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EVALUATION OF ASEAN MENTAL MODELS PATTERN OF WEB USER-CENTERED INTERFACE DESIGN USING EYE-TRACKING TECHNOLOGY

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ABSTRACT

This study utilised eye-tracking technology to evaluate the results from the ASEAN mental model pattern of web object locations in a web user-centered interface design. Two experts and four volunteers participated in an eye-tracking experiment. The selected web object locations led to fewer fixations and participants found the target web objects faster. The eye-tracking data showed that users have clear expectations of where web objects are located on a web page. With the utilisation of the eye-tracking technology, a more precise and objective tool can be used to improve the classification of web user-centered interface design. It was concluded that eye-tracking technology is accurate and useful for knowing what a user looks at and understanding the user's behavior. Finally, it was established that there was an improvement when using the information generated by the eye tracker. The study showed that web objects located according to user expectations were found faster and remembered more easily. Placing web objects at expected locations and designing their appearance according to user expectations facilitates orientation, which is beneficial for first impressions and the overall user satisfaction with the website experience.

Keywords: Eye-Tracking, Mental Models, Web User-Centered Interface, Web Objects, User Expectation

1. INTRODUCTION

Internet users desire quick and easy web page orientation, which leads to increased efficiency and user satisfaction (Tuch *et al*., 2009; Yom and Wilhelm, 2004; Zhang *et al*., 2002). Faster visual recognition of web objects allows users to orientate themselves more easily (Leuthold *et al*., 2011). To do so, users do not solely rely on the features of a website, but also on their mental model of the system they interact with and their knowledge, experiences and expectations of how a web page functions and its appearance (Foulsham and Underwood, 2008). By manipulating object features, web designers can draw users' attention to specific areas on a web page and by arranging web objects on web pages according to users' mental models pattern, the efficiency of web page orientation may be facilitated and quality of interaction enhanced (Norman, 1983). The aim of the present study is to investigate the relation between location typicality, the conformance of web object positioning with user expectations and efficiency in finding target objects on web pages. The investigation uses the illustrated interface in a case study of the ASEAN Clearing-House Mechanism web interface. In addition, this study investigates whether or not there are differences in the susceptibility of certain web objects and/or web page types to location typicality (Roth *et al*., 2012).

According to Liu *et al*. (2011), the latest eye-tracking technology can, with minimum intrusiveness, trace a viewer's eye movements while viewing on-screen information. These eye movements can be used to represent

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the processing of information (Underwood and Radach, 1998; Liu *et al*., 2011). In order to evaluate and confirm the efficiency and satisfaction of the mental model, eye-tracking evaluation is conducted in the present study and is supported by ratings of web objects importance.

2. EMPIRICAL STUDIES OF USER MENTAL MODELS PATTERN

Dujovne and Velasquez (2009) defined web objects as “any structured group of words or a multimedia resource that is present on a web page that has metadata which describe its content” (Velásquez, 2013). Through interaction with the internet, users develop certain expectations, which in turn form mental models when they access a web page and its corresponding web objects (Roth *et al*., 2012).

When users repeatedly encounter certain web objects at specific locations, they form expectations of web object placement over time. Positioning navigational areas at expected locations and using specific web objects consistently helps users to remember them (Oulasvirta, 2004). Several studies show that people expect to find web objects in certain locations (Bernard, 2000; 2001; 2002; Bernard and Sheshadri, 2004; Oulasvirta *et al*., 2005; Shaikh and Lenz, 2006; Roth *et al*., 2012; Vasantha and Harinarayana, 2011; Rouse and Morris, 1986). The literature provides data about location typicality for several web objects. Overall, expectations regarding the location of most web objects are quite congruent across these studies (Roth *et al*. 2012). The present study examines expectations regarding web objects located on informational websites in particular. Bernard (2000) used the phrase “typical web page within a website”. According to Shaikh and Lenz (2006), expectation shifts occur due to technological advances changing the appearance of the internet. Therefore, the present study also looks into the changing patterns.

Several studies have shown that the recognition of objects was facilitated when objects were placed in the proper context (Biederman *et al*., 1982; Davenport and Potter, 2004; Palmer, 1975). For example, objects were more difficult to recognise when they were located in an improbable location or were of an inappropriate size, so that the contextual relations were violated (Biederman *et al*., 2006). Simply knowing the gist of a scene speeds up its identification (Roth *et al*., 2012). Oulasvirta *et al*. (2005) found that people were better able to remember specific web objects if the objects were placed according to their expectations (Roth *et al*., 2012). The present study uses data about users’ mental models pattern from Aslina and Azizah (2013), which provide the web object placement and then evaluate the results’ validity using eye tracking. This study hypothesizes that the higher the location typicality of a web object, the faster the object will be spotted on the web page and the fewer fixations are required until it is found. In contrast to previous studies which used existing websites, the present study uses web page from the ASEAN Clearing-House Mechanism (aseanbiodiversity.org) and compares the layout on those page with the layout proposed in the present study.

