

The role of cognitive factors in the effectiveness of multimedia learning in the University students



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Abstract

A core premise behind multimedia learning research is that it seems to be more likely to result in more effective learning than those that are not set accordingly. This empirical study investigates the impact of attentional performance, working memory capacity and the effect of number of multimedia elements on the recall performance of university students in a multimedia learning environment. It is predicted that the performance of individuals will increase as the number of multimedia learning materials increases. Furthermore, the individuals who have better working memory capacity and perform better in the attentional performance test recall more information from the presented subject material. In this study, individuals ($M = 21.3$; $SD = 3.02$) were introduced to a topic in four different conditions by the same lecturer. After the presentation, post-tests were conducted to assess the recall performance, working memory capacity and attentional performance of the participants. It's important to highlight that a language test was conducted in order to understand their English proficiency. According to our results, there was an effect of the number of multimedia elements on the performance of the participants, more multimedia elements resulted better performance on the post-test. Furthermore, attentional performance and language skills of the individuals influenced the recall performance. This study provided a guidance to educators in the University about the effect of multimedia learning capacities in the purpose of learning.

Keywords: Multimedia Learning, Working Memory, Attentional Performance, Recall Performance

Table of Content

1. Introduction	3
1.1. Multimedia Learning Setting in Learning and Teaching	3
1.2. Working Memory Capacity with Multimedia Learning Setting	7
1.3. Attentional Performance in Multimedia Setting	8
2. Hypothesis	11
3. Methods	11
3.1. Participants	11
3.2. Materials	11
3.2.1. Demographic Questions	11
3.2.2. Learning Material.....	11
3.2.3. Recall Performance	12
3.2.4. Attentional Performance	13
3.2.5. Working Memory Capacity	13
3.2.6. Adult ADHD Self-Report Scale	14
3.2.7. Language Test	14
3.3. Procedure	14
3.4. Statistical Analysis	15
4. Results	15
5. Discussion.....	17
6. References	22

1. Introduction

According to research concerning the use of multimedia in instruction, achievement among students is positively impacted by this format. In this paper we wanted to search about whether students who learn a particular subject — such as mathematics or social studies — using multimedia learning techniques such as video, 3D technologies, animation, etc. — perform better in tests than students who learn the same topic using traditional teaching techniques. A core premise behind multimedia learning research is that multimedia learning messages that are developed with the human mind in consideration seem to be more likely to result in more effective learning than those that are not set accordingly. This review investigates the impact of attentional performance and working memory capacity on the recall performance of university students in a multimedia learning environment. We are interested in how young adults' attentional skills and working memory capabilities affect their recall abilities. It is assumed that as the quantity of multimedia educational material increases, so will personal performance. Additionally, those who do higher on the selective attention test performed and also have greater working memory capacity are able to retain more details from the lectured material.

The success stories of multimedia learning tools in teaching and learning processes vary with target age, demographic differences, and location where the experiment was conducted. Therefore, this paper aims to investigate the influence of attentional performance and working memory capacity on recall performance of university students in a multimedia learning setting.

1.1 Multimedia learning setting in learning and teaching

Individuals acquire information through listening, reading, or hearing the information in our daily life. We can also highlight that people learn information more deeply by combining both text and illustrations rather than using only one of them alone. Early educational testing dates to the Middle Ages, with the development of the earliest universities in Europe in the 1300s. To provide applicants for degrees with a chance to show their ability, official oral assessments and instruction were developed. Written tests and lessons overtook oral exams and lectures in the majority of academic contexts as paper became much more affordable and widely accessible. Since then, words have become the principal means of education for centuries. Advances in computer and communication technologies led to an increase in the usage of more

visual representations, like dynamic images, animations, graphs, and video, in education which enhance the understanding or memorisation of knowledge not only with words but also with pictures. Presenting both words (such as spoken text or printed text) and pictures (such as illustrations, photos, animation, or video) (Mayer, 2014, pp.22) are known as multimedia.

Multimedia is a combination of more than one media type such as text (alphabetic or numeric), symbols, images, pictures, audio, video, and animations usually with the aid of technology for the purpose of enhancing understanding or memorization (Abdulrahman et al., 2020, pp.1). However, we also need to keep in mind that depending on the individual, using an excessive number of multimedia materials might cause a distraction for the individual.

