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Effects of cueing and signalling on change blindness in multimedia learning environment

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Abstract

In this study, it was aimed to investigate the change blindness that may occur in multimedia learning environments used cueing and signaling effects. For this purpose, a multimedia animation which had some changes about computer parts was designed. Twenty-one undergraduate students participated in the experiment voluntarily. Eye and mouse movements were recorded and analysed with eye-tracking method, and participants were asked to say when they noticed the changes; their voices were simultaneously recorded. The results show that the participants were more focused on the objects being signaled, and less detected the changes in other areas. It is seen that the percentage of detecting the change occurring on the most focused object is low, except for the object using the signaling and visual cueing. The change in the object that was used the signaling and the visual cueing is the most detected change.

Keywords: Multimedia learning, change blindness, eye tracking.

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1. Introduction

In rich visual environments, when moved from one scene to another, the details of the scenes or objects cannot be perceived. In such a case, an observer can miss the changes that occur in visual scenes. Human beings generally fail to recognise major differences in visual scenes. This phenomenon is called 'change blindness' (Henderson, 1997; Simons & Ambinder, 2005; Smith & Henderson, 2008). In the process of change blindness, we often fail to detect major and important changes although we are subject to experience in the enriched areas (Smith & Henderson, 2008).

Rensink, O'Regan and Clark (1997) emphasised the attention factor in causing change blindness. It was found that the participants realised the changes in the objects as a result of devoting their attention to the changes, yet they could not detect the differences in the objects they did not focus. O'Regan, Deubel, Clark and Rensink (2000), in their study, found that the participants (40% of the participants) could not recognise that the objects under change even though they were directly looking at the objects. In terms of learning content, it can be seen that performance is low in the areas that are not adequately focused (Ayres & Sweller, 2005; Cierniak, Scheiter & Gerjets, 2009; Jamet, Gavota & Quaireau, 2008; Mayer, 2009; 2014a; Mutlu-Bayraktar & Bayram, 2013).

When compared to the pictures, it is considered that it is more difficult to detect the changes in multimedia environments, where changes are abundant. Although it is acknowledged that visual objects can foster learners' performance (Moreno & Park, 2010; Plass, Heidig, Hayward, Homer & Um, 2014; Plass, Moreno & Brunken, 2010; Tchoubar, 2014), if they are not properly designed, visual objects can have neglecting influences (Agostinho, Tindall-Ford & Roodenrys, 2013; Liu, Lin, Tsai & Paas, 2012; Siranovic, 2007; Sorden, 2005; Sweller, 2010). Especially, important information is often presented with visual scene changes. These changes can include more stimuli than we can pick up at once in our limited visual perception area (Cater, Chalmers & Ledda, 2002). Due to the limited visual coding, a failure of the detection of the changes may emerge even though one focuses on the changes (Saiki & Holcombe, 2012). This situation results in the change blindness.

In multimedia learning process, the emphasise is placed on the need to include differently coded external representations such as texts, formulas, shapes and sounds to encourage learning in various ways (Ainsworth, 2006; Mayer, 2014b; Ozcelik, Arslan-Ari & Cagiltay, 2010; Plass et al., 2014; Rusanganwa, 2013). While presenting information to the learners, it is found effective to diversify the stimuli in terms of attracting the learners' attention (Hui-Yu, 2016; Soemer, 2016). Attention is important as the starting point for the three types of cognitive processes which are tied to the multimedia learning process. These cognitive processes are named as selection, organising and integrating. Selection can be defined as the process in which learners select words and pictures presented in a multimedia environment by choosing the ones related to the topic with the help of attention and transferring these into their short-term memory (Mayer, 2009; 2014a).

Materials designed according to the multimedia learning principles proposed by Mayer (2009) were proved to greatly contribute learning in several studies (Crooks, Inan, Cheon, Ari & Flores, 2012; Harskamp, Mayer & Suhre, 2007; Hyona, 2010; van Genuchten, Scheiter & Schuler, 2012). Also, several suggestions regarding the design of the multimedia learning were offered to eliminate circumstances that cause cognitive load (Kalyuga, 2009; Mayer & Moreno, 2010; Moreno & Park, 2010). In addition to this, the effects of change blindness, which were put forward in several studies, should be examined in multimedia environments.

