students with a shorter span of attention to be engaged in the lesson longer.

9. Conclusion

This study aimed to examine how various environmental stimuli (visual, auditory, and kinesthetic) which are delivered in the forms of receptive and productive learning impact on students' short-term memory capacity to retain numeric information.An experimental study was conducted among 50 high school students whose ability to remember a set of 10 distinct numbers was tested in two different settings: receptive learning through auditory and visual stimuli and productive learning through auditory and kinesthetic stimuli. The results showed that the memory performance of student participants in the productive tasks (writing and speaking) outperformed their own ability in the receptive tasks (listening and watching) at the statistical significance level of 95%. From an educational perspective, this can be explained that the students were more active mentally and physically in the two productive tasks, making them attend to the given information more carefully so they could retain the information more precisely. From the cognitive processing information theory, this could be explained in the light that the students in these learning modes were given stronger sensory inputs, especially kinesthetic ones, which allowed them to retrieve the information in their short-term memory storage more precisely. Educational suggestions would be made. In general, it is important to adopt kinesthetic learning tasks where students practice their productive skills in classrooms as this would help enhance students' memory capacity especially the short-term memory. In addition to this, for students with learning difficulties who are physiological affected by their own mental condition, prior to reaching medication as a solution, it is advised for teachers to try to integrate kinesthetic tasks for them to engage so that reliance on medication which can potentially results in a diverse range of side effects can be avoided.

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