A crucial question is how to define a style of presentation when multimedia entails delivering information in two or more different formats. There are three approaches to this problem which are the presentation modes, sensory modalities, and the delivery media view. The delivery media view, multimedia requires two or more delivery devices (Mayer, 2014, pp.23). These devices can be a computer screen, speakers, or the lecturer's voice with the projector. According to the presentation modes view, multimedia requires verbal and pictorial representations (Mayer, 2014, pp.23). For this mode of view using printed texts with the pictures or diagram can be an example. Last but not least, according to the sensory modalities view, multimedia requires auditory and visual senses (Mayer, 2014, pp.23). These can be narration of a lecture and the slides with the animation. Overall, multimedia only highlights the importance of using the words and pictures together.

Multimedia learning, on the other hand, refers to the learner's construction of knowledge from words and pictures (Mayer, 2014, pp.24). When humans construct mental structures via words (such as spoken text or written word) and images (such as animation, photos, or video), multimedia learning occurs. As this definition makes clear, multimedia pertains to the display of words and images, while multimedia learning corresponds to how the learner constructs knowledge from images and words. Lastly, multimedia instruction (or a multimedia learning environment) involves presenting words and pictures that are intended to promote learning (Mayer, 2014, pp.24). This is a design where it enriches the learning environments where the individuals then build mental representations easily.

The purpose of researching multimedia learning is represented by the multimedia principle. There is evidence that suggests that, in some situations, people learn more profoundly through words and pictures together than those from words alone. The multimedia learning highlights the fact that the instructional materials must be created with consideration for the way the human mind functions. Overall, Multimedia researchers are particularly interested in how individuals learn from text and visuals, and how to create engaging multimedia learning environments to enhance the construction of mental images from words and images.

It has been demonstrated, by research on using multimedia for learning, that there are more positive results observed in learners who combine pictures and words than those who use words only (Abdulrahaman et al., 2020, pp.2). In general, multimedia learning techniques can be divided into two as to whether they are effective to be used as teaching techniques or for learning techniques. Some of the benefits of the multimedia application tools for teaching and learning are summarized as follows:

- (1) Ability to turn abstract concepts into concrete contents
- (2) Ability to presents large volumes of information within a limited time with less effort
- (3) Ability to stimulates students' interest in learning
- (4) Provides teacher with the ability to know students position in learning (Abdulrahaman et al., 2020, pp.2).

Learning multimedia necessitates an awareness of a few notions such as the cognitive theory of multimedia learning, which states three assumptions about how individuals learn from instructive multimedia content, are required for multimedia produced for learning. Mayer, (2017), explores three assumptions underlying a cognitive theory of multimedia learning – dual channels, limited capacity, and active processing. The dual-channel assumption is that humans possess separate information processing channels for visually/spatially represented material and auditorily/verbally represented material (Mayer, 2017, pp.47). It is proposed that a visual/pictorial channel along with an auditory/verbal channel make up a person's information processing platform. Humans start to carry out a comparative in the visual channel when it is offered to the vision (such as in graphics, motions, videos, or even on texts), and within the auditory channel when it's delivered towards the hearing (such as in narratives or nonverbal noises). Even though instruction gets into the individual's information system by way of one channel, humans have the capacity to adapt it to another channel. For instance, illustration of a

cloud moving up above to the freezing level is firstly handled in the visual channel of the individual, but the individual could also be capable of mentally putting together the appropriate spoken explanation in the hearing pathway.

The second assumption is that humans are limited in the amount of information that can be processed in each channel at one time (Mayer, 2017, pp.49). Once an illustration or animation is being shown, the individual could only keep a small number of pictures within the visual channel of working memory in one go, remembering just a piece of the supplied information instead of an identical version. It is important to highlight that we need to consider that each channel might have a limited procedure capacity. Additional tests like memory tests, need to be conducted in order to understand how much knowledge can be processed.

The third assumption is that humans actively engage in cognitive processing in order to construct a coherent mental representation of their experiences (Mayer. 2017, pp.50). These cognitive activities involve attending to pertinent incoming information, arranging that data into a cohesive mental representation, and fusing that knowledge with existing information. Individuals are active thinkers that attempt to comprehend the meaning of multimedia displays, to put it simply. Contrary to popular belief, individuals are active learners that strive to add quite enough knowledge to recall as possible, preserving duplicates of current experiences in memory like tape recorders to be played back at a later time.