3. STUDY I: SURVEY OF WEB OBJECTS LOCATION FOR USERS’ MENTAL MODEL PATTERN

3.1. Participants, Design and Procedure

A total of 101 participants, mainly ASEAN residents in different professions, participated in the experiment. Malaysia was the main focus for the pilot test. Therefore, 16% (17) of the participants were from Malaysia (**Fig. 1**). The participants were recruited via an online announcement, email and face-to-face through a workshop. The average age of the Malaysian respondents was above 33 years (range: 24-41) and there were nine males and eight females. In order to study the users’ expectation of web object locations, a mock browser window consisting of 6×7 horizontal and vertical grid squares adapted from the mental model in the Bernard and Sheshadri (2004) method design was used. The experiment involved the placement of ten selected web objects (logo, title, internal links, external links, login, language, search engine, content, calendar, advertisement), with the participants required to number the expected location of each object.

3.2. Results and Measurements

The frequencies indicating the participants’ expectations were obtained by counting the number of times the participants selected each square for each web object. The results are presented in relation to each object (**Fig. 3 to 12**). Each shade represents a specific range of times each square was selected as the expected location of a particular web object. The darker the shade, the greater number of times a particular square was selected (**Fig. 2**). This study examined the expectations of individuals from Malaysia regarding the location of certain objects on a web page.

