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The effect of sustained attention level and contextual cueing on implicit memory performance for e-learning environments

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ABSTRACT

Cognitive-based individual differences, among which are attention and attention design, play a crucial role in designing personalized e-learning environments. In this study, the effects of dynamic and static cue types presented to users in e-learning environments on implicit memory performance of individuals with different sustained attention levels are investigated. The statistical analyses suggest that the contextual cues prepared in different presentation types do not have a common significant effect on implicit memory performance of individuals with high or low sustained attention levels. Besides it is determined that the cues presented in two different forms, i.e. dynamic and static, has an effect on participants' implicit memory performance as long as sustained attention is ruled out. Better results obtained by static cueing compared to dynamic cueing, on the other hand, is important for learning environment design for individuals experiencing attention deficit.

1. Introduction

Cognitive-based individual differences, among which are attention and attention design, play a crucial role in designing personalized e-learning environments. What individuals see, hear, feel or remember not only depend on information they perceive through their senses, but also are related to what they pay attention to (Driver, 2001). The external world contains too many stimuli for individuals and they face a considerable amount of stimuli at any given time that they cannot process. Like all other communication tools, the sensory system functions effectively within the confines of its capacity; but fails in the case of information overload (Roda & Thomas, 2006; Solso, Maclin, & Maclin, 2009). Therefore, maintaining the sustainability of attention by choosing effective methods in educational environments is quite worth exploring in detail (Rapp, 2006).

In order to enhance and realize learning, researchers pay a special attention to implicit memory, since it occurs especially when acquiring complex information in an incidental manner, without awareness of what has been learned (Sun, 2008). Arguably, using contextual cueing may be effective when designing content in e-learning environments to encode information implicitly.

The primary goal of this study, therefore, is to examine the effect of contextual cueing in different presentation types in e-learning environments on implicit memory performances of individuals with different sustained attention levels. Consequently, it is aimed to develop design principles that are compatible with individuals' cognitive characteristics to help in their participation in learning activities, and also that design elements are determined that will ensure the utmost benefit from e-learning environments.

1.1. Sustained attention and implicit memory

In learning environments, particularly in e-learning environments where multimedia based applications are employed, the individuals' attention level is an important component of learning. Creating learning experiences during environment planning, design and presentation that aims at maintaining participants' attention is crucial for participant motivation, class participation and for learning.

In order for participants engaged in e-learning environments to gain meaningful learning experiences, systems have been developed that are sensitive towards participants' attention levels, considering the individual differences based on cognitive characteristics. With these so-called adaptive systems, participants' behaviors are analyzed and suitable options are provided to the participants in line with these data (Rapp, 2006).

Attention is classified into three groups, namely selective, divided and sustained. Sustained attention is defined as an

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attention type wherein attention is continuously directed at a single task, by means of focusing attention to a certain point for a long period and through concentration (Coull, 1998; Roda, 2011).

Attention is crucial for learning particularly since problem solving is a requirement in school life. Moreover, in order to develop sustained attention in children with ADHD, various strategies such as self-control may be employed to improve children's academic achievement. Although this improvement in academic achievement does not produce clinically significant results, it does provide above mean scores. These results constitute data that should be taken into consideration with regards to sustained attention (Purdie, Hattie, & Carroll, 2002).

Clinical studies propose that the relationship between intelligence and academic achievement is balanced by means of sustained attention. Whether this finding is present outside of a clinical environment was investigated in a research in which 231 first and second grade high school students participated. Sustained attention was examined with regard to verbal, numeric and general intelligence scores. According to research findings, it is determined that sustained attention is significantly related to school performance. This study is important since it looks at the relationship between sustained attention, intelligence and school performance outside a clinical environment (Steinmayr, Ziegler, & Träuble, 2010).

Attention basically comprises three points of view: some chosen stimuli are processed more compared to others; we are limited in running simultaneous processes due to our limited capacity and process sustainability involving visual stimuli requires effort. Multiple Object Tracking (MOT) as a paradigm incorporates these three components. Proposed by Pylyshyn and Storm in 1988, this paradigm is based on a simple task. In the experiment, flickering objects are determined as targets and participants are supposed to find the targets' positions among multiple moving objects (Scholl, 2009).

