World Journal on Educational Technology

Vol 4, issue 2 (2012) 81-98

www.world-education-center.org/index.php/wjet

Using Eye Tracking to Study on Attention and Recall in Multimedia Learning Environments: The Effects of Design in Learning

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Received May 03, 2012; revised June 24, 2012; accepted August 12 , 2012

Abstract

In this study, the effect of multimedia learning environment prepared according to the attention types (focused - split) on recall performances of learners with attention level (high - low) was investigated by using eye movement measures. The participants were 37 undergraduate students who were presented with either focused attention or split attention multimedia learning environment. After attention levels of the learners were determined by d2 Test of Attention, they were separated to two groups as high and low. On the other hand, the instructional media were designed according to focused and split attention types. Multimedia in split attention type was applied to the half of the learners in groups determined with respect to attention level and multimedia in focused attention type was applied to the other half. Eye tracking (number of fixations, hetmap, dwell time) data were collected during the study. Their recall performances were measured with recall tasks. After that, the researchers evaluated recall performances of all learners and eye movement measures. According to Two Way ANOVA test results, it seems that application of different multimedia applications in terms of attention type on the learners having different attention capacities has no significant effect on number of fixations. The multimedia applications prepared in different attention types to the learners has significant effect on number of fixations. Attention capacities of learners have no significant effect on number of fixation. According to eye tracking measurements, in the focused attention multimedia application, it seems that the learners look at the parts where they are supposed to focus on and the most videos are shown. On the other hand, it seems that the learners look at the parts that video, text and picture are shown together in split attention multimedia application. According to Independent Samples t-test results, recall performances of the learners show a significant difference according to multimedia applications on behalf of focused attention multimedia application.

Keywords: Computer assisted simulation training, simulations, higher education, communication;

1. INTRODUCTION

What is the value of adding pictures to words and supporting with audio in learning environments? Do students learn more deeply from this combination than from words alone? These questions started to the study about multimedia learning. A number of recent

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studies have demonstrated the significance of multimedia learning environments (Mayer, 2001; Betrancourt, 2005; Fletcher & Tobias, 2005; Sweller, 2005; Ayres & Pass, 2007, Holotescu & Grosseck, 2011). Multimedia instruction refers to design multimedia presentations with audio-visual materials in ways that help people build mental representations (Mayer, 2005, Freiman, et.al, 2011).

Mayer (2001) explained the multimedia principle as people learn more deeply from a multimedia explanation presented in words and pictures than in words alone. He classified the modalities into words and pictures. Visual materials can be presented as static pictures, illustrations, graphics, animation, simulation, photos, video or text (Mayer & Anderson, 1992; Mayer, et al., 1996). In addition to multimedia principles Low & Sweller (2005) and Mayer (2005) explained the modality effect as people learn more deeply from multimedia instruction when graphics are explained by audio narration rather than onscreen text.

When people learn from a multimedia application, they must engage in five cognitive processes: (1) selecting relevant words, (2) selecting relevant images, (3) organizing selected words, (4) organizing selected images and (5) integrating word-based and image-based representations. The most crucial step involves making connections between word-based and image-based representations (Mayer, 2001). If the modalities aren't integrated and related in their presentation, people can't pass the step successfully. Thus in media where information is presented with multiple sources, visualizations must be presented linked and related on the screen (Ayres & Sweller, 2005).

In a meta-analysis, Ginns (2006) showed that integrated formats, which placed text information directly into the picture, were superior to split-source formats, in which text and picture were physically separated. In addition to visual materials students learn unequivocally better when the learning material is presented in audio–visual format than when it is presented in visual-only format (Mousavi, et al., 1995). However, in the first stage of processing, when information are presented multi-sources unsynchronously as text, images and narration on the same screen, attention has to be split (Seufert, et al., 2008). Although many advantages of multimedia environment are suggested, if the audio-visual information isn't presented synchronously or words and shapes aren't integrated, learners face with problems about attention (Mutlu, 2010; Ayres & Sweller, 2005). The problem called split attention effect dividing of the attention between two simultaneous inputs (Chandler & Sweller, 1992).