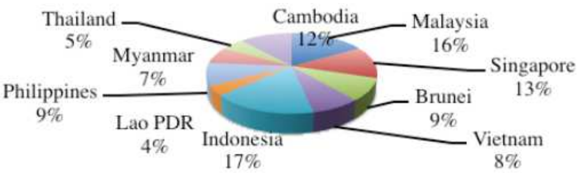

Fig. 1. Distribution of participants from different countries

Fig. 2. The darker the shade, the more selected

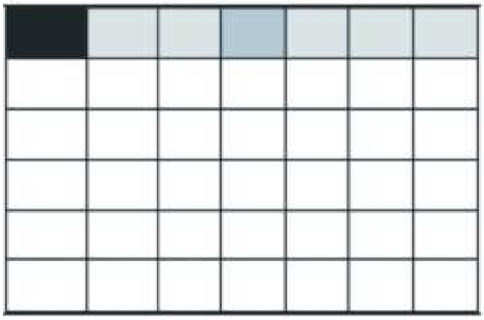

Fig. 3. Logo

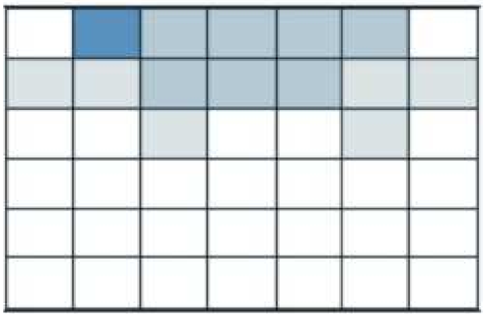

Fig. 4. Title of web page

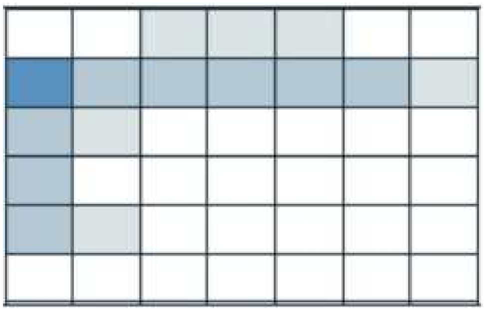

Fig. 5. Internal links

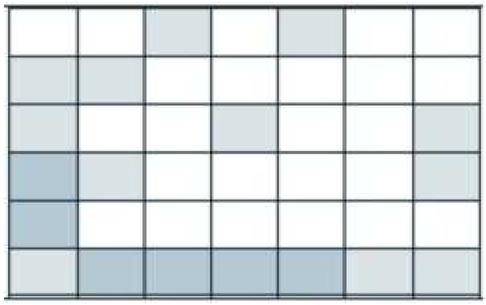

Fig. 6. External links

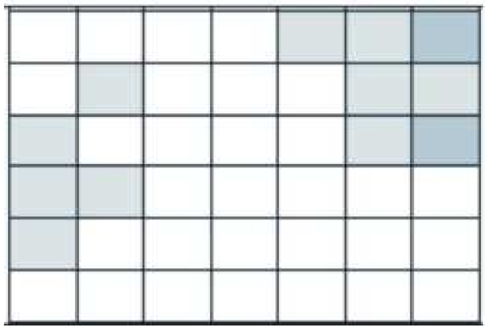

Fig. 7. Login

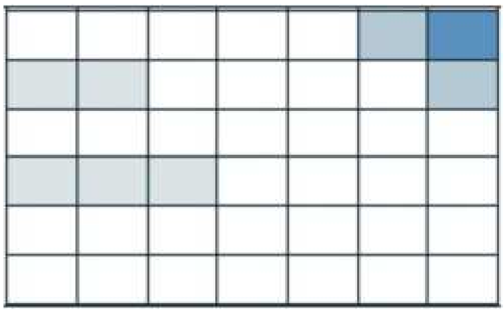

Fig. 8. Language selection

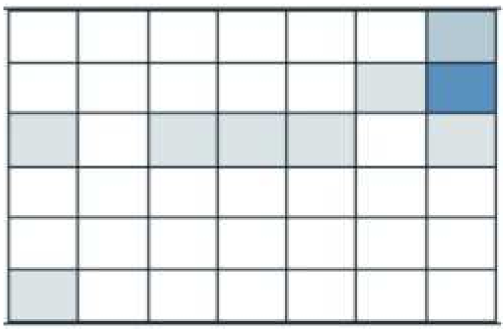

Fig. 9. Search engine

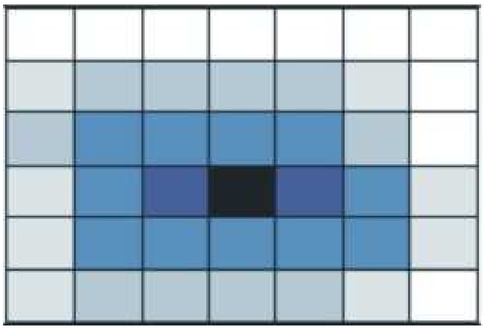

Fig. 10. Content

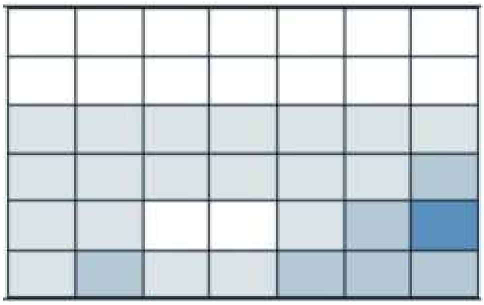

Fig. 11. Calendar

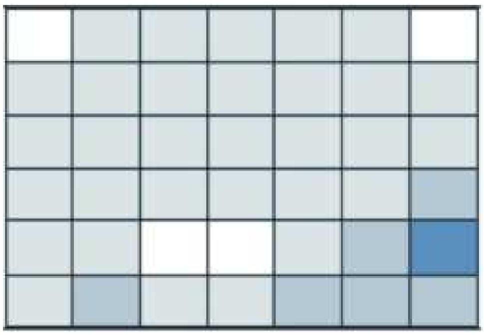

Fig. 12. Advertisement

4. STUDY II: EYE-TRACKING EVALUATION

Eye tracking is a technique used to measure an individual's eye movements. Thus, a researcher can know what a person is looking at in each moment and can trace the sequence in which their eyes move from one place to another. Following eye movements can help human computer interaction researchers understand the processing of visual information and the factors that may impact on the usability of the interface (Nurul-Hidayah *et al*., 2011). Thus, recordings of eye movements can provide a source of objective data for the evaluation of interfaces, which in turn may provide information to improve interface design (Velásquez, 2013).

According to Velásquez (2013), eye-tracking systems have been used to investigate how sighted persons use and perceive the objects and features on a website. This new knowledge is very important for stakeholders such as website designers, webmasters and advertisers because many innovations can be improved for web page design, creation and visual representation. Thus, more sustainable interfaces can be created. In addition, Liu *et al*. (2011) explained that an individual's eye movements provide valuable information about how information is retrieved and processed (Underwood and Radach, 1998).

The number of fixations can be attributed to the efficiency of a viewer's search for information on the computer screen. The greater the number of fixations, the less efficient the viewer's search for information is assumed to be. The frequency of a viewer's fixations on a specific element or area of a visual display shows the importance of that element or area. Furthermore, the time spent gazing at a particular component of the visual scene can identify the viewer's area of interest. In addition, when longer fixations are present, it is likely that the viewer has faced a higher difficulty level. The fixation duration is also believed to reflect the time the viewer needs to process the information related to the fixation (Rayner, 1998). The scan paths, or sequences of fixations of eye movement data, reflect changes in the areas of interest over time and can be used to realise the mental imagery constructed by the viewer while viewing the visual image (Liu *et al*., 2011).