A MOT task deals with attention through various aspects. Accordingly, MOT tasks require an attention continuing through a period of time, rather than changing attention. Secondly, it involves a sort of attention that focuses on multiple objects within a time interval rather than a single object. Thirdly, MOT is an active task in contrast to tasks used in many experimental studies wherein one waits for a target to appear. Finally, the magnitude of need for attention may be manipulated by MOT through tracking load (Scholl, 2009).

In their studies, Ogawa, Watanabe, and Yagi (2009) aimed at learning a dynamic image in a visual context and evaluating sustained attention during this process via MOT and contextual cueing. It was found that in cases, where trajectory was not changed in repeated experimental sets, the implicit contextual cues improved MOT performance. This result may be interpreted as it facilitates sustained attention process for repeated trajectories in dynamic images as well as renders visual search more effective by guiding the division of attention in environments involving normal contextual cueing. The results of this study produced data particularly for explaining implicit learning. Learning may be achieved by ensuring that cues in repeated environments support visual coding by means of contextual cueing.

The fact that learning processes involve complex tasks and that individuals are exposed to too many stimuli in e-learning environments is considered indicative of sustained attention's importance in learning processes.

Memory, where design differences in learning environments gain importance and processes regarding attention take place, is another crucial component that affects visual attention. There are different memory classifications in the literature. The first one of the models proposed on memory is the memory model where James (1890) classifies memory into two, namely primary and secondary. Subsequent studies have shown that this model is inadequate to explain memory. Memory models were approached in relation to serial and parallel information processing models. Serial information processing model led to the 3-component structure of memory model proposed by Atkinson and Shiffrin in the 1968's. According to this model, memory is divided into three categories, namely sensory, short-term and long-term. In the parallel information processing model, on the other hand, Craik and Lockhart (1972) considered memory as a process which led to the levels of processing model. According to this model, information may be coded on three different levels: shallow, medium and deep. Baddeley and Hitch (1974), on the other hand, proposed the working memory model and modeled memory in a more active manner. According to the working memory model, memory consists of executive functions, phonological loop, visuo-spatial sketch and multimodal episodic buffer. According to Tulving's (1983) hierarchical memory model developed on the basis of type of information stored, memory is categorized into episodic, semantic and procedural. According to the memory model proposed by Graf and Schacter on the basis of consciousness in 1985, on the other hand, memory is distinguished as implicit and explicit (Cangöz, 2005).

While implicit memory is defined as the type of memory where information acquired previously affects the performance of a task being performed and information is recalled automatically and unconsciously, explicit memory is defined as the type of memory in which prior information is recalled during the performance of a task (Schacter, 1987).

Attention and implicit memory structures play a crucial role in learning processes. Attention, in turn, is affected by several components in e-learning environments. These are distinctiveness of stimuli, intention, memory and perceptual organization. An element perceived as distinctive in visual environments is more conspicuous compared to others, regardless of attention. Thus, the higher number of distinctive features in a target leads to more effective results in a search conducted via a visual interface (Hillstrom & Chai, 2006).

1.2. Contextual cueing

During screen design in e-learning process, several elements are placed on screen and it is expected that individuals gain the utmost benefit from the content presented in such environments. While interacting with content in front of the screen is in itself a distracting factor, elements included in a screen design may easily distract individuals' attention. At this point, a problem arises regarding directing attention in screen designs for e-learning environments.

Individuals' attention may be immediately directed without adding extra information to designs in e-learning environments by introducing contextual cueing or attentional cueing (Mayer & Moreno, 2003). During the effective information selection phase in learning environments, individuals use previously recorded visual data in their previous experiences. This mechanism is called contextual cueing or memory based attentional guidance (Ogawa et al., 2009). The basic goal behind using such cues is to direct attention in learning environments to reduce work load (Roberts, 2008).