Images and words come into the multimedia presentations and go directly into the sensory memory with the help of eyes and ears. In this memory part, it allows for pictures and printed text to be held as exact visual images for a very brief time period (Mayer, 2017, pp.52). Following that the knowledge goes into the working memory where the main work of multimedia learning happens. Working memory is used for temporary holding and manipulating knowledge in active consciousness (Mayer, 2017, pp.53). Finally, the knowledge is stored in the long-term memory. Unlike working memory, long-term memory can hold large amounts of knowledge over long periods of time but to actively think about material in long-term memory it must be brought into working memory (Mayer, 2017, pp.54).

In sum, while targeting varied learners' demands, the multimedia is a combination of more than one media type like text, pictures, audio, video, and animations usually with the aid of

technology for the purpose of enhancing understanding or memorisation of the knowledge. However, we also need to keep in mind that depending on the individual, using an excessive number of multimedia materials might cause a distraction for the individual.

1.2 Working memory capacity with multimedia setting

According to the article by Alan Baddley (1992) the term working memory refers to a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning and reasoning. Working memory is where the majority of multimedia learning takes place. Mayer (2017) indicated that working memory is used for temporary holding and manipulating knowledge in active consciousness.

According to the article by Alan Baddeley and Robert Logie (1999, pp.2),

“working memory comprises multiple specialised components of cognition that allow humans to comprehend and mentally represent their immediate environment, to retain information about their immediate past experience, to support the acquisition of new knowledge, to solve problems, and to formulate, relate and act on current goals.”

Such activities require a working memory system that is both dynamic and flexible in its capabilities, and this was one major attraction of the working memory formulation over the simpler modal model (Morris & Jones, 1990, pp.112)

It has been discovered that working memory requires the simultaneous processing and storing of information. It may be decomposed into three parts as, the central executive, the visuospatial sketch pad, and the phonological loop. An articulatory loop, holding speechlike representations; a visuo-spatial scratch pad, holding imaginal representations; and a central executive, which acts as an overseer directing attention and coordinating the activities of the other components (Morris & Jones, 1990, pp.111). Accordingly, it is likely that any accurate representation of the phonological loop will share a great deal of similarities with an adequate model of language comprehension and vocabulary development. The mechanisms of visual perception and action are most likely closely tied to the visuospatial sketch pad. Lastly, the central executive certainly displays a system focused on the attentional regulation of behaviour, and later changes will almost likely be influenced by concurrent advancements in the research on attention and the control of action.

In the relation with the working memory the central executive system is the more crucial part of the working memory as Baddeley (1986) suggested that the central executive may act as a kind of supervisor involved in the selection of strategies and integration of multiple courses of information (Morris & Jones, 1990, pp.119). Morris also mentioned that the central executive is 'coupled' to the visuo-spatial sketch pad during active encoding of spatial material and that this coupling is broken during maintenance rehearsal to liberate executive resources for other tasks after such encoding (Morris & Jones, 1990, pp.119)

Working memory is based on two representations modes which are named pictorial and verbal (Mayer, 2017, pp.53). While the visual and auditory half reflects the raw material which enters working memory by visual information of images and audio impressions of words, the graphical and verbal side represents the knowledge generated in working memory using graphical and verbal representations and relationships between them.

The notion of a working memory system, which spontaneously retains data as a component of the accomplishment of complicated cognitive tasks, is improving rapidly. Studies that have utilized the individual difference approach have linked working memory to performance on a range of important tasks, including language comprehension and reasoning (Baddeley, 1992, pp.559)

To summarize everything that has been written, working memory is the vital part of cognition that allows individuals to perceive as well as mentally represent their immediate environment, store information about past experiences, facilitate knowledge acquisition, solve issues, connect, and act upon current objectives. Multimedia learning happens within the learner's information processing model, which includes different channels for verbal and visual computation, a system with severe capacity constraints for each channel, and a framework which needs proper cognitive processing for each channel for active conditions for learning.

1.3 Attentional performance in multimedia learning

School, employment, and relationships are just a few of the many spheres of life where attention is crucial. It enables individuals to concentrate on details in order to make memories. Additionally, it enables people to put aside outside distractions in order to concentrate and finish particular activities.

With the development of technology, multitasking has become increasingly desirable, possible, and frequently necessary. Despite the fact that multitasking is the simultaneous performance of many tasks, the majority of tasks that call for active attention cannot really be completed at the same time. Considering this, it is frequently a matter of interpretation whether every activity is deemed multitasking. People are often urged to multitask, for example, watching TV while working out or listening to music while studying. We constantly encounter situations when it is recommended that we focus on several things at once rather than just the one item at hand, however the question of whether this is even possible persists.