While the literature has revealed the significant potential of eye movement data to detect a viewer's mental workload, the majority of these studies collected eye movement data solely during or following reading or picture perception (Liu *et al*., 2011). In this study, by utilising eye-tracking technology, the ASEAN mental model pattern of web objects placement on a web usercentered interface design is evaluated. This study intends to detail how the placement of web objects according to users' expectations leads to an efficient web usercentered interface requiring fewer and shorter fixations. The study aims to validate and confirm the pattern schema of the ASEAN mental model on web user-centered interfaces and to provide suggestions for instructional designers in developing standardised and effective web user-centered interfaces in future. In addition, because the first impression of a web page is formed almost instantaneously (Lindgaard *et al*., 2006), examining where users focus their attention in the first few seconds of exposure to a page may be particularly helpful in identifying components that are expected to be placed in certain locations on the page. This is achieved by identifying the web object that is fixated upon in the first fixation and by mapping the order in which the web objects are viewed. The time taken by the viewer to complete the information- seeking task is then calculated to differentiate the placement effectiveness.

4.1. Participants

Two multimedia experts (one male and one female) and four volunteer students (four females) in the final year of a Bachelor degree in multimedia computing at Universiti Technologi MARA (UiTM) participated in the pilot test. All the participants were required to be familiar with websites and have at least 5 years' web experience. Three of the six participants wore glasses but this was not a barrier to tracking their eye movements. Most of the participants were familiar with the eye tracking evaluation procedure. A web user-centered interface prototype design was utilised to address the research purposes using the case study of the ASEAN Clearing-House Mechanism web page as the content page. Each participant viewed (in a randomised order) four layout illustrative web user-centered interface pages on which the original (Layout 0) and proposed layouts (Layout 1, Layout 2 and Layout 3) were presented. The eye movements of the viewers were collected for use in reconstructing their thought patterns and strategies while processing the web object placement information. All the screenshots were combined into PDF to increase realism. In this study, only Layout 0 and Layout 2 (Malaysian preferences) are analysed and explained.

4.2. Procedure

The experiment took place in the UiTM eye-tracking laboratory. The participants were tested separately. Upon entering the usability lab, the participants were briefed on the purpose of the study. They were asked to fill out a short questionnaire on computer knowledge and demographics. The participants were then introduced to the eye tracker and the eye tracker was calibrated individually to each participant. This involved a brief procedure in which the participant watched a dot move to the four corners and the center of the screen. The calibration process for each user took about ten to fifteen seconds. The experimental task procedure was then presented on the screen. The participants were given instructions to find each web object randomly. To familiarise the participants with the task procedure, a short introduction to the ten web objects was conducted. The participants were instructed to spot the target web object as quickly as possible on the illustrated interface layout on screen. The target cue was displayed for two seconds before the stimulus onset. Immediately after spotting the object, the participants signaled the experimenter by saying 'next'. Then the experimenter triggered the next target cue by pressing the next button. Throughout the study, the experimenter controlled the keyboard and continued to the next screen after the participants found the target object or completed the task. This helped the participants to stay focused on the screen. Once the eye-tracking experiment was completed, the participants were required to answer questions in a short interview during which they were asked to rate the importance of each of the objects for an informational website using a five-point Likert scale. The participants were then thanked for their participation and each participant was given a souvenir and a token of RM15 to show appreciation for their contribution and time.

4.3. Eye-tracking Device

An eye-tracking device manufactured by Tobii Technology was used in this study. The tracker works with two infrared light sources and the reflection of the light from the retina is recorded by a camera. The eye tracker functions remotely from the user and does not require the removal of glasses, allowing for a natural environment. The eye tracker looks much like a regular monitor. Infrared light is bounced off the user's eyes and sensed by several infrared sensors on the monitor. Based on this, the software is able to interpolate the position of the participant's eyes. Participants can move freely only in a limited area so that the tracking system can record accurately. The present study used the Tobii T60 Eye Tracker, which consists of a 17 inch monitor. Along the experimental, audio and video are recorded for later analysis of users' behavior.

4.4. Measurements

The data collected during the eye-tracking experiment included information about the participants' fixations and how long the participants looked at an object on the web page. This information was obtained by using gaze plots analysis. Fixations have been linked to intense cognitive processing (Pan *et al*., 2004) and are viewed as a reliable indicator of an individual's attention (Vertegaal and Ding, 2002). In addition to fixation, data were gathered on the length of time it took for the participants to fixate on specific areas of interest after the web page was presented. Based on these data, it was possible to determine the first fixation and the order/sequence in which the participant found an object on the web page. Then, short interviews were conducted immediately after the eye-tracking data were collected. The participants were asked to indicate the objects that most captured their attention and which layout they preferred the most. To measure the importance of the objects, the participants were asked to rate the importance of each object for an informational website on a five-point Likert scale (from 5 = extremely important to 1 = extremely unimportant).