Definition of split attention in research literature indicated that it is the partitioning of the attention between two simultaneous inputs (Oosterlaan & Sergeant, 1996). According to Nebel et al. (2005) it is the distribution of limited intellectual skills in between different knowledge resources.

The split attention effect was explained within the framework of cognitive load theory by considering processing limitations of our cognitive architecture (Van Merriénboer & Sweller, 2005). When presenting with information to the learners, varying stimuli prove to be effective on attracting attention. However, attention is divided and the learner's mental efforts may be diverted elsewhere during the presentation of these stimuli (Mayer, 2001). It states that multiple sources of information should be presented in such a way that learners do not need to split their attention between them. In the case of an instructional text, picture, animation and film of sources of information should be presented in a spatially integrated format rather than a spatially separated format (Clark & Mayer, 2008). Besides varying modalities (audio-visual), the comprehensive, simultaneous and well-integrated composition of resources has been also shown to be effective on the learning process and attention (Sanchez ve Rodicio, 2008; Mayer, 2005).

It is possible to determine the split attention effect that appeared when using multimedia applications by eye tracking systems. Eye tracking results give information about the parts attended; information on which people do not pay attention, the situation disturbed people (Russell, 2005). Eye tracking method by the way of tracking the eye movements helps to detect individual differences and to interact with the resource presented (Bayram & Avcı, 2010).

Some studies were conducted through examining the split attention effects of audio-visual learning environment on learning outcomes with eye-movements. Rayner (1998) addressed the idea that eye-movement parameters such as number of fixations, fixation duration, duration time, and scan paths are especially relevant to learning. Underwood, et al. (2004) reported that fixation durations were longer on pictures than on sentences, which is consistent with results that recognition of words in sentences requires less processing time and shorter fixations than does the recognition of objects in pictures.

Oosterlaan & Sergeant (1996) described the focused attention that is the concentration of the attention on a specific part of the knowledge.

Instructional media that contain both information types rather than offering them separately (as audio and visual) have been found to be more effective (Mayer, 2005; Mayer & Moreno, 2002, Smeureanu & Isaila, 2011). Moreover, the way this information is offered closely to each other keep the attention focused (Sweller, 2004; Ayres & Sweller, 2005). In previous studies, it has been showed that the segmentation of learning material facilitates learning (Clark & Mayer, 2008; Mayer, 2005). Various researchers have shown that the segmentation of text, in particular, is beneficial to improve text recall as well as text comprehension. For instance, Mautone and Mayer (2007) investigated how signaling techniques, such as highlighting, improve graph comprehension. Jamet, Gavota, and Quaireau (2008) showed that the signaling technique of colouring facilitates learning from multimedia material. As in the case of the segmentation of learning material, it is commonly assumed that signals guide the learners' attention and make relations between different pieces of information more salient. Signaling helps learners in identifying, attending, and organizing important information.

Schmidt-Weigand et al. (2010), in their works focusing on modality effect and visual attention have presented their 16-steps multimedia instruction on the formation of lightning. They examined two experiments examined visual attention distribution in learning from text and pictures. In experiment 1, the instruction was system-paced (fast, medium, slow pace), while it was self-paced in experiment 2. During learning, the participants' eye movements were recorded. Results from both experiments revealed that learners spent more time studying the visual materials with spoken text than those with written text. In written text conditions learners consistently started reading before alternating between text and visualization; moreover, they spent more time on reading the text than inspecting the visualizations, and they sometimes don't focus images, video, etc. Overall, the results confirm prior findings suggesting that the distribution of visual attention in multimedia learning is largely guided by the text.

Ozcelik et al. (2010) purposed to examine the effects of signaling on learning outcomes and to reveal the underlying reasons for this effect by using eye movement measures. The study groups were 40 undergraduate students who were presented with either signaled or nonsignaled multimedia materials. Eye movement data were collected during the study. The results indicate that the signaled group outperformed the nonsignaled group on transfer and matching tests. Eye movement data show that signaling guided attention to relevant information and improved the efficiency and effectiveness of finding necessary information.