Psychologist and philosopher William James wrote in this 1890 book “the principles of psychology” give the definition of attention as;

“It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains [p. 404] of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state which in French is called distraction, and Zerstreutheit in German.” (James, 1890, pp. 403-404)

We can call attention as a highlighter, and which avoids distractions and focuses on our studies. People may employ a variety of attention techniques. These are: sustained attention, selective attention, alternating attention, focused attention, and limited attention.

We must be judicious about what we choose to focus on because attention is a finite resource. We need to filter out a huge number of other things in our surroundings in addition to focusing on a certain thing in it. Selective attention refers to the differential processing of simultaneous sources of information. In nature these sources are internal (memory and knowledge) as well as external (environmental objects and events) (Johnston & Dark, 1986, pp.44).

To give an example, in 1953, Cherry used the "cocktail-party problem" to highlight the main questions of selective attention. The cocktail party problem (CPP), first proposed by Colin Cherry is a psychoacoustic phenomenon that refers to the remarkable human ability to selectively attend to and recognize one source of auditory input in a noisy environment, where the hearing interference is produced by competing speech sounds or a variety of noises that are often assumed to be independent of each other (Haykin & Chen, 2005, pp. 1875).

One of the factors which determine the academic achievement in students is the selective attention. Among the latter, the ability to focus on the task at hand and ignore distraction, also

termed selective attention, appears to have reverberating effects on several domains important to academic foundations, including language, literacy, and mathematics (Stevens & Bavelier, 2012, pp.30).

It is necessary to think about how domain-specific abilities may crucially leverage domain-general selective learning ability in an educational period focused with letters and numbers and the simple evaluation of skill sets. Selective attention training and assistance may be used as a force multiplier across domains to the extent that it is appreciated. This places further stress on the scientific community to create accurate and reliable measures of certain attentional traits that will be responsive to developmental change throughout the time periods necessary for evaluating educational and intervention outcomes in an era of accountability.

In order to develop a meaningful mental representation of their surroundings, people actively participate in cognitive functioning. Paying enough attention to pertinent incoming information, arranging coming elements into a single cognitive system, and integrating receiving the information with some other information are examples of active cognitive processes. According to Mayer (2017), there are three cognitive processes which are crucial for active learning: selecting relevant material, organizing selected material, and integrating selected material with existing knowledge. Selecting relevant material occurs when a learner pays attention to appropriate words and images in the presented material (Mayer, 2017). This method involves transferring input from the environment into the cognitive system's working memory. Organizing selected material involves building structural relations among the elements – such as one of the five kinds of structures described in the preceding section (Mayer, 2017). In working memory, this process entails cognitively organizing selected data into a logical cognitive framework. Lastly, integrating selected material with existing knowledge involves building connections between incoming material and relevant portions of prior knowledge (Mayer, 2017). This procedure entails linking cognitive structures to one another as well as transferring relevant past knowledge of long-term memory to working memory.

In sum, humans use cognitive processing to create a logical mental picture of their experiences. Paying very close attention to pertinent new information, organizing new information in a single cognitive system, and combining receiving information with the other information are examples of active cognitive processes. In a nutshell, humans are dynamic processors that try to decipher multimedia displays.

2. Hypothesis

In this paper, we wanted to observe the influence of attentional performance and working memory capacity on recall performance in university students in a multimedia learning setting. We predicted that by manipulating the number of multimedia elements, the performance of the individual will increase. In addition to this, we predicted that the participants who perform better in the attentional performance test, which is an indicator of sustained and selective attentional abilities, and have better working memory capacity, remember more details from the subject materials.

3. Methods

3.1 Participants

Participants were second-year international bachelor's degree students in psychology from the Faculty of Humanities and Social Sciences (PTE-BTK) of the University of Pécs. Before the experiment, an informed consent form was distributed to the participants. Overall, 41 individuals attended between 20 to 41 years of age ($M = 22.8$; $SD = 5.57$). All the participants signed the consent form. Totally we had 41 participants, 24 of them were female, 10 of them male and 4 of the participants did not share their genders. All the participants were adult individuals with no neurological or other disorders reported by themselves.