In studies examining content designs in e-learning environments, research regarding the effects of contextual cueing mostly focus on several variables, such as the effects on different presentation types (Anllo-Vento & Hillyard, 1996; Green & Woldorff, 2012; Heiser & Tversky, 2006; Lorch, Lorch, & Klusewitz, 1995; Mann, Newhouse, Pagram, & Campbell, 2000; Rickards, Fajen, Sullivan, & Gillespie, 1997), learning (Boucheix, Lowe, Putri, & Groff, 2013; Imhof, Scheiter, Edelmann, & Gerjets, 2013) and the effects on recall (Lorch et al., 1995; Rickards et al., 1997).

These cues directing attention may come in various presentation types depending on the design's goal. The cue types used in designs are visual or auditory. The most frequently used visual cues are coloring and representations involving arrows and lines. These may be static as well as cues incorporating moving elements. Verbal speech and auditory notification tones may be provided as examples for auditory cues. Moreover, contextual cueing may be incorporated into designs by using anti-cueing technique. This technique leaves the area to which the individual's attention is to be drawn visually with the intended visual features and colors the other areas where focusing is undesired in such a manner that they do not attract attention. Fading may be provided as an example for anti-cueing (Lowe & Boucheix, 2011; Roberts, 2008; Wolfe & Horowitz, 2004).

As indicated by Downing (1988), perceptual sensitivity may be enhanced by means of cue's position. Moreover, visual information processing may be facilitated by focusing attention (Sears & Pylyshyn, 2000). According to the contextual cueing paradigm developed by Chun and Jiang (1998), patterns of images direct attention implicitly. So, implicit memory plays a crucial role in this process in which attention is directed (Johnson, Woodman, Braun, & Luck, 2007).

1.3. Implicit memory research regarding attention and contextual cueing

Memory and attention are two processes that cannot be considered separately. Memory's capacity is limited and attention is the mechanism which determines what is to be coded. As the subject is considered in terms of explicit and implicit memory, researchers have accepted attention's impact on explicit memory. However, this is not the case for implicit memory. As studies on implicit memory and attention are examined, it is observed that while some studies found that attention has an effect on implicit memory (Crabb & Dark, 1999; Mulligan, 1997, 1998; Rajaram, Srinivas, & Travers, 2001), there are also researches which found that implicit memory is not affected by attention (Isingrini, Vazou, & Leroy, 1995; Szymanski & MacLeod, 1996; Wolters & Prinsen, 1997).

According to contextual cueing, implicit memory influences visual scanning efficiency. Researchers propose that implicit memory affects the division of attention by regulating the flow of information via the visual cortex (Palmer, Ames, & Lindsey, 1993). Johnson et al. (2007) conducted a study based on this idea with 21 university students. In this study, the participants' response times in the environment in which they were engage, and the correctness of their responses were recorded. Moreover, the data obtained from the participants during this process by means of an EEG device were examined. With the physiological data from the research results, strong evidence was obtained indicating that implicit memory directs attention. It was determined that there was an increase in repeated lines in the participants' response time rates compared to new ones. Such an increase in rates are interpreted as proof that contextual cueing provides early division of attention in the visual field.

Altun and Cangöz (2012) compared individuals' implicit and explicit memory performances in environments containing hypertext with regard to hypertext structure (hierarchical–network), presentation type (verbal–visual), and instruction type (implicit–explicit). It was determined that instruction type and presentation type were effective in a word stem completion test. It was also determined that participants exhibited better word stem completion performance where verbal presentation type is employed, compared to environments with visuals under both implicit and explicit instruction conditions.

Based on these findings and the arguments in the related literature, the following research questions were sought answers in this study:

(a) Does different cue presentation type have an effect on implicit memory performance, regardless of sustained attention level?
(b) Does different contextual cue presentation type have an effect on implicit memory performance of individuals with different sustained attention levels?

2. Method

2.1. Research model

This research was designed as a 2 × 2 factorial design. Implicit memory performance was the dependent variable, while sustained attention level and the presentation type of the cues used in the e-learning environment were the independent variables. The participants' sustained attention level and the type of cues presented in the story reading environment they engaged in were determined to have two levels; high–low and static–dynamic.