4.5. Results

Using gaze plots, this section presents an analysis of the order in which the participants viewed areas on the web page. The importance ratings are also analysed. From the ten web objects, only four are analysed and discussed, namely, internal links, external links, content and advertisement. This is because three web objects were additional objects (calendar, login and language) from the proposed enhancement of Layout 0 and three objects (title of web page, logo and search engine) were taken out because both layouts placed them in the same location, so they are not relevant for comparison purposes. The gaze plot data on the web page viewing were aggregated.

This information revealed the order in which the participants viewed the particular areas. For example, on Layout 2, the ten objects were randomly arranged. The time to first fixation was the time from when the page was first shown to the participant until the target object received fixation. This was measured in seconds for each web object for each participant. The times were then averaged across participants for each task. Based on this calculation, the average and percentage of duration in which users completed the task were determined. The plots of the fixation order for each page are shown in **Fig. 13 to 16**. Only Layout 0 and Layout 2 are shown for the purpose of analysing Malaysian preferences. The results for each participant are presented in two comparison gaze plots on two different layouts. The gaze plots of the web objects (internal links, external links, content, advertisement) for two comparison layouts (a: Layout 0 and b: Layout 2) with two experts (E1-blue and light purple; E2-light green and light blue) and four volunteers (4P) (P1-purple; P2-light blue; P3-light green; P4-yellow) are analysed and discussed, along with the importance ratings in **Table 1 to 5**.

As shown in **Fig. 13**, all the participants (experts and volunteers) found the internal links object faster on Layout 2 (fixation no. 3 to no. 6) than on Layout 0 (fixation no. 4 to no. 28). This shows that the location of the internal links on Layout 2 (top-left) was the expected location for all participants. This result is consistent with the findings in previous studies by (Bernard, 2000; Bernard and Sheshadri, 2004; Shaikh and Lenz, 2006). In the short interviews, all the participants also preferred this location of the internal links, which means that both results corresponded with their eye movements. The participants rated the internal links object as an important object for an informational website (**Table 1**).

As shown in **Fig. 14**, both experts and three volunteers (P1, P3, P4) found the external links object faster on Layout 2 (fixation no. 1 to no. 9) than on Layout 0 (fixation no. 2 to no. 21). The fourth volunteer (P2) struggled to find the external links object on Layout 2 (fixation no. 15). The location may have been unfamiliar to this participant; however, she later stated in the short interview that the location of the object (at the bottom of the web page) was good and overall she still preferred Layout 2. The external links object was rated by the participants as having low importance for an informational website (**Table 2**). Since the external links object is a hyperlink that points to a page on a different website, the participants might have thought that this object was not useful for an informational website.

Table 1. Importance rating of internal links object

		Frequency	Percent
Valid	Important	4	66.7
	Extremely important	2	33.3
	Total	6	100.0

Table 2. Importance rating of external links object

		Frequency	Percent
Valid	Unimportant	1	16.7
	Less important	3	50.0
	Important	2	33.3
	Total	6	100.0

Table 3. Importance rating of content area

		Frequency	Percent
Valid	Important	2	33.3
	Extremely important	4	66.7
	Total	6	100.0