3.2 Materials

3.2.1 Demographic Questions

To have a demographic knowledge about the participants, we asked them to fill out a short demographic questionnaire after signing the informed consent form. We asked their age, gender, personality psychology seminar group they belong to, how many hours they sleep ($M = 6.82$, $SD = 1.32$), asked their caffeinated beverage and lastly how tired they felt out of 10 ($M = 5.37$, $SD = 2.33$).

3.2.2 Learning Material

After completing the demographic questionnaire, according to the syllabus of the personality psychology lecture, Cloninger's personality dimensions topic was shown to the participants during the multimedia exposure. Multimedia presentations were created with Microsoft

PowerPoint. We created three presentations with the same text and visuals. Each slideshow had, including the title page, 17 pages, 4 slides for each condition. Related to the topic, multimedia elements like animation, pictures and small videos were available in the slides. Each presentation contained slides with 0, 1, 2, and 3 multimedia elements. The order of the number of multimedia elements were counterbalanced across the seminars. For example, in the first slide of group 1, there was only one multimedia learning material, in the first slide of group 3 there was only 2 multimedia learning materials.

3.2.3 Recall Performance

Right after the presentation, a post-test was conducted regarding the lecture. The post-test created by us was related to the presentations. Each question's multimedia learning material varied for every group; however, all the groups had the same number of multimedia learning materials (control = 4; multi 1 = 4; multi 2 = 4 and multi 3 = 4; the title page did not include any multimedia learning material). For everyone, at the end, the overall calculation was made for control, multimedia 1, 2 and 3 conditions separately. Overall, we had 32 multiple choice questions and each slide had two questions about it. In general, we had 8 multiple choice questions per condition. As you can see from table 1., the standard deviation of the post test questions varies from 1.72 to 1.91.

Table 1. - Descriptive statistics for post test questions results separated by conditions

	control	Multimedia 1	Multimedia 2	Multimedia 3
Mean	3.59	3.37	4.00	4.44
SD	1.84	1.79	1.72	1.91
Minimum	0	0	0	1
Maximum	8	7	7	8
Skewness	0.122	0.162	-0.0934	-0.0757
Kurtosis	-0.368	-0.659	-0.562	-1.13
Shapiro-Wilk p	0.182	0.107	0.135	0.016

3.2.4. Attentional Performance

To test the attentional performance of the participants, we used the D2 test of attention which is a timed test of selective attention and is a standardized refinement of a visual cancellation test (Brickenkamp & Zillmer, 2008). D2 test is a timed paper and pencil test which assess in response to the discrimination of similar visual stimuli, the test measures processing speed, rule compliance, and quality of performance, allowing estimation of individual attention and concentration performance (Brickenkamp & Zillmer, 2008). The task involves a high level of focus and physical resistance. The letters d and p with one to four slashes are positioned separately or in pairs on and around the letter in the test items. To identify each d, the individual must scan through each line and cross it out with two dashes.

All other letter and line combinations are considered "irrelevant," and should not be canceled out. A practice sample is included with the test form, as well as spaces for collecting identifying data and analytical scores. The standardized exam, on the other hand, consists of fourteen lines, each one with 47 figures, for a maximum of 658 items. Each line has a time limit of 20 seconds for the subject.

In order to assess their performance, the total number of figures they evaluated (N), the total number of errors (E) and the total number of the omissions (O) were registered. We used these terms to calculate the attention performance of the participant with the following equation: $((E+O)/N) \times 100$. It's important to highlight that the higher scores in this test indicate the worse attentional performance of the individual. Achieved scores in this test differ from 1.25 to 19.04.

3.2.5. Working Memory (WM) Capacity

We used the Backward Digit Span test, the most commonly used test in clinical neuropsychology to assess working memory capacity (Hilbert et al., 2015). The digit span is basically following a single auditory/visual exposure of a number of digit numbers from a sequence that an individual can recall. The Digit Span Backward assesses the number of digits an individual is able to repeat immediately following their presentation, but in reverse order (*Apa Dictionary of Psychology, (nd.)* digit span). Participants were asked to follow the slides carefully to a sequence of digits and then write them down on a piece of paper. The number of integers increased by one after two sequences. The score of the digit span is calculated when the participant made errors in two consecutive same-length sequences and the last correct

sequence indicates the digit span of the participant. Higher scores in this test show that the individual has greater Working Memory capacity. For normal adults, the typical digit span is seven plus or minus two. As it appears in the figure 1. our participants achieved scores differing from 5 and 9 sequences with mean score of 6.77.

