Learning from Animation: Smooth Pursuits of Synaptic Transmission of an Impulse with Contextual Cues

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Abstract

Multimedia animations can provide better learning experiences for learners by carrying microscopic science concepts or subjects to macroscopic level. The purpose of this study is to explore how learners with and without prior experience study a multimedia learning material in an only graphically-animated design and in a verbal contextual cue design through eye tracking methodology. A total of 39 undergraduates from the Biology Education Department participated in the study. A three minute animation, describing how the inter-neurons transfer of stimulus happens through synapses, containing two different cue based design (verbal contextual or graphical animated) was used to collect data. The animation was transformed to an experiment on an eye tracker to collect eye movements. A repeated measure ANOVA was executed for data analysis. Results showed a significant within subjects’ treatment effect for design types (verbalized cue vs. graphical animation) in terms of eye movements while between subjects effects for comparison of prior experience groups were not found being significant. Based on the findings from this study, it is suggested that further studies could be designed with a expert groups as well as expanding the content.

Keywords: Multimedia in biology, contextual cue design, prior experience, eye movements;

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1. Introduction

Cognitive Model of Multimedia Learning (Mayer, 2001, 2009) suggests that students learn better when audio-visual animation is presented instead of visual-only animation (Brunken, Plass, & Leutner, 2004; Brunken, Plass & Leutner, 2002; Mautone & Mayer, 2007; Moreno & Mayer, 2002), which is known as modality effect. Multimedia animations have been used in science teaching or in promoting students’ learning with the purpose of providing effective learning environment for them (Cook, 2006; de Koning et al., 2011; Özmen, 2011; Özmen, Demircioğlu & Demircioğlu, 2009) as well as determining deep and special characteristics of learners (Sanchez & Wiley, 2010; Starbek, Erjavec & Peklaj, 2010). However multimedia that integrate visual and verbal content are commonly used for displaying instructional material in science education, it is important to identify how to effectively design these learning materials by a deeper understanding of the cognitive basis of what makes for an effective representation of scientific concepts (Cook, 2006).

One of the intriguing paradigms regarding cognitive learner characteristics in multimedia studies is the issue of attention types: split vs. focused attention. When presenting the materials in a multimedia, instructional designers are to make a decision whether they present it by piecing out each important component for learners or present the whole material on a plane for learners to make their own decisions where to focus. Information presented as non-conforming to the former, this principle might have caused the learner’s attention to be divided between two different tasks.

In their research, Mutlu and Altun (2012) explored the effect of multimedia learning environment designed with two different attention types (focused - split) in terms of their recall performances of learners with different short term memory spans (high – medium - low) with 60 undergraduate students. The findings of this study supported the findings in that recall performances in media with integrated visual and audio information produced higher recall scores than those with split attention design. The researchers suggested that presenting the information on the screen in different modalities (pictorial vs. verbal) with different layouts (separated vs. integrated) might have an impact on recall performances regardless of participants’ STM span. Moreover, the study results also showed that, regardless of their STM spans, all students showed higher recall performance in focused attention type multimedia application.

In order to grasp learners’ attention during instructional intervention, it is suggested to employ varying stimuli when presenting learners with information. In the literature of the effectiveness of instructional media, research suggest that 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 and Moreno, 2002). Information presented as non-conforming to this principle caused the learner’s attention to be divided between two different tasks. For example, it is believed that trying to read a text while an animation is playing will cause the attention to be divided between two different tasks (Sorden, 2005; Cierniak, Scheiter & Gerjets, 2009). Providing texts as description at the bottom of the image is thought to be sufficient in presentations where texts and images are used together. In animations, on the other hand, objects could also be in motion; requiring learners pursue the flow at the same time with verbal, graphical, and textual information.