By utilising signalling and cueing techniques and drawing attention to important points, it is aimed to increase performance (Hui-Yu, 2016; Jamet, 2014; Mautone & Mayer, 2001; Ozcelik et al., 2010; Richter, Scheiter & Eitel, 2016). With the same methods, it is seen that the rate of successful change detection can be enhanced (Aginsky & Tarr, 2000; Lin, Atkinson, Savenye & Nelson, 2016). In light of these findings, it is important to investigate the possible effects of signalling and cueing techniques used in multimedia environments on change detection.

Based on the studies of Bergman (2015) and Rensink (2009), it can be stated that change blindness has both positive and negative effects. Besides, it can be argued that change blindness, which manifests itself in many areas of our daily lives, will inevitably influence the learning process in an educational environment. To illustrate, if materials used in the educational process are not prepared according to the multimedia design principles, these materials can create confusion and cause students to have difficulty in determining the change in the visual materials prepared and as a result cause change blindness.

1.1. Purpose

In this study, it is aimed to investigate the change blindness process in multimedia learning environment using signalling and visual cueing. For this purpose, the eye movements were examined during the process of detecting the changes in multimedia.

2. Method

In this study, the research model was defined as a case study. The case study is a qualitative research method that the researcher examines the case in detail by means of data collection tools such as observations, interviews, audio-visuals, documents and reports rather than examining the limited number of variables and observing one or more cases over a certain period (Coskun & Erdin, 2014; Creswell, 2007; Davey, 1991; Karasar, 2015). Within the scope of the small group case study method with the participants, it was aimed to investigate the situation of change blindness in multimedia environment through eye-tracking. The multimedia environment, where the changes occur, was studied by the participants and the change detection process was recorded with eye-tracking method. Eye movements were recorded and analysed by eye-tracking method, and at the same time, in-depth information was gathered through thinking aloud technique.

2.1. Participants

Overall, 21 students from a state university voluntarily participated in this study. All of the participants were undergraduate students in the Department of Science Education. They voluntarily took part in the experiment for extra course credits. Their mean of age is 19.4. Participants were 13 females and 8 males.

2.2. Data collection tools

Within the scope of the research, eye-tracking and interview data were collected. The devices in Human–Computer Interaction Laboratory were used to collect eye-tracking data.

Participants were invited to the Human–Computer Interaction Laboratory according to their appointment times. Participants were then taken into the laboratory one by one to participate in the process of the experiment. Before the experiment started, the participants were asked to follow the points that appeared on the scene with his/her eyes in order to calibrate the eye-tracking device. If the screen calibration was at an appropriate level, the participant was asked to study on the multimedia animation and to think aloud by specifying the changes she/he noticed. In this process, participants' eye and mouse movements, voice, and the number of correct answers were recorded.

2.3. Multimedia

In this study, an animation, which describes components of a computer with supported narration, was used. In some scenes, there were changes on the computer components. In order to ease the process of change detection, signalling and cueing techniques were used.

2.4. Eye-tracking devices

Eye-tracking data can provide valuable information about the attention processes of the learners. The participants studied this material and they were then tested individually at the Human–Computer Interaction Laboratory.

In this study, researchers used an eye-tracking device (experimental—test computer), an observer computer and some software.

2.4.1. Eye-tracking device (test-experimental computer)

It is a device that provides data about where, what, how long and how many times the participant looks at the screen and records eye movements during the time that the user performs the experiment. The device is also connected to the observer computer that records screen image of the user.

2.4.2. Observer computer

The experiment was prepared, and the experimental processes were carried out in the Human–Computer Interaction Lab, and data were recorded and analysed using the observer computer.

2.4.3. Software

iView X is the software that provides connection between eye-tracking device and observer computer.

Experiment Center is the software that enables to form eye-tracking test, manage and control the test. The experiments created with Experiment Center software is connected to the user's computer via iViewX software. Then, recording is performed with BeGaze software. BeGaze is the software that keeps the records for evaluation of stored data.