3.2.6. Adult ADHD Self-Report Scale (ASRS-v1.1)

The participants were asked to complete the Adult ADHD Self-Report Scale (ASRS-v1.1) (Blanco et. al., 2009). It is based on the diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) of the American Psychiatric Association (Blanco et. al., 2009). We used the short version of the ASRS v1.1 Screener for ADHD. Each of the items in this scale was rated on a 5-point Likert-type scale ranging from Never to Very-Often. Participants were asked to put “X” in the box which describes the best about how they felt over the past six months. This scale has fairly high psychometric properties. Results from McDonald's ω were 0.789 for ADHD Self-Report Scale.

3.2.7 Language Test

We conducted The European Language Certificates (TELC) (*Telc NYELVIZSGA* 2022) to the participants. We used the English language test in order to understand the language efficiency of the participants.

3.3 Procedure

The study was conducted in the personality psychology seminar groups at the University of Pecs. Individuals who participated in the study was registered to these courses at the beginning of the semester with their own preference. They were introduced to the same topic by the same professor but with three different PowerPoint presentations. The presentations only differed in the order of the multimedia learning conditions. The presentations were presented by the projector. The slides were divided into 4 conditions, control, multi 1, multi 2, and multi 3 which indicates that there is no multimedia learning material in the control slide, while there is only one multimedia learning material in the multi 1 slide, and so on. Each of the presentations included four control, four multi 1, four multi 2, and four multi 3 slides. In each group, participants were exposed to one of the presentations which were explained by the same lecturer. Right after the lecture, a post-test was conducted to assess the recall performance of

the participants in multimedia learning setting. After the test, attentional performance and the working memory capacity of the participants were tested using the D2 test of attention and the Backward Digit Span test. Lastly, participants were asked to fill out the Adult ADHD Self-Report Scale. It's also important to note that, a language test was conducted to test whether their English proficiency is enough to understand the lecture and follow the instructions. All the university students participated individually; they were informed to not discuss the questions.

3.4 Statistical Analysis

Statistical analyses were conducted using the JAMOV Statistics Programme (Version 1.6.23 for macOS).

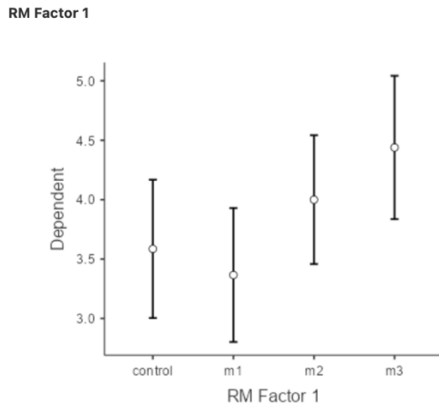
To test our hypothesis, we conducted, repeated measures of ANOVA test for all the dependent variables without any covariates. After that, a covariance analysis test was performed with four covariates. Working memory capacity, attentional performance, Adult ADHD Self-Report Scale, and language test were entered as covariates. Follow-up correlation analyses were conducted to test significant interactions.

4. Results

Results from the repeated measures ANOVA indicate that, between the dependent conditions, there is a significant effect ($F(3,40) = 3.47$, $p = 0.018$, $\eta^2 = 0.080$). According to the result from Tukey Corrected Pairwise comparison, we can say that in between the dependent variables only Multi 1 and Multi 3 ($t(40) = -2.899$; $P_{tukey} = 0.030$) had a significant result. Control and multi 1 ($t(40) = 0.598$; $P_{tukey} = 0.932$), Control and multi 2 ($t(40) = -1.206$; $P_{tukey} = 0.627$), Control and Multi 3 ($t(40) = -2.069$; $P_{tukey} = 0.181$), multi 1 and multi 2 ($t(40) = -2.274$; $P_{tukey} = 0.121$), and lastly, multi 2 and multi 3 ($t(40) = -1.177$; $P_{tukey} = 0.645$) had a nonsignificant results.

Figure 1 – The distribution of recall performance on the post-test in the four conditions (control multi 1, 2, and 3)

Estimated Marginal Means



To measure the Working Memory capacity, the Backward Digit Span test conducted, and results showed that WMC ($F(1,28) = 1.764$, $p = 0.195$, $\eta^2 = 0.059$) did not have a significant effect on the post test results. For the interaction between Backward Digit span test and post-test results ($F(3,84) = 1.861$, $p = 0.142$, $\eta^2 = 0.062$), the interaction is not significant which indicates that the backward digit span does not have significant effect on recall performance.