In order guide participants’ attention, the contextual cues are one of the often employed strategies by the instructional designers. Attention could be focused either on a space or on an object. When the attention is focused on the object, the features related to this object are more accessible than the others (Egly, Driver, & Rafal, 1994). A contextual cue can be presented in verbal, iconic, and/or a combination of both, especially when onset distracters are present. Especially, during a search task, such as looking for a specific item in an environment where there are feature or conjuncture elements preventing and/or popping up what is searched out, contextual cues interfere the performance and the efficiency of the search process depending on how effective they were applied. In their study, Peterson and Kramer (2001) examined the detrimental influence of onset distracters on search performance and found that contextual cues partially suppress the abruption of distracters.
Another learner characteristic that is essential in multimedia design is learners’ prior knowledge or pre-experience levels. Some research studies emphasize the interpretation of graphical media among learners with high and low level of content knowledge (i.e., Cook, Wiebe & Carter 2008). These researches usually suggest that experts in domain knowledge differ from novices in identifying and interpretation of visual images (i.e., Krupinski et al. 2006; Pani, Chariker & Fell, 2005). In studies with eye tracking methodology, researchers draw attention to the differences in performance among various expertise levels where experts are usually reported to perform visual search with fewer saccadic movements with more accuracy in comparison to less trained participants (see, Krupinski et al. 2006; Leung et al. 2007); and, focus on more to relevant information rather than irrelevant information (Canham and Hegarty, 2010). Additionally, Henderson (2003) added that prior knowledge had a significant role on eye metrics such as on numbers of fixation.

To conclude, as mentioned by Mutlu and Altun (2012), designing materials according to the instructional design principles has a mediating role in controlling learners’ attention. When the pictorials were accompanied by verbal information, the content designers were suggested to integrate them rather than presenting them separately. Some content areas are known to be better grasped if presented and integrated within animations. Yet, this integration is not unproblematic itself. In other words, it is important for signals to be powerful enough to provide successful cueing for the direction of attention within an animation (Boucheix, Lowe, Putri, & Groff, 2013). Thus, it would be necessary to explore how the elements in an animation are processed by individual learners from screen. In the next section, the literature related to science teaching in general and biology teaching in particular will be reviewed.

1.1. Science Teaching Multimedia and Eye-Tracking

In science teaching and learning, computer technologies are expected to be integrated by both learners and teachers. Especially in complex science subjects, learners cannot learn enough the subject matter deeply and meaningfully without technological tools. Furthermore, technological tools may help learners by the way of constructing their scientific models in their minds via animations (Ainsworth and VanLabeke, 2004; Boucheix and Schneider, 2009; Mayer and Moreno, 2002). Multimedia animations as technological tools can provide better learning environment to learners by the way of carrying microscopic science concepts or subjects to macroscopic level, thus learning quality may increase (Dalacosta, Kamariotaki-Paparrigopoulou, Palyvos, & Spyrellis, 2009; Ozmen, 2011).

On the other hand, for deeper understanding, the question of why learners can learn better from audio-visual animations, eye-tracking methodology has been applied recently. It has been stated that, eye-tracking process shows evidence related to learners’ internal reflections and motivations during the learning process (Shimojo, Simion, Shimojo & Scheiter, 2003). Additionally, it gives real time information about learners’ visual attentions (Hillaire et al., 2010; Masciocchi & Still, 2013; Petersen and Nielsen, 2002) and also their concentrations (Doran, Hoffman & Scholl, 2009). According to the literature review conducted by Fox (2009), there are a lot of studies focusing on learners’ cognitive processes during reading from science texts (e.g. Cromley, Snyder-Hogan, & Luciw-Dubas, 2010; McCrudden, Magliano, & Schraw, 2010) and also learners’ attentions (Mayer, 2010; van Gog, 2010) with eye-tracking methodology.

In a study, using eye tracking methodology to study cognitive processes, Bayram and Bayraktar (2012) investigated the effect of different audio-visual learning environments on recall performance with students’ attention test scores and eye movement measures. As a result they have found that among multimedia environments prepared according to attention type, it was seen that learners in focused attention type modality had higher recall performances than in split attention type modality.

Emphasizing the importance of understanding the effect of prior knowledge and prior exposure with or without a well-designed environment, Sönmez, Altun & Mazman (2012) investigated how prior
content knowledge and prior exposure to microscope slides on the phases of mitosis effected students’ visual search strategies and their ability to differentiate cells that are going through any phases of mitosis. Based on the results of the eye-tracking data; prior content knowledge was found to have an effect on participants’ visual search strategies and their recognition time for the slide samples that has high colour contrast. Participants with higher levels of prior knowledge were able to recognize and identify the phases of mitosis correctly in a shorter period of time in comparison to participants with low level of prior knowledge. However, no difference was found among groups for the slides that has low colour contrast.