The study of Malinowski, et al. (2007) aims to evaluate the split attention, behavior and perception of the students presented with multiple sources with four different materials. Electrophysiological measurements were recorded to measure the continuity of attention over presented materials. The measurements reveal an analogy between behavioral data and split attention. Considering perception situations, the measurements have revealed that there is split attention between different presentations and the sources provided. The measurements reveal that spatially distanced sources cause split attention and drops in the success rates in the execution of given tasks in contrast to sources presented with higher spatial proximity. For examining the allocation of visual attention between text and visualization, Schmidt-Weigand et al. (2010) computed the number of transitions between text and visual materials. This measure provides an index of the frequency with which learners shift their visual attention between the two information media. All of these studies indicate a promising direction of using eye tracking to assist our understanding of the impact of multimedia on students' cognitive process. Therefore, the eye tracking technique was employed in this study to investigate how different multimedia instruction formats cause different recall performance when students are engaged in learning about "motor".

1.3. Purpose of the Study

In this study, our focus is on the use of the eye tracking methodology to study cognitive process during audio-visual learning tasks, especially during learning from written texts, images, videos and narration. We propose investigating effects of the different audio-visual learning environments on recall performance with students' attention test points and eye-movement measures.

1.4. Questions of the Study

1. Do recall performances of the learners show any significant differences according to multimedia applications?
2. Do learners' numbers of fixations show any significant differences depending on common effect of multimedia applications and attention type?
   - 2.1. Do learners' numbers of fixations show any significant differences according to multimedia applications?
   - 2.2. Do learners' numbers of fixations show any significant differences according to attention capacities?
3. Does dwell time of learners show any differences?
4. Does heatmap of learners show any differences?
5. Does time spent on the learners show any significant differences according to types of multimedia applications?

2. METHOD

2.1. Participants

Overall, 37 students from Marmara University voluntarily participated in the study. All of the participants were undergraduate students in Computer Education and Instructional Technology Department. They voluntarily took part in the experiment for extra course credits. Their mean age is 20.8.

2.2. Materials

2.2.1. Instructional Materials

2.2.1.1. Focused Attention Multimedia Learning Environment

In this medium, the "motor" lesson contents were prepared as per the Multimedia Instructional Design Principles of Mayer (2001) with the aim of eliminating the presence of split attention causes. This instructional media has been designed as visual and audio kinds with the goal of focused attention, in order to enable the realization of recall. The presentation types have been diversified by supplementing visually presented information with audio explanations. With the aim of focusing attention, images were presented as separate from the video during scenes of video explanations. The information presented in images was thus presented with the objective of offering the explanation in audio and enabling focusing on the image and the explanation. The information presented in the images were supplemented with audio and presented in progression. The texts relevant to the images were presented in an integrated manner to the explained images. The material was designed to allow the self-pacing of the student. The students were presented with operation instructions for perusing the material (See Figure 1 and 2).

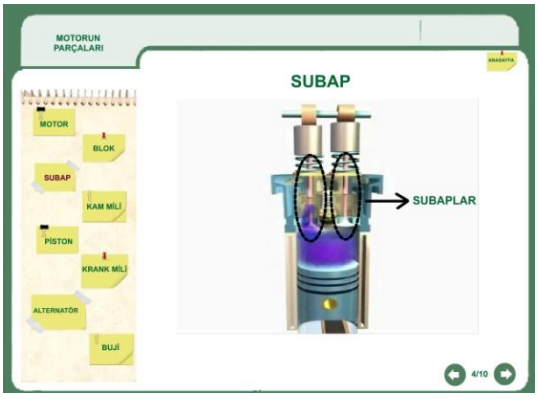

Figure 1. Screenshot of a presentation focused attention on the video (Focused Attention Multimedia Learning Environment)