2.2. Participants

In the study, participants were chosen by means of the convenience sampling method. In order to group participants with regard to their sustained attention levels, the sustained attention test was applied to 76 students in their 1st, 2nd, 3rd or 4th year at Hacettepe University Computer Education and Instructional Technologies Department who volunteered to participate in the study. Also, it was checked that all the participants included in the study had normal vision or corrected normal vision.

The participants who took the sustained attention test were divided into two groups, high and low, by calculating the average of their scores across the three stages of the MOT test. In order to divide the participants into high and low groups, the grouping technique of 'bottom 27% – top 27%' was employed. As a result of this process, 22 people were placed in the low group and 22 people in the high group to participate in the next stage of the study. The range of the participants' average points in the three stage MOT test is provided in Table 1.

Divided into high and low groups with regard to their sustained attention levels, participants with the same attention level were assigned to environments involving static or dynamic cues unselectively. The distribution of participants over the environments is provided in Table 2.

2.3. Data collection tools

2.3.1. Sustained attention test

In order to determine participants' sustained attention levels, a computer based test developed at Yale University according to MOT was used. The test was developed with MATLAB (R2012a, 32-bit) and Psychtoolbox-3 expansion. The test was run on a touchscreen LCD monitor which has a diagonal screen measurement of 17 inches, a resolution of 1280 × 1024 pixels and 5 ms

Table 1
The mean scores of the participants' in MOT test.

Attention groups	Score ranges	Participants
Low	$2 \leqslant \bar{X} \leqslant 5.33$	22
High	$8 \leqslant \bar{X} \leqslant 9.67$	22

Table 2
The distribution of participants.

	Cue types	
	Static cue	Dynamic cue
Sustained attention level		
Low	11	11
High	12	10

response time. The test was used with the permission of the original developers.

The instructions in the test were translated into Turkish by working on the test's source codes. Then, the file sent for a single stage was arranged to accommodate four different stages (practice, easy, moderate and hard levels).

In the test, firstly a practice session is offered to participants in order to help them adapt to the environment. Then, as they proceed to the main application, eight balls appear on the screen. A certain number of the balls flicker, depending on the level, to indicate which balls for the participant to trace. Following this stage, all balls – filled – move around the screen randomly for 10 s. The participants are expected to trace the balls that previously flickered and detect them when all balls stop. Fig. 1 shows two screenshots of the test.

The test consists of a total of four sessions, the first of which is for practice. In the practice session, one of three objects is to be traced in the first two actual trials (after the practice trial), while two out of three objects is to be traced in the third actual trial.

After completing the practice session, participants complete the sessions at the easy, moderate and hard levels respectively. In these sessions, the number of objects that are to be traced is increased at each stage. Each stage in the application takes approximately 3–4 min. Thus, the application takes a total of 12–16 min, to include the practice stage.

Participants can score between a minimum of "0", up to a maximum of "10" points for each of the three levels of the sustained attention test. Each correct detection of a ball by the participants during the sustained attention test is calculated as "1" point to obtain the final level score and level.

2.3.2. Word stem completion test

A word stem completion test was prepared in order to determine participants' implicit memory performance. In this study, a story was presented over the internet to determine how participants' implicit memory performance was affected by contextual cueing. This story was chosen in such a manner that it would attract the students' attention and that they had not encountered the story previously.

The words included in the story were analyzed according to the variables of imagination, concreteness, frequency, extent of association set and association set variables, as mentioned in "Türkçe Kelime Normları" published by Tekcan and Göz in 2005. All of the words included in the word stem completion test prepared within the scope of this study were approached through the "frequency" variable aspect. The fact that words to be evaluated within the study are common or rare affects recalling performance. While common words are recalled better compared to rare words (free recall), it is indicated contrarily that in recognition tests, rare words are recognized better than common ones (Anderson, 1974; McCormack & Swenson, 1972).