Although there are various studies about individual differences in science learning through multimedia, there is no clear evidence showing the differences among the learners’ characteristics in the learning process in an audio-visual animation by utilizing eye tracking metrics. From this point of view, this study aimed to investigate how learners’ observational patterns vary in terms of their prior experience with the content area. To conclude, the purpose of this study is, first, to explore how learners with and without prior experience investigate and/or study a learning material in an only graphically-animated design and in a verbal contextual cue design; and, secondly, what would eye tracking metrics tell us about processing of those contextual cues. More specifically, the following research questions were sought answers.

1.2 Research Questions

1. Does learners’ approach to animations with different cue designs show differences in their eye tracking metrics? And, what types of a role prior experience play in this process?
   a. Does learners’ approach to animations with verbal contextual cue designs change in terms of observation length and count across prior experience?
   b. Does learners’ approach to animations with graphical animated cue designs change in terms of observation count across prior experience?

2. Is there any interaction effect of design types and prior experience on learners’ observation lengths and observation counts?

2. Method

2.1 Study Group

The study group consisted of total 39 undergraduates students being 19 of second year and 20 of third year students, all of whom were in the Biology Education Department of the Faculty of Education at Hacettepe University. While third year students had already taken a physiology course and studies the synaptic transmissions earlier, second year students didn’t take any course about this topic. Thus, the study group was classified into two sub groups; participants with prior experience (third year students) and participants with no prior experience (second year students).

2.2. Data Collection Instruments

The nervous system as a topic in biology is hard to be understood by the students and misconceptions occur because of its nature since it carries abstract concepts (Lazarowits and Penso, 1992; Bahar, Johnstone & Hansell, 1999; Tekkaya, Çapa & Yılmaz, 2000; Tekkaya, Özkan & Sungur, 2001). Moreover, there is a learning difficulty reported in the literature regarding the nerve system regarding impulse transmission topic (Özsevgeç, 2007). Therefore, a three minute animation, which was created by one of the researchers, describing how the inter-neurons transfer of stimulus happens through synapses, was used to collect data. The animation was saved as a video file. Therefore, for the sake of consistency, video will be used when referring to animation throughout the paper.
The video contained both oral narrations of the content and animated contextual cues in three forms: (a) arrows, (b) textual cues and (c) other graphical cues, such as magnified views, rotation in a motion etc. The original animation was created by PhysioViva Educational Animations Company. After getting the permission, the audio-visual animation was adopted by the researchers and Adobe After Effects software was used during the adoption process. The content of the audio-visual animation covered the subjects such as the structures of pre and post synaptic neurons, and impulse transmission process between two neurons by which explanatory animation scenes related to axon, synaptic gap, role of neurotransmitter chemicals, post-synaptic dendrites, sodium channels, receptors, and sodium ions. In addition, the animation had two modalities: first, the audio explanations were simultaneously presented with the textual information (verbalized content+animated cues+textual cues); secondly, animated representations with no audio explanations (only animated cues and no verbalization) accompanied.

Screen views of two different design type of video (verbal contextual cue vs. only graphically animated cue) are presented in figure 1.

2.3 Experimental Procedure

The animation was transformed to an experiment set by Tobii software on eye tracker. Tobii T120 Eye tracker was used to record eye movement data by two binocular infra-red cameras integrated within the panels of the monitor. The eye tracker was paired with 17” LCD monitor with 1280 X 768 resolutions, 120 Hz sampling rate and an accuracy of 0.5°. Observation length and observation count are the eye movement metric used in this study. Observation length is defined as the total time in seconds for every time a person has looked within an AOI, starting with a fixation within the AOI and ending with a fixation outside the AOI. Observation count is defined as the number of visits and re-visits to an AOI (Tobii, 2008).

Data were collected with eye tracker in one individual session for each participant. Participants were told they will watch a three minute video and any other instructions or guidance were not provided. All the participants were calibrated before the experiment and then the video was opened. Experiment session was terminated with the end of the video.
After collection all the data, two different video segment scenes was created from the whole video. The first scene was obtained from a session in which video contained both narrative telling of the content and other contextual cues (textual, animated arrow and animations) synchronously while second scene was obtained from a session which the narrative telling of the content was ended after that video duration only contained animation about the told content. The first scene was labeled as verbal contextual cue and second scene was labeled as graphical animation cue.