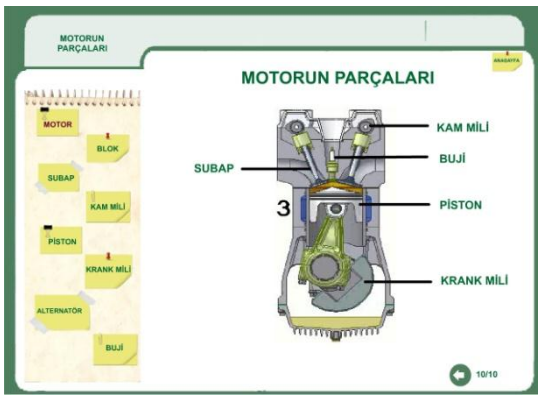

Figure 2. Screenshot of a presentation where texts are integrated onto the images, placed in close proximity and presented with audio explanations (Focused Attention Multimedia Learning Environment)

2.2.1.2. Split Attention Multimedia Learning Environment

In this medium, the "motor" lesson contents were prepared in audio presentation according to the possibility of the occurrence of split attention effect. Images and texts were added into the scenes containing information presented in the videos. The audio

information was prepared to present different sections than those presented as texts. The text descriptions of the images were presented spatially distanced from the images themselves. The application's preparation allowed the student's self-pacing. The students were presented with operation instructions for perusing the material (See Figure 3 and 4).

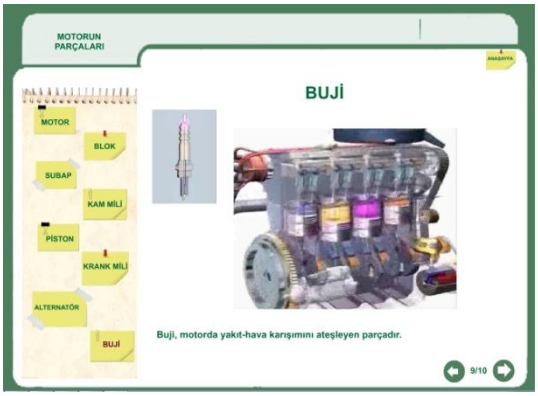

Figure 3. Screenshot of a presentation between the Video, Image and Text (Split Attention Multimedia Learning Environment)

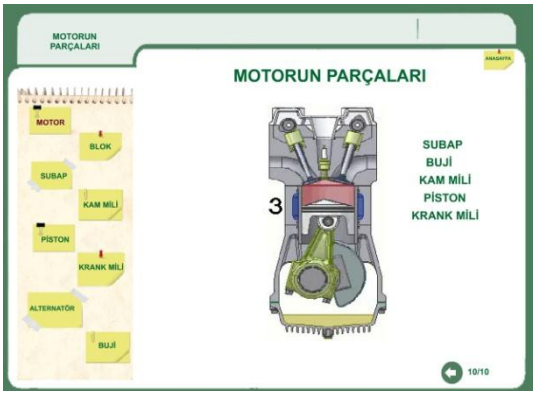

Figure 4. Screenshot of a presentation where texts and image are seperated (Split Attention Multimedia Learning Environment)

2.2.2. Data Collection Materials

2.2.2.1. Attention Test

The test was developed by Brickenkamp in 1962. In following years, its various revisions were performed. The purpose of the test is to evaluate the continuous attention and visual search skills (Spreen & Straus, 1998). d2 test is a measurement of the selective attention and mental concentration. Although d2 test was firstly developed to measure the attention of drivers, today it is being used to evaluate the attention at different areas such as psychopharmacology, education, clinics, industry etc. (Brickenkamp & Zillmer, 1998).

In this study the d2 test of attention was used for determining students' attention level. The d2 is a timed test of selective attention. The items are composed of the letters "d" and "p" with one, two, three or four dashes arranged either individually or in pairs above and below the letter. The subject is given 20 seconds to scan each line and mark all "d's" with two dashes (See Figure 5). There are 14 lines of 47 characters each for a total of 658 items.

Figure 5: Samples of the test characters

In the test analyses TN, CP, E1, E2 and TN-E are used for deciding the attention levels.

Total signed item number (TN): TN is a quantitative measure of performance of all items that were processed, both relevant and irrelevant ones.

Total rights found (CP): CP is derived from the number of the correctly crossed out relevant items ("d" with two dashes) minus the errors of commission (E2).