The D2 attentional performance test ($F(1,28) = 0.866$, $p = 0.360$, $\eta^2 = 0.030$) did not have a significant effect on the post test results. According to the results of within subject effects of D2 test and post test results ($F(3,84) = 2.654$, $p = 0.054$, $\eta^2 = 0.087$) is marginally significant which indicates that the D2 attentional performance test does have significant effect on the results.

The Adult ADHD Self-Report Scale (ASRS-v1.1) ($F(1,28) = 1.059$, $p = 0.312$, $\eta^2 = 0.037$) did not have a significant effect on the post test results. When we check the within subject effects results of Adult ADHD Self-Report Scale (ASRS-v1.1) ($F(3,84) = 0.548$, $p = 0.651$, $\eta^2 = 0.019$) we can say that interaction is not significant on all the results.

Lastly, the language test ($F(1,28) = 1.003$, $p = 0.325$, $\eta^2 = 0.035$) did not have a significant effect on the post test results. When we check the within-subject effect results of the Language test ($F(3,84) = 4.946$, $p = 0.003$, $\eta^2 = 0.150$) we can say that interaction is significant in all the results and also compared to other covariates, language test has an effect on the results.

In addition to these, as you can see it in the table 3,. we conducted a Pearson's correlation test to see the relationship between dependent variables and covariates. According to the results, Multi 1 and D2 test (Pearson's $r = -0.382$, $p = 0.020$) negative and Multi 3 and Language scores (Pearson's $r = 0.372$, $p = 0.017$) had a positive significant correlation, other correlations do not show a significant effect.

Table 3 - Correlation results of the covariates (D2, ASRS_Score, Language, Digit Span tests), and dependent variables (control, multi 1, 2, and 3) in terms of Pearson's correlation results.

		D2	Language	Digit Span	ASRS Score
control	Pearson's r	0.194	0.147	-0.297	-0.043
	p-value	0.249	0.357	0.074	0.792
Multi1	Pearson's r	-0.382	-0.058	0.111	-0.064
	p-value	0.020	0.719	0.513	0.693
Multi2	Pearson's r	-0.173	0.098	-0.227	-0.090
	p-value	0.306	0.544	-0.177	0.582
Multi3	Pearson's r	-0.245	0.372	-0.145	-0.034
	p-value	0.143	0.017	0.391	0.833

The results from covariance analysis showed that language skills and attention covariates showed a significant effect on the post test results. However, it's important to highlight that the Backward Digit Span Test, and Adult ADHD Self-Scale showed a non-significant interaction on all the results while D2 Attentional Performance test showed a marginally significant interaction and language scores showed a positive significant interaction. Lastly, according to Pearson's correlation test results, there are only two significant results. These are Multi 1 and D2 test, Multi 3 and Language test. Since Pearson's r values are high enough, to say that there is a low to moderate linear relationship between the variables.

5. Discussion

In this part, the outcomes from the literature review are described in order to address the research questions raised. In this article the questions were raised to see how the attentional capability and working memory capacity influenced recall performance in graduate students in

a multimedia training environment. Also, the effect of number of multimedia learning materials were questioned.

A multimedia instructional message is a communication containing words and pictures intended to foster learning (Mayer, 2017). Words and visuals such as pictures and gifs, help people learn more profoundly than just words. Words were the primary medium of education for hundreds of years, including spoken phrases and, more recently, printed words. The segmenting principle states that people learn better when the lesson is presented in user-directed segments, rather than as a continuous unit, particularly when learning the steps in a process (Parong & Mayer, 2018) Multimedia learning occurs within the learner's information processing system, which includes multiple paths for verbal and visual processing, a framework with serious capacity limitations for every stream, and a framework which requires adequate cognitive processing within every stream for effective teaching to take place.

It is also important to highlight that the working memory is where most of the multimedia instruction took place. Even though working memory capacity is considered as something crucial in the processing of multimedia, the working memory of our participants did not affect the recall performance as much as we expected. This can be explained by the selective attention paradigm. In the study of Kane et al. (2001), they found no difference between high and low WMC participants in the prosaccade task but high WMC participants performed significantly better than low WMC participants on the antisaccade task (Colflesh & Conway, 2007).