Table 4. Importance rating of advertisement object

		Frequency	Percent
Valid	Unimportant	3	50.0
	Less important	3	50.0
	Total	6	100.0

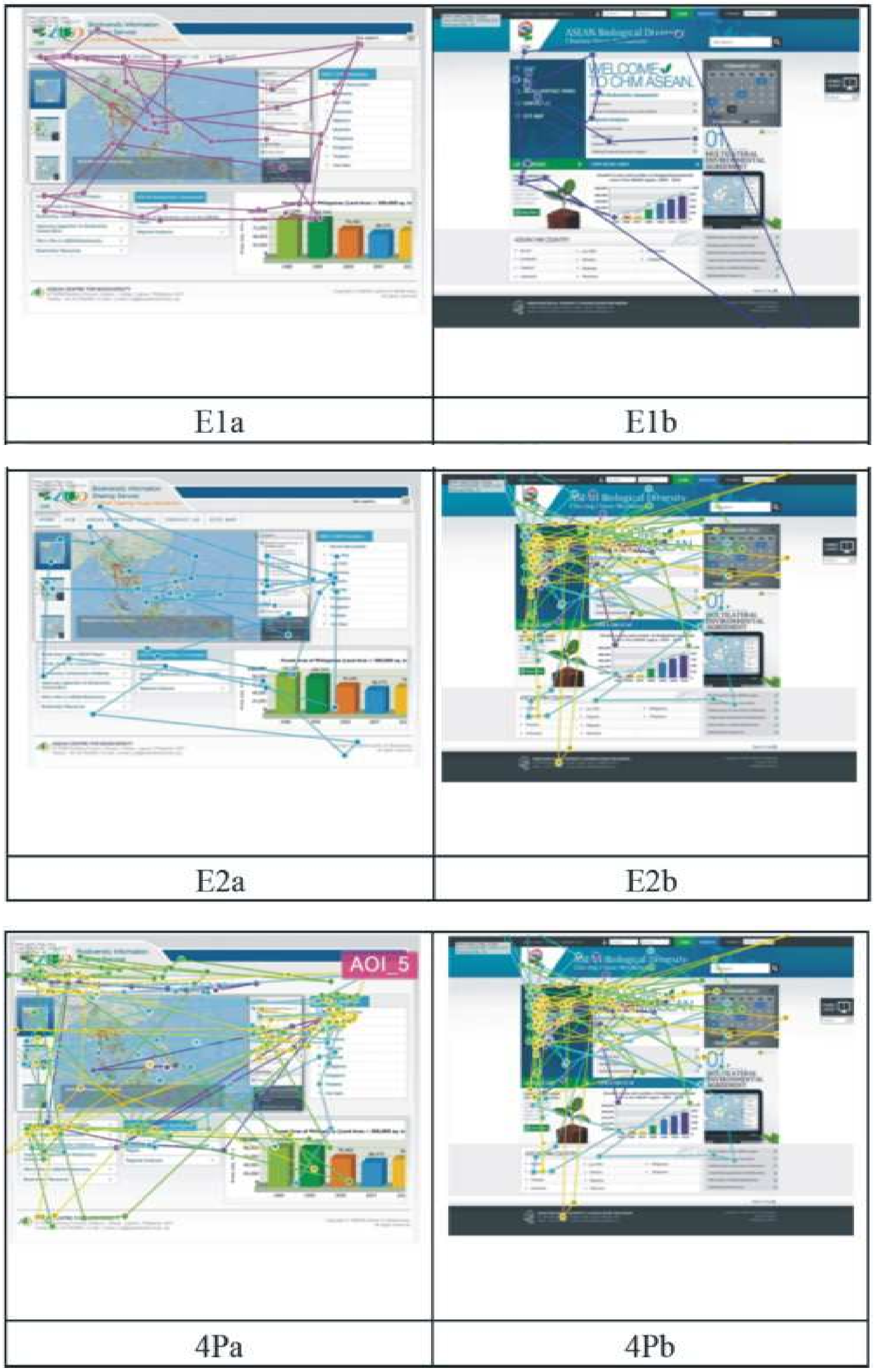

Fig. 13. Gaze plots of internal links object