In this respect, five, six and seven letter words, with a frequency value of 100–1000 were determined. In the next phase, it was ensured that there were at least three words starting with the first three letters of each chosen word (Eg.: DEV___, DEVLET, DEVASA, DEVE, DEVİNİM, vb), with the help of the Turkish Dictionary by the Turkish Language Association, and words which did not fulfill this condition were eliminated. Subsequently, target words were incorporated into the story in line with the text by making necessary adjustments on the story. In order to evaluate test performances objectively, in addition to the 36 target words, 36 words that were not in the text and had a frequency value of 100–1,000 were included.

2.3.3. Distraction task

After the participants read the story presented, they performed mathematical operations as a distraction task before proceeding to the word stem completion test. Since the study involves a verbal task, a numerical task was chosen for the distraction phase.

2.3.4. Procedure

While transferring the story to the web environment, the target words were placed into the story, the text was divided into nine separate screens without disrupting the flow of the story. A design was created in such a manner that each screen included 100–160 words and four target words. Moreover, the number of letters of the four target words displayed on each screen was determined. Accordingly, each screen contained 2 five letter, 1 six letter and 1 seven letter words. Two separate story reading interfaces were prepared containing static or dynamic cues. A red ellipse was used as the static cue, while a moving red arrow was used as the dynamic cue. Participants who finished reading could quit the story reading environment by clicking on the "I Finished the Story" button. The participants were given a mathematical operation form in this phase and expected to perform the operations on the form. Afterwards, the word stem completion test was handed out and the participants were asked to complete the words on the list to words that first came to their minds.

3. Results

3.1. The effect of cue presentation type on implicit memory performance

The 76 participants' word stem completion test scores were analyzed according to cue presentation type regardless of their

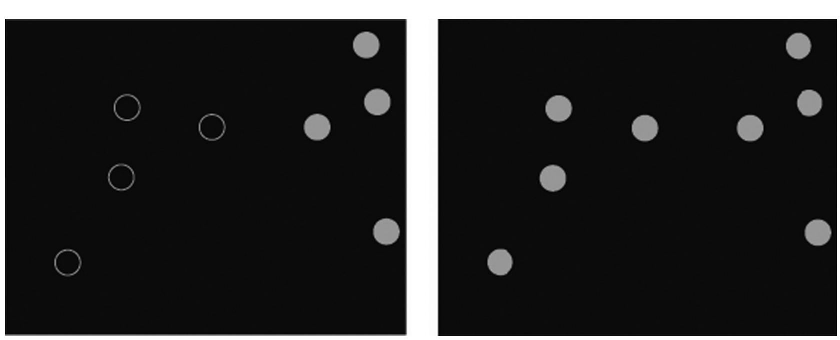

Fig. 1. Sustained attention test screenshots.

sustained attention levels. In the analysis performed to determine whether the data exhibited normal distribution or not, it was found that the distribution was not normal ($p < .05$). Thus, Mann Whitney U test was applied which is a non-parametric data analysis technique.

As may be seen in Table 3, it was determined as a result of the analysis that the participants' implicit memory performance was significantly different according to cue presentation type at a level of $\alpha = 0.05$ ($U = 502.50$, $N_1 = 37$, $N_2 = 39$, $p = 0.022$). The implicit memory performance of participants in the environment containing static cues ($\bar{X} = 11.05$) is higher compared to the environment containing dynamic cues ($\bar{X} = 9.27$). This finding may be interpreted as implicit memory performance varies depending on the cue presentation type and that static cueing has a more positive effect on implicit memory performance. Results of the analysis presented in Table 3.

3.2. The effect of cue presentation type and sustained attention level on implicit memory performance

Two-way ANOVA analysis was performed in order to evaluate individuals' implicit memory performance according to their attention level in e-learning environments containing cues prepared in different presentation types. In the analysis, the scores from the word stem completion test were regarded as the dependent variable. The values obtained as a result of this analysis are presented in Table 4.

As Table 4 is examined, it is observed that the combined effect of cue presentation type and sustained attention level is not a significant factor in implicit memory performance [$F_{(1,\ 40)} = 3.563$, $p > .05$].