E1: Number of right answers left out without doing

E2: Number of the wrong answers

Test performance (TN-E): TN-E is the total number of items scanned minus error scores (E1+E2). It is a measure of the quantity of work completed after a single correction for errors (Brickenkamp & Zillmer, 1998).

Adaptation study of d2 test for 11-14 age groups in Turkey was performed by Toker (1988, 1990). In addition, reliability and validity studies for Turkish athletes were performed by Çağlar and Koruç (2006). In the study including total 701 athletes, 437 of whom are men and 264 of whom are women, the mean age is 19.30.

2.2.2.2. Eye Tracking Measures

Eye tracking data can provide valuable information about the attention processes of the learners. The participants studied these materials and they were tested individually at the Marmara University Human Computer Interaction Laboratory. It will be completed.

In this study, SMI Experiment and Begaze 2.4 programs were used for measuring eye-movement data. Participants were seated approximately 60 cm away from the computer monitor. After calibration, participants were presented with multimedia learning environments.

2.2.2.3. Recall Performance Test

After the developed multimedia applications were performed, the recall test was applied to all students in order to determine the effects of materials on learners' recall performances. The recall test consisted of 5 open ended questions about the parts of motor. Every concept of the answers was 10 point. The recall test was administered to measure to what extent the learners recalled factual information that was explicitly stated or could be implicitly drawn from the materials. The test results were evaluated by two researchers.

2.3. Procedures

The participants were tested individually in a single session at the HCI laboratory. First, a performance test was applied to all of the participants to determine topic-specific knowledge of students about the parts of motor before the multimedia applications developed by the researchers. It determined the equality about knowledge. It consisted of 10 multiple-choice questions. Next, every subject underwent an automatic eye-tracking calibration. Then, participants were asked to study the materials. The participants' eye tracking data were collected by SMI Experiment and Begaze 2.4 programs while they were studying the instructional multimedia materials. The number of fixations, eye heatmap, and total fixation count and eye dwell time data were obtained with the aid of SMI Experiment and Begaze 2.4 programs. Recall tests were administered when each subject finished studying the instructional materials. There were no time limitations, either for studying the instructional content or for answering the tests.

The participants were separated into two groups according to their test of attention levels (low & high). The experimental groups were derived following a 2 (low & high attention level) X 2 (focused and split attention learning environment) experimental design (See Figure 6).

According to the model, recall performance, number of fixations, time spent, and dwell time are dependent variables. Multimedia learning environment prepared according to the attention types is independent variable.

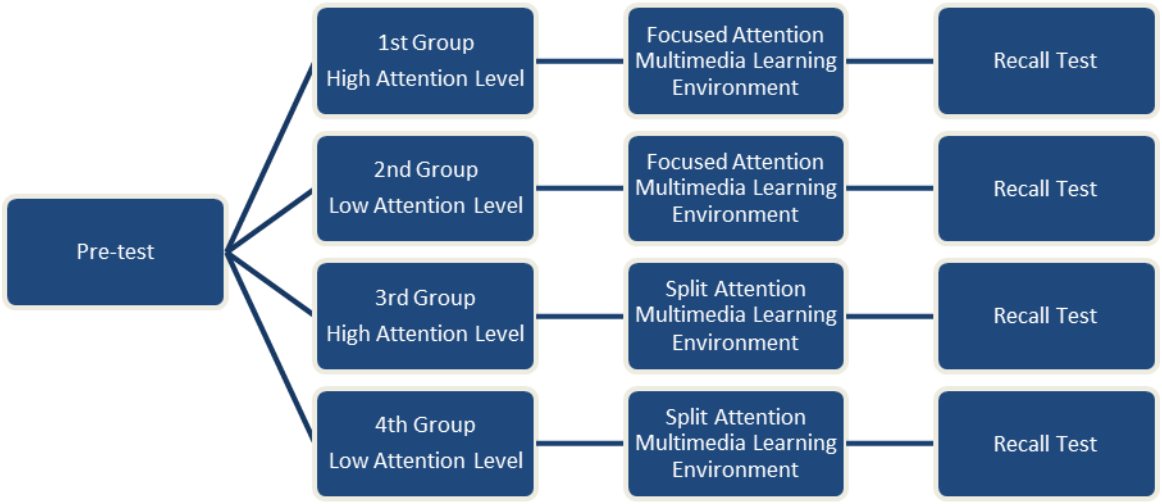

Figure 6. The Experimental Design

3. RESULTS

In this chapter, the data about study time of learners with multimedia learning environment, number of fixations, recall performances and the findings achieved by analysis of the data according to two different environments and attention levels are presented. In addition, the results about heatmap and dwell time of learning environments are presented.