2.5. Process

First, meetings were arranged to invite the participants to the Human–Computer Interaction Laboratory. Then, participants individually took part in the experiment process. The participants were asked to study the multimedia material that describes computer components and to indicate the changes they realised. The participants' voice, eye, and mouse movements were recorded.

2.6. Data analysis

The records about eye and mouse movements recorded with the Experiment program were analysed through the Be Gaze program. In the analysis, the fixation numbers, duration, and heat map data were obtained, and heat maps of the screens were analysed.

3. Findings

In the animation that was prepared within the multimedia environment for the purposes of this study, it was realised that the participants mostly focused on the biggest object. Later on, it was seen that the participants concentrated on each component that was signalled and cued.

The frequency and percentages of change detection during the animation were shown in Table 1.

Table 1. The descriptive statistics of change detection

Change	f	%
In central object	5	41.66
In signalled Object	10	83.33
Object addition	8	66.66

In the scene, in which change occurred, when the keyboard was being described, five participants out of 12 (41.66%) detected the change on the screen (Table 1). In this phase, the eye movement results show that the participants first focused on the keyboard and some of them focused on the monitor in the moment of change and consequently detected the change (Figure 1).

Figure 1. The heat map of the changed occurred in the major object

It was found that the most detected change was on the object being verbally described and 10 participants out of 12 (83.33%) were found to detect the change (See Table 1). The participants easily detected changes on the objects that were verbally described and signalled (Figure 2). In addition to this, it was seen that out of two objects with the same signalling, the participants focused more on the object that was cued with an arrow, and they focused on the other object at the moment of change.

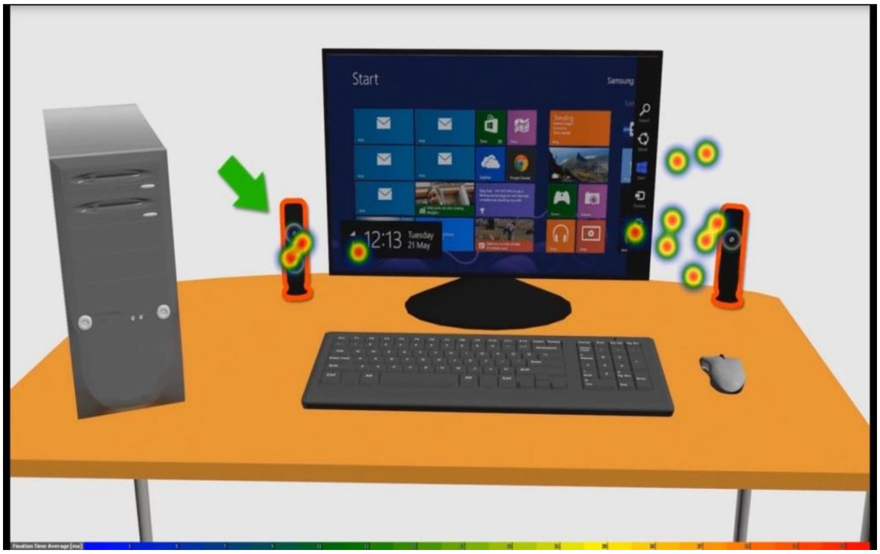

Figure 2. The heat map of the moment of change on the signalled object

In the multimedia-learning environment, where there were fewer objects, it is seen that the changes were easily detected. Eight participants (66.66%) more easily managed to detect the change in the screen where there were fewer objects (See Table 1). It is also found that the fact that participants could focus more easily on the change when there were fewer objects was put forward through eye movements (Figure 3).