According to the ANOVA table, it is also observed that cue presentation type does not have a significant effect on the word stem completion scores [$F_{(1,\ 40)} = 1.001$, $p > .05$]. It is evident in the results that participants' high or low sustained attention level does not have a significant influence in the word stem completion test scores [$F_{(1,\ 40)} = 0.006$, $p > .05$].

4. Discussion

In this study, the effects of dynamic and static cue types presented to users in e-learning environments on implicit memory performance of individuals with different sustained attention levels are investigated. This section of the study comprises the results reached by interpretation of the findings obtained from analyses and the discussion thereof.

The statistical analyses suggest that the contextual cues prepared in different presentation types, namely dynamic and static, do not have a common significant effect on implicit memory performance of individuals with high or low sustained attention levels. Sustained attention is affected by various factors such as the individual's mental state and the external factors of the environment where the individuals are physically present (Ballard, 1996a). Sustained attention is also susceptible to numerous psychological or physiological based factors, such as motivation (Gianvecchio, 2002; Tomporowski & Tinsley, 1996), stress (Galinsky, Rosa, Warm, & Dember, 1993; Hancock & Warm, 1989; Szalma, 2009) or sleep deprivation (Doran, Van Dongen, & Dinges, 2001; Oken, Salinsky, & Elsas, 2006). Consequently, it should be noted that sustained attention test provides a momentary measurement.

Table 3
Mann Whitney U test results of the participants' WSC test scores according to cue presentation type.

Cue type	N	Mean	Mean rank	Sum of ranks	U	p
Dynamic	37	9.27	32.58	1205.50	502.50	.022
Static	39	11.05	44.12	1720.50		

As long as the studies in the literature are examined, it is observed that in implicit memory studies the focus is on divided attention (Rajaram et al., 2001; Spataro, Mulligan, & Rossi-Arnaud, 2011; Wolters & Prinsen, 1997) and selective attention (Ballesteros, Reales, Garcia, & Carrasco, 2006; Mulligan, 2002). The results obtained in studies where implicit memory and visual attention were investigated together do not suggest clear information regarding attention's role in coding and recalling processes. Some studies indicate that attention has an effect on implicit memory (Crabb & Dark, 1999; Mulligan, 1998; Rajaram et al., 2001), while some argue that there is no such effect (Isingrini et al., 1995; Szymanski & MacLeod, 1996; Wolters & Prinsen, 1997).

The findings obtained as a result of the analyses performed in this study also suggest that sustained attention does not have an effect on implicit memory performance. There is a difference of opinion in studies examining the relation between implicit memory and attention. The basic view defended by the research claiming that attention does not have an effect on implicit memory is that coding in implicit memory occurs when an individual is not in a state of conscious awareness, that is attention is not involved, and that the process proceeds automatically. However, as long as the research results suggesting that attention has an effect on implicit memory performance are considered, it is understood that such an effect on implicit memory may be achieved by directing attention.

Another aspect investigated within the scope of this study is cuing as a design element for directing sustained attention. Sustained attention was directed by cues in different presentation forms to examine whether there was a difference in implicit memory performance. In this process, it is observed that manipulation of different attention levels through contextual cueing in different presentation types does not produce an effect on implicit memory performance.

According to the findings obtained from the analyses performed within the scope of the research, it is determined that the cues presented in two different forms, i.e. dynamic and static, has an effect on participants' implicit memory performance as long as sustained attention is ruled out. In this analysis the participants' sustained attention levels are ignored and implicit memory performance of all participants who took sustained attention test are evaluated after entering the story reading environment. It is determined that the implicit memory performance of participants in the static cueing environment is higher than the participants in the dynamic cueing environment.

The significant difference among participants' implicit memory performances without focusing on a certain cue type indicates that implicit memory is sensitive to stimuli's physical characteristics. Better results obtained by static cueing compared to dynamic cueing, on the other hand, is important for learning environment design for individuals experiencing attention deficit.