Following this procedure, repeated measures of ANOVA were conducted between dependent variables. Results indicated that there is a significant effect between dependent conditions. It is important to highlight that according to the results from Tukey Corrected Pairwise comparison only multi 1 and multi 3 had a significant result. Previous studies show the use of multimedia and technology in education and social studies increase students' academic success (Ilhan & Oruç, 2016). This result can be explained by the nonverbal information may support comprehension of verbal information and, vice versa, verbal information may support the interpretation of illustrations and other nonverbal information (Takacs et al., 2015).

In addition to these, repeated measures of ANOVA were conducted between dependent variables and covariates separately. According to the results from between subjects effects,

interactions were non-significant. However, according to the results from within subjects effects, language and D2 attention test had a significant interaction.

Following this, correlation analyses conducted to understand the interactions and according to that, multi 3 had a positive correlation with language. This might indicate that with worse foreign language skills, processing multimedia learning information might become more demanding as the number of multimedia elements are increasing. In addition to this, multi 1 had a positive correlation with D2 attention test. According to our results we only know that processing multimedia information is might be more demanding for people with less effective selective attention. However, the significant relationship was only proved for the multimedia one condition. We have data about the attentional and recall performance of the individuals however, we can only investigate the relationship between them. We cannot come to a conclusion which proves that the less multimedia learning materials used, individual gives more attention to the literature. Yet, we cannot know much about the attention which participants gave to the presentation. To know about the attention, further empirical studies can execute eye-tracking studies. We are only aware of the fact that the participants with worse attentional performance, performed worse in multi 1 on the post test. Also, in the correlation data, all the correlation coefficients were negative which indicates that multimedia had an overall negative effect on processing information when multimedia elements were present. Apart from these, other covariates (Digit span test and ASRS Scores) had no effect on the general results of the post test.

We expected to find an effect of the multimedia learning materials on the post test results and yet we found a significant effect. The more we used a multimedia learning material, the higher individuals scored in post-test. Lastly, we expected to find better post test results from the participants who have better attentional performance and working memory capacity, but we could not find a significant effect.

Several limitations of the present study may be highlighted. According to the results of our analysis, there is no effect of these performances on the post test results. These results can be the consequence of the number of participants. We had a limited number of participants who participated, and this affected the statistical results. When we generalise the results to the general population, the sample size of 41 in this study is comparatively low to obtain a generalised result from a global perspective.

In this research, the target participants were second-year psychology students. Of our participants, the majority were female ($n = 24$). Our university psychology course mostly includes female students. A 2003 study in the journal *Teaching of Psychology* (Vol. 30, No. 1) suggests that women are also drawn to psychology because they perceive themselves as more empathic than men do (Willyard, 2011). This is an evolutionary impact because in the forager times, the women were mostly staying at home and the men were going hunting. This role division might lead men to improve their attention span while leading women to improve empathy. Conducting the same experiments with almost equal numbers of genders may affect the results.

For the future researchers it is worth noting that, our research on the amount to which individuals are influenced by multimedia learning settings included only a limited number of questions. Further empirical studies about this research could consider several other issues. Other issues could include more visuals and auditory multimedia settings. Conducting more experiments about the effect of number multimedia learning materials will explain more about whether using multimedia learning material is a distraction or not to the individuals. Also, including more movements, and active learning which includes participants might result in the auditory and pictorial information being more closely linked in time. *“In fact, the temporal contiguity principle of the multimedia learning theory predicts deeper learning when the verbal and nonverbal information is presented close to each other in time rather than further apart”* (Takacs et al., 2015, p.700).

In summary, this study shows the effect of number of multimedia learning materials however does not provide enough evidence to show the influence of attentional performance and working memory capacity on recall performance in university students in a multimedia learning setting. For further studies it is worth noting that having more varied multimedia learning materials might give more advance results about the effectiveness of the learning materials. In addition to this, having more participants in equal number of genders will give more generalised result. Doing this study in different countries can give a global perspective about how the effectiveness of using these materials vary on different cultures. Study shows both to the students and to the lecturers an importance of having multimedia learning materials. They can use more multimedia learning materials in their presentations which will enhance their presentations. On the other hand, these kinds of studies show the importance of the

number of multimedia learning materials. It is good to have however, after some point it might be distracting for the individuals. This study was one of the research projects which can help to raise awareness of having and the usage of multimedia learning materials.

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