Learners using two multimedia learning environments developed according to types of split and focused attention were determined as low and high attention levels according to the results of attention test (See Table 1). There are total 19 students, 11 of whom have low attention level and 8 of whom have high attention level in the multimedia environment with focused attention type. On the other hand, there are 18 students, 10 of whom have low attention level and 8 of whom have high attention level in the multimedia environment with split attention type (See Table 2).

Table 1. Descriptive statistics of d2 attention test scores of learners

Multimedia Applications	D2 Attention Test	N	Min	Max	Mean	SD
Focused Attention Multimedia	TN	19	402	652	572.42	79,207
	E1	19	4	91	41.00	27.787
	E2	19	0	16	6.32	4.888
	CP	19	104	283	210.26	55.624
	TN-E	19	346.00	637.00	525.1053	87.7020 8
Split Attention Multimedia	TN	18	469	648	588.17	54.731
	E1	18	2	138	45.00	33.040
	E2	18	0	22	6.61	6.021

CP	18	127	285	213.67	40.710
TN-E	18	428.00	631.00	536.5556	59.30204

Table 2. Descriptive statistics about features of learners

Multimedia and Attention Types		Frequency	Percent
Focused Attention Multimedia	Low	11	57.9
	High	8	42.1
	Total	19	100.0
Split Attention Multimedia	Low	10	55.6
	High	8	44.4
	Total	18	100.0

3.1. Recall Performance Findings and Comments

Research Question 1. Do recall performance of the learners show any significant differences according to multimedia applications?

Independent t-test results of recall performance findings are represented in Table 5.

Table 3. Independent Samples t-test results of recall performances of learners according to different multimedia

Multimedia	N	M	SD	t	df	P
Focused Attention	19	50.53	22.23			
Split Attention	18	35.56	19.47	2.182	35	0.036

When Table 3 is analyzed, recall performances of the learners show a significant difference according to multimedia applications on behalf of focused attention multimedia application ($t(35)=2.182$, $p<0.05$). According to the environments, recall performance of the group applied with Focused Attention Multimedia Application ($M=50.53$, $Sd=20.23$) is higher than that of the group applied with Split Attention Multimedia Application ($M=35.56$, $Sd=19.47$, See Table 3). According to this result, it seems that the learners using Focused Attention Multimedia Application recall terms better.

3.2. Findings of Number of Fixations and Comments

Research Question 2. Do learners' numbers of fixations show any significant differences depending on common effect of multimedia applications and attention type?

One of the research questions in the study is to examine the effects of the multimedia applications prepared according to different attention levels on number of fixations that the learners with different attention capacities have. Two way ANOVA results about this question were presented in Table 5.

Table 4. Descriptive statistic results related to number of fixations of individuals having different attention capacity.

Multimedia Learning Environment	Attention Capacity	M	N	SD
Focused Attention	Low	1296.18	11	315.92
	High	1358.75	8	393.34
	Total	1322.52	19	341.50
Split Attention	Low	1108.10	10	301.55
	High	1009.00	8	230.84
	Total	1064.05	18	269.54
Total	Low	1206.61	21	316.37
	High	1183.87	16	360.12
	Total	1196.78	37	331.32

Table 5. Two way ANOVA results of number of fixations according to multimedia and attention capacities.

Source	Sum of Squares	Df	Mean Square	F	P
Model	679294.23	3	226431.411	19.807	.097
Multimedia	656060.559	1	656060.559	96.423	.015
Attention Capacity	3026.868	1	3026.868	.133	.862
Multimedia * Attention Capacity	59278.889	1	59278.889	.156	.445
Error	3272584.036	33	99169.213		
Total	3951878.270	37			

When Table 5 is analyzed, it seems that application of different multimedia applications in terms of attention type on the learners having different attention capacities has no significant effect on number of fixations according to Two Way ANOVA results (p=0.445, sd=1). In other words, the common effect of applied multimedia environments and attention type on number of fixations of learners was not found significant.