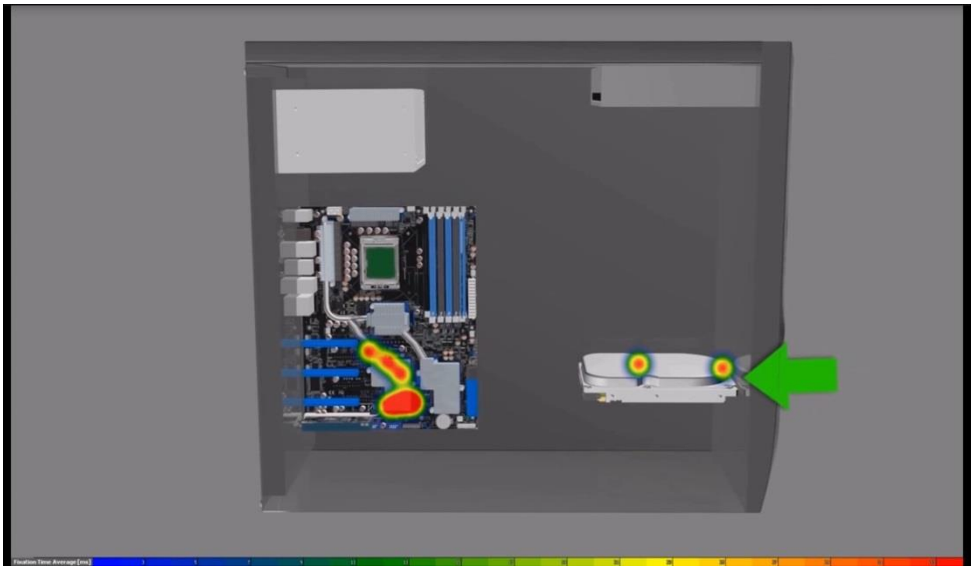

Figure 3. The heat map of the screen that presented fewer objects

4. Conclusion

In this study, it was aimed to investigate change blindness which possibly emerges in multimedia learning environments. For this purpose, a multimedia animation was created, and the participants, whose eye movements were recorded in the process of the study, were asked to detect the changes in the multimedia environment.

In multimedia learning environments, many studies have shown that using signalling and visual cueing has an effect on learning (Mautone & Mayer, 2001; Ozcelik et al., 2010; Richter et al., 2016). In this study, the change detection occurring in a multimedia which designed using signalling has been investigated. It appears that the participants focused more on the objects being signalled and less detected the changes in other areas of the screen. In studies conducted with eye tracking, signalling effects have shown that attention can focus more on the area of interest (Alemdag & Cagiltay, 2018; Desiron, Betrancourt & de Vries, 2018; van Gog, 2014). Eye tracking showed that attention has been directed towards area of high interest, where attention has been found to be faster and stronger than in the area of low interest. The change where occurs on the area of high interest was detected easily than the area of low interest (Hollingworth & Henderson, 2000).

Except for the object that was signalled and visually cued, it was seen that the percentage of the change detection in the most focused object was lower. When the heat map of the participants' eye movements was analysed, the participants focused on the most central and major object, apart from the signalled object. If there is a signal or the importance of the changing object is high (central change), the change is easily detected (Rensink et al., 1997; Simons & Rensink, 2005).

It was seen that the changes, which occurred in signalled and visually cued areas, were the most detected changes. In order to visually perceive the changes in the object on the screen, the existence of the focus is necessary. The signalling and cueing techniques create such an environment that leads one's attention to the objects. Without focused attention, visual memory cannot compare the images (the original and the changed one) and change detection becomes impossible (Rensink et al., 1997).

In the multimedia, when the speaker was being described, there were two distinct signalling on both parts of the speaker yet visual cue was directed to only one part of the speaker. It was found that the participants, at first, focused on the cued object. The change took place in the un-cued object and when the change occurred, the participants focused on the previously un-cued object. It can be said that it is the most detected change and it is due to the effects of signalling and cueing. In multimedia learning environment, cueing has a positive effect on learning outcomes because of the reduction in total cognitive load and avoidance of cognitive overload (Lin et al., 2016; Xie et al., 2017). Many studies show that cueing and signalling help focus attention. Jamet (2014) stated that cueing is related to the attention guiding effect. Hui-Yu (2016) indicated that attention cueing helped reduce the learners' mental load. In a meta-analysis study, comprised 46 years of signalling research in learning with media, it was found that signalling is beneficial for retention and transfer performance (Schneider, Beege, Nebel & Rey, 2018).