After splitting the scenes from the whole video, area of interests were determined. These areas are determined based on the contextual cues to obtain eye movement on those areas. Three different areas of interest were determined as synapse ending, synaptic cleft and receptor side. The figure 2 shows the area of interests on the video screen.

Eye metrics on those three of the areas were summed up to obtain a total data for each of the observation length and observation count metrics.

2.4 Data Analysis

A repeated measure ANOVA was executed for data analysis. Prior experience status (yes-no) was defined as between subject factors and design type (verbalized cue design and graphical animated design) were defined as within subject factors for each of the eye movement metrics (observation length and observation count).

Before the analysis, assumptions regarding the statistical analyses were tested. Assumption of homogeneity was met by Box’s test of equality of covariance (p=.11) and Levene’s test for equality of variances was met founding result not significant (p > 0.05) for each of variable.

3. Findings

Descriptive statistics verbalized cue design and graphical animation design across prior experience groups of observation length and observation count data are presented in Table 1.
Repeated ANOVA results showed a significant within subjects’ treatment effect for design types (verbalized cue vs. graphical animation) in observation length (Wilks’ Lambda = .24, F (1, 37) = 116.3, p=.000, partial eta squared = .759) and also in terms of observation count (Wilks’ Lambda = .087, F (1, 37) = 389.7, p=.000, partial eta squared = .913). As seen in Table 1, individuals focused on the graphical animation design more than the verbal contextual cue design. However between subjects effects for comparison of prior experience groups were not significant (F (1, 37) = .001, p=.978). Furthermore, any significant differences were not found in terms of design type by prior experience interaction for observation length (Wilks’ Lambda = .999, F (1, 37) = 0.25, p=.875) or observation count (Wilks’ Lambda = .990, F (1, 37) = .368, p=.548).

4. Discussion

This study has investigated the effect of different cue designs embedded in animation and the effect of prior experience while processing this information. Two different cue designs were used in this study: The first is verbal contextual cue design in which all the cue modalities (verbal, audio and motional graphical) presented synchronously. The second is graphical animated cue design in graphical animation of content is presented following the oral narration of the content ended (asynchronously). Participants’ eye movements were used to understand how they processed the content.

The result of this study has revealed out that although there is no effect of having prior experience neither in verbal contextual cue design nor graphical animated design, the effect of design type on the eye movements was found. In other words, participants were more focused on the graphical animated design than the verbal contextual cue design. This finding can be a result of split attention principal of multimedia learning (Mayer, 2009). Since in the verbal contextual cue design, information is presented in the same modalities (animation of graphics and textual cues with oral narration), participants’ attention could have been interrupted by the introduction of those cues.

On the other hand, when there were no audio accompanied by the animation synchronously, participants heavily focused on the other contextual cue elements while observing the animation. In
their study of on redundancy effect in multimedia materials, Mayer (2001) stated that when presenting a multimedia content with narrated text and pictures, adding verbal cues in the form of printed text did not improve learning. The inclusion of graphical cues without any verbal narrations happens to help decrease the redundancy; hence, participants with and without prior experience did not differ in their eye tracking metrics.

Another finding of this study has showed that there were no significant differences between participants who have and do not have any prior experience in neither of the design types. Contrary to this finding, in related literature, it was suggested that individual characteristics as having experience, prior knowledge or being expert in the domain are the important factor that affect learning process in multimedia learning design and those characteristic generally mediate processing visual representation (Cook, 2006; Kriz and Hegarty, 2007). This inconsistency may be attributed to the sampling procedures. When determining the groups, the only criterion was that being taken only one course (physiology). This can be insufficient to show an experience indication. Further studies could be designed with more balanced and controlled groups. Additionally, a prior knowledge test about the topic or having different kinds of courses more than one could be taken as other indicators for experience level.

Similar to this study, Sönmez, et.al. (2012) found that there were no significant differences between participants in terms of prior knowledge especially in multimedia environments that were not developed on the basis of design principle. When instructional design principles were not taken into account, individual differences could easily be overlooked leading to frustration, non-learning experiences and misinterpretation of the benefits of multimedia. For further studies, studies which emphasize other cognitive characteristics such as working memory capacities could be explored together with eye-tracking data. Moreover, in this research, the study was carried out through a specific age group with a single content. It is suggested that further studies be expanded by using larger age groups and contents.

References