3.3. Do learners' numbers of fixations show any significant differences according to multimedia applications?

When Table 5 is analyzed, it seems that multimedia applications prepared in different attention types to the learners has significant effect on number of fixations (p=0.015, sd=1). According to the environments, it is seen that the group applied with Focused Attention Multimedia Application (M=1322.52, Sd=341.50) has higher number of fixations than the

group applied with Split Attention Multimedia Application (M=1064.05, Sd=269.54) (See Table 4). According to this result, it is possible to say that the learners in Focused Attention Multimedia Applications are more focused.

3.4. Do learners' numbers of fixations show any significant differences according to attention capacities?

It seems that attention capacities of learners have no significant effect on number of fixation (p=0.862, sd=1). In other words, the learners' number of fixations having low or high attention capacities does not show any differences (See Table 5).

3.5. Dwell Time Findings and Comments

This type of analysis presents dwell time into the squares obtained by dividing screen into squares by guide lines. Red areas are the sites that users look at the longest time. Yellow and green areas represent the sites looked at lesser and blue areas represent the sites looked at the least in terms of time. In the Focused Attention Multimedia Application, it seems that the learners look at the parts where they are supposed to focus on and the most videos are shown (See Figure 7). On the other hand, it seems that the learners look at the parts that video, text and picture are shown together in Split Attention Multimedia Application (See Figure 8).

Figure 7. Dwell time results of learners in Focused Attention Multimedia Application

Figure 8. Dwell time results of learners in Split Attention Multimedia Application

3.6. Heatmap Findings and Comments

This type of analysis presents the map of looked parts in terms of colors according to focus time. The areas showed in red are the sites that users look at the longest time. Yellow and green areas show the sites looked at lesser and blue areas represent the sites looked at the least in terms of time. In Focused Attention Multimedia Application, it is seen that the

learners look at the parts that the most videos are shown and this is parallel with the results of dwell time (See Figure 9). After videos, the learners focused on mostly menu buttons and title, respectively. In Split Attention Multimedia Application, it seems that the learners focus on the parts that video, text and picture are shown together. They focus mostly on video part, then on text part (See Figure 10). According to the heatmap analyses of two environments, focusing on videos in focused attention multimedia application was more intense. In addition, while focusing on menu buttons is less in split attention multimedia application, it seems that focusing on text is much more.

Figure 9. Heatmap analysis of the learners in Focused Attention Multimedia

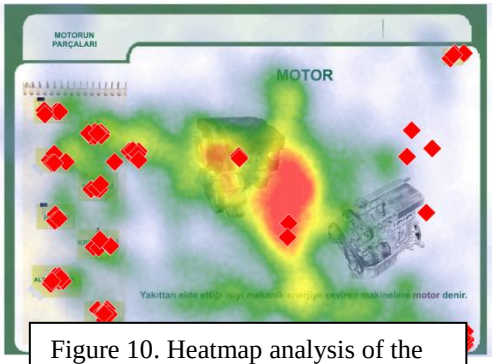

Figure 10. Heatmap analysis of the learners in Split Attention Multimedia

3.7. Time Spent Findings and Comments

Research Question 5. Does time spent on the learners show any significant differences according to types of multimedia applications?

Independent Samples t-test results of the research done to examine the effect of multimedia applications on time spent on the learners were presented in Table 6.

Table 6. Independent Samples t-test results of application time spent of the learners according to multimedia.

Multimedia	N	M	SD	T	df	p
Focused Attention	19	195.78	30.76	3.041	35	0.004
Split Attention	18	166.66	27.45			

The time spent on the learners show significant difference according to multimedia ($t(35)=3.041$, $p>0.05$). According to this result, the time spent in the environment by the learners using Focused Attention Multimedia Application ($M=195.78$, $sd=30.76$) is longer than the time spent by the learners using Split Attention Multimedia Application ($M=166.66$, $sd=27.04$, See Table 7). Presentation of each modality in Focused Attention Multimedia Learning Environment separately requires longer focusing.