On a scene with fewer objects, participants seem to be able to focus more easily on the change. At the same time, addition or omission of the object (presence/absence) and location change are the most detected change type (Aginsky & Tarr, 2000).

According to these results, it is suggested to use signalling and cueing techniques that were designed in the light of multimedia learning principles in order to emphasise the change. It is thought that especially the redundancy principle and split attention effect (Mayer, 2009) can cause change blindness more. It is recommended to use signalling and cueing at the same time in learning environments designed according to the multimedia learning principles so that change can be recognised more easily.

In multimedia environments, where change blindness will be investigated, it is also suggested to look for cognitive process like attention, perception and memory. It can be showed how individuals in different cognitive characteristics are affected by cueing and signalling effect. In addition, the effect of cueing and signalling on change blindness occurred on text and image can be examined.

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A	radius of
B	position of
C	further nomenclature continues down the page inside the text box

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An example of a column heading	Column A (*t*)	Column B (*T*)
And an entry	1	2
And another entry	3	4
And another entry	5	6

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Avoid hyphenation at the end of a line. Symbols denoting vectors and matrices should be indicated in bold type. Scalar variable names should normally be expressed using italics. Weights and measures should be expressed in SI units.

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Footnotes should be avoided if possible. Necessary footnotes should be denoted in the text by consecutive superscript letters. The footnotes should be typed single spaced, and in smaller type size (8 point), at the foot of the page in which they are mentioned, and separated from the main text by a short line extending at the foot of the column.

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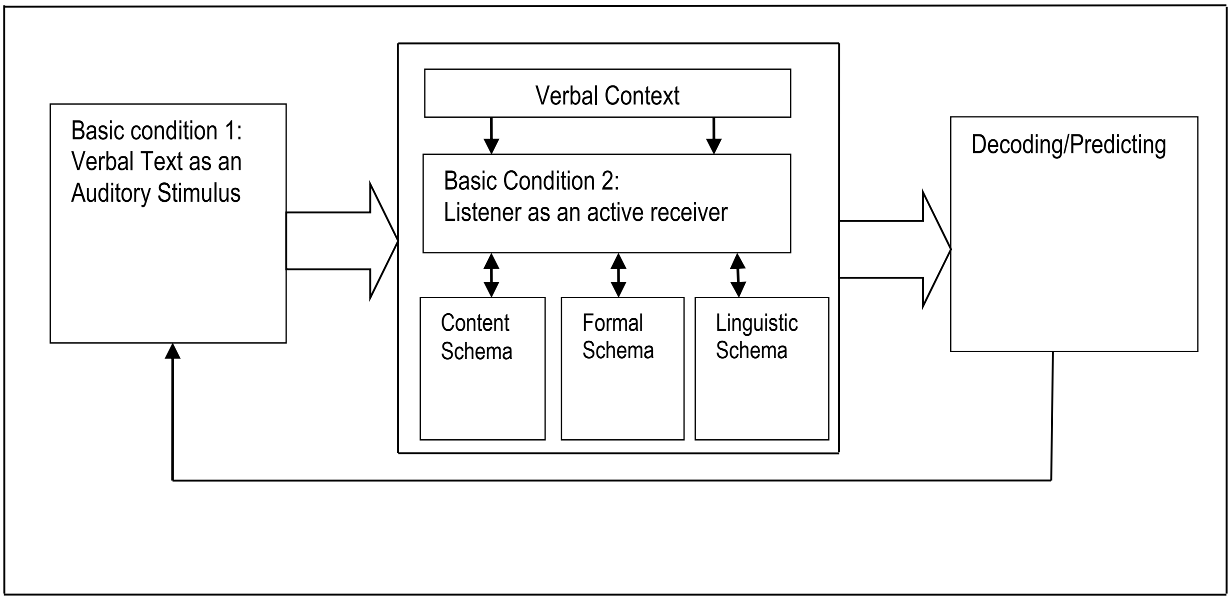

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