This finding regarding static cueing's superior effectiveness is in parallel with the results of the Imhof et al. (2013) study where three separate environments (multiple static-simultaneous visualizations with a moving arrow, multiple static-simultaneous visualizations without an arrow and a single visualization with an arrow) are evaluated. The environment with the static cue was determined to be the most effective among the three compared environments. A contrary finding is disclosed in Boucheix and Lowe's (2010) studies. In their study, decentralized coloring was used as a dynamic cue and an arrow was used as a static cue. Participants' scores from an animation depicting a piano mechanism were compared. The results indicate that dynamic cueing provides better understanding compared to cases with no cues or an arrow.

Table 4
ANOVA results of WSC test scores according to the effect of cue presentation type and sustained attention level.

Source	Type III sum of squares	df	Mean square	F	p	ηp^2	Observed power
Cue presentation type	14.871	1	14.871	1.001	0.323	0.024	0.164
Sustained attention level	0.094	1	0.094	0.006	0.937	0.000	0.051
Cue presentation type X sustained attention level	52.946	1	52.946	3.563	0.066	0.082	0.453
Error	594.358	40	14.859				
Total	662.432	43					

Conflicting findings are also observed in cueing study results. Moreover, it should be noted that contextual cues in e-learning environment designs are generally images or animations. However, it is possible to create content in various presentation types depending on the field of content that is to be presented in learning environments and on the media that is to be used. Contents may be communicated by way of using various presentation types, such as narration, animation, simulation, video, podcast and interactive activities. As the purposes of the studies conducted in this field are examined, it is observed that cueing focuses on images and animation due to their complex structures. Within such variety in presentation types, images, animations and other content types are generally supported with texts. For this reason, examining the effects of contextual cueing in various presentation types on texts on implicit memory performance is one of the important implications of this study.

Although academic achievement is not regarded as a variable within the scope of this study, all the applications performed, like in any other study, intend to lead to successful individuals and development of successful environments. Attention's role in individuals' academic achievement is also very important due to its position in information processing.

In this respect, the importance of attention in text reading processes is demonstrated in the study by Steinmayr et al. (2010). As long as attention's general characteristics are considered, it is concluded that focusing on sustained attention as a performance related to more complex processes such as proper understanding of texts, proper interpretation of texts and putting thoughts on paper is more important than focusing on academic achievement in a specific field. Thus, the impact of sustained attention on school performance may be evaluated independently from a specific field. Moreover, strategies for sustained attention development should be provided to students due to its effect on academic achievement. It should be ensured that sustained attention is improved indirectly by developing skills such as self-monitoring and self-regulation.

As in any learning activity, it is one of the most important aims of e-learning processes that participants learn in the best possible manner. Implicit memory is an important variable for e-learning environments due to its effect on permanent learning. The mind is in constant effort to utilize attention resources efficiently. We are, however, are surrounded by numerous stimuli that affect or may affect our attention. Particularly e-learning environments involve too many visual and auditory stimuli and thereby cause constant shifts in individuals' attention. Faulty designs or designs created without taking individual characteristics into consideration, on the other hand, direct individuals' attention inadequately or not at all. Contextual cueing is employed in e-learning environments due to both its effectiveness in directing attention and its effects on implicit memory performance.

The fact that contextual cueing has positive effects on implicit learning by guiding attention is an important point that requires consideration by e-learning content designers. Moreover, determining effects of different cue presentation types on individuals with different cognitive characteristics will provide crucial data for personalized environments.

5. Suggestions

In this study, a computer based measurement tool developed on the basis of multiple object tracking paradigm was used in order to determine participants' sustained attention levels. Attention levels may also be determined by using different measurement tools developed for this purpose. Paper-pen tests and computer based tests may be compared to evaluate their effectiveness.

A personality trait test may be applied to participants before being included in the research process. Participants' sustained attention levels may be evaluated according to personality traits such as extraversion or introversion as well as characteristics such as neuroticism, agreeableness, conscientiousness and openness, whose effects on sustained attention are identified in the literature.

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