4. DISCUSSION

As a result of developing information and communication technologies, e-learning began to take quite a lot part in education area. Use of multimedia applications are focused in terms of providing permanent learning with education environments prepared for e-learning (Hussein, 2010; Tavukcu, Gezer & Ozdamli, 2009). Multimedia contents are developed by centralizing learner features in accordance with principles of human-computer interaction. In education contents, to diversify stimuli provides effective use of attention channels and activation of more than one sense. It is needed that these contents should be prepared in such a way that attentions of learners are not disturbed. From this point of view, attention levels of learners and the effects of attention types on the design were focused in this study.

When the results of study are analyzed, it is seen that the group used Focused Attention Multimedia Applications has higher number of fixations than the group used Split Attention Multimedia Applications. According to this result, it is possible to say that the learners in Focused Attention Multimedia Applications are more focused. This result shows parallelism with heatmap and dwell time results of eye tracking data acquired during the study.

In multimedia learning environment, text and pictures should be presented by integration of both to prevent occurrence of split attention effect. In addition, more than one stimuli (sound, text, video, picture) should be presented by integration of all and paying attention to redundancy principle. In this study, heatmap analyses show that learners have disturbance of attention in the multimedia which video, picture and text having possible split attention situations is presented separately. Concurrently, it seems that recall performances of the learners studying in this environment are lower than the learners studying in focused attention multimedia.

In parallel with these results, Cierniak, Scheiter & Gerjets (2009) determined that if text and pictures are not presented as integrated, there is decrease in applied test points of learners learning with split attention effect.

In heatmap analyses, it is seen that focusing on focused attention multimedia application is better than in split attention multimedia application. While the learners in focused attention multimedia focus mainly on videos, their attentions are disturbed among video, picture and text in split attention multimedia. It seems that while the learners in focused attention multimedia application focus initially on video found in the middle of the screen, they look at video for a short time and then they focus on text in split attention multimedia. In the results of the study performed by Faraday (2001) which provide support to this study, he found that pictures are needed to be wider than texts and while middle and upper parts of any page are most remarkable places, left and bottom parts are remarkable secondarily.

Presentation of modalities given in multimedia learning environments as integrated and simultaneously prevents occurrence of split attention effect (Mayer, 2005). In this study which attention levels of learners were examined, designing multimedia learning environments with considering multimedia principles and without prevention of occurrence of split attention effect has negative effect on recall performances and disturbance of attentions even if they are the individuals with high attention level.

Among multimedia environments prepared according to attention type, it was seen that the learners in multimedia application prepared according to focused attention type had higher recall performances than in multimedia application prepared according to split attention type. According to this result, it is seen that a multimedia prepared according to focused attention type provides higher recall performances even if attention capacity changes. In a similar study performed by Mutlu (2010), it was found that the learners grouped according to short-term memory capacities (low, medium, high) showed higher recall performances in focused attention multimedia application than in split attention multimedia application. In parallel with these results, Dutke and Rinck (2006) found that there is a little difference between matching performances of learners having low level of working memory capacities in focused multimedia.

In this study, the focused attention multimedia was used for a longer period of time compared to the split attention multimedia that is prone to the split attention effect. The materials that present the visual and audio information were used for shorter durations, as the learners could not focus.

When all these results are considered, recall performances of students with low attention, memory or perception can be increased by designs prepared according to focused attention effect in multimedia learning environment design. As a result, in multimedia design, presentations of visual and audio modalities as integrated simultaneously are the principles needed to be paid attention even if cognitive skills are strong.

Based on the findings and results of the study performed for evaluation of multimedia software prepared with eye tracking methods for university students according to attention levels, these suggestions for further studies can be considered; long-term contents can be evaluated via eye tracking data and can be measured via permanence test in multimedia environments. In addition, eye tracking data can be analyzed via usability study for interactive tasks given to learners in multimedia learning environments.

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