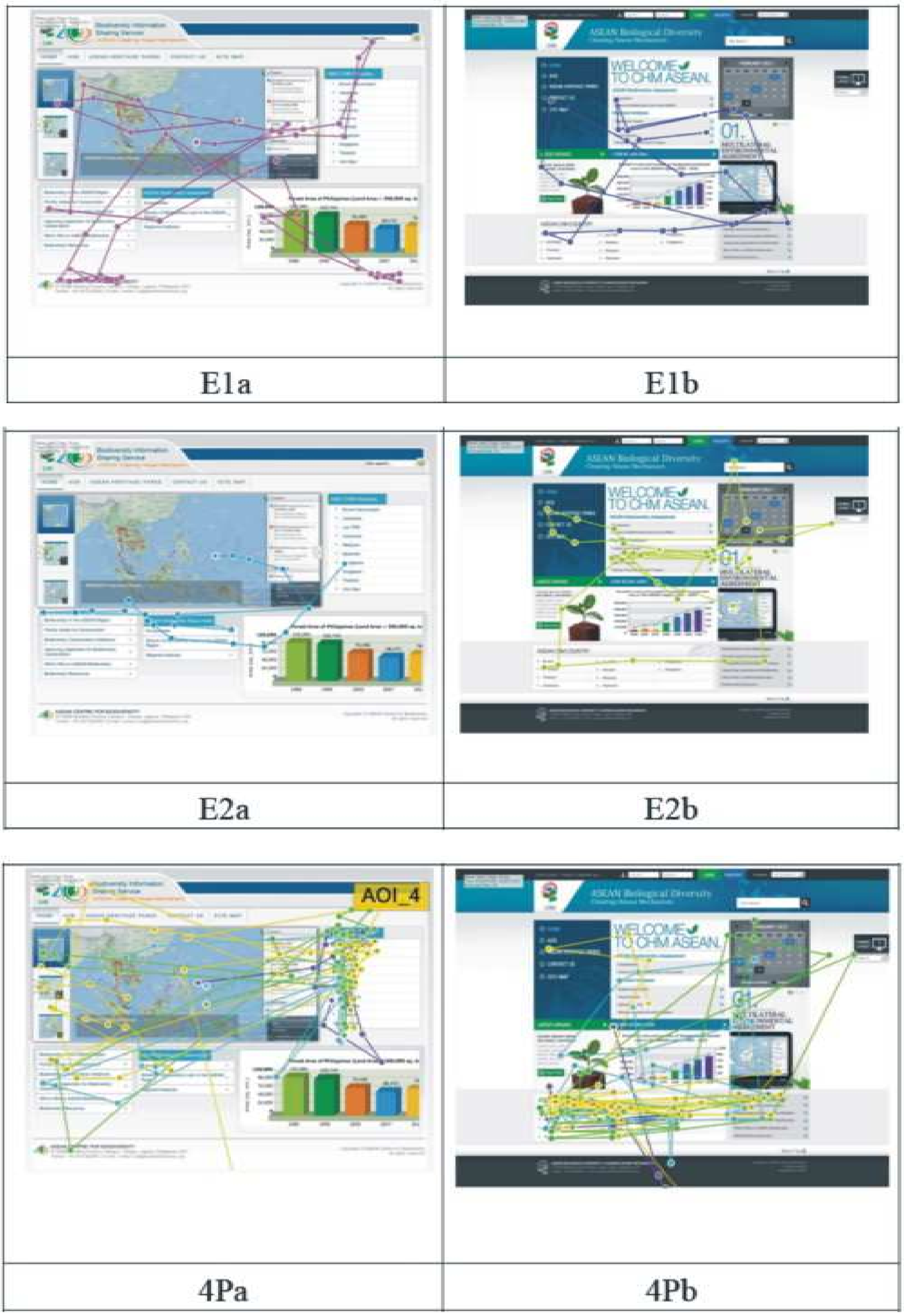

Fig. 14. Gaze plots of external links object

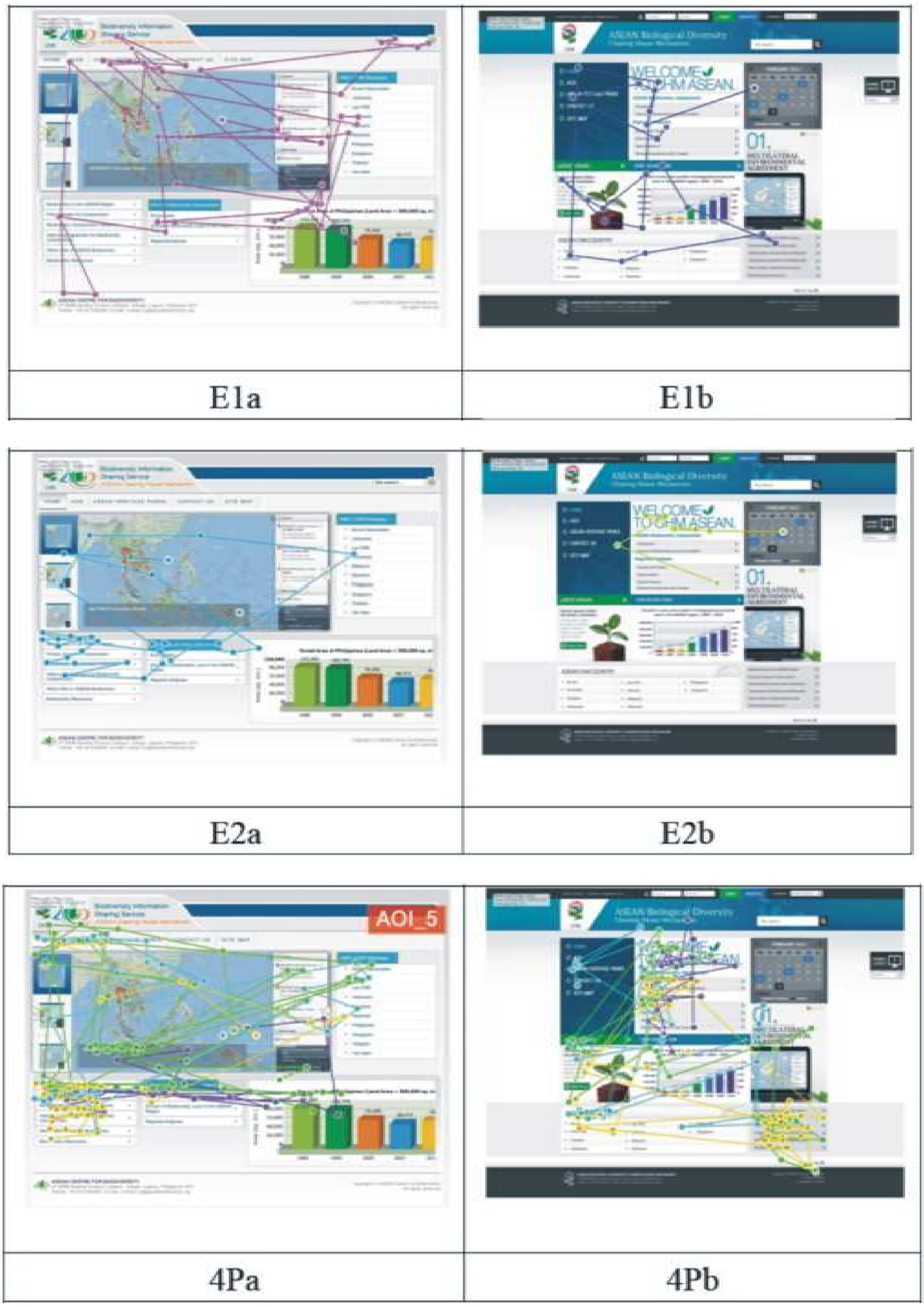

Fig. 15. Gaze plots of content area

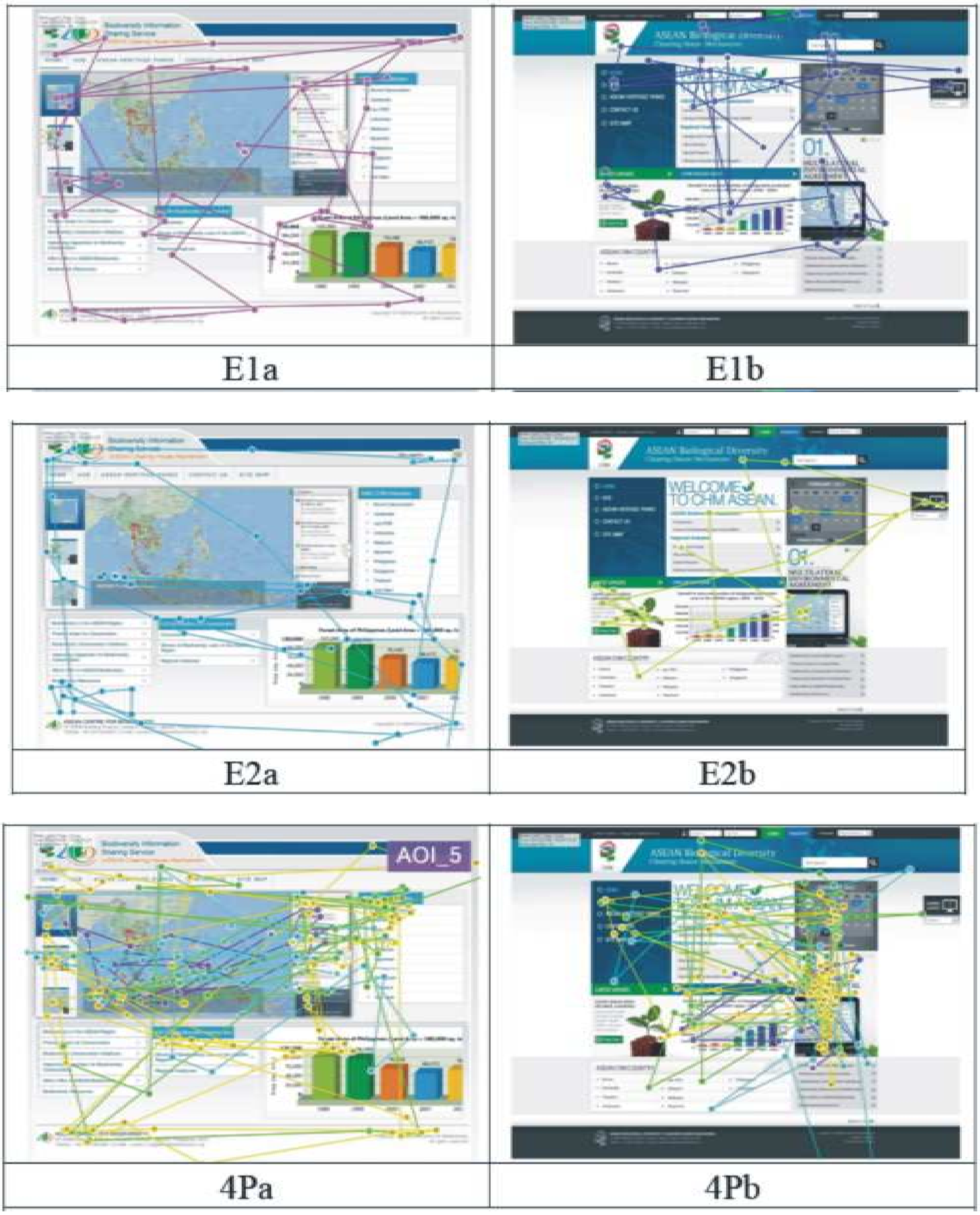

Fig. 16. Gaze plots of advertisement object

Table 5. Total time (duration of fixation) in seconds to complete the task

	Layout 0 (minutes)	Layout 2 (minutes)	Difference (minutes)	Efficiency (%)
E1	4:10	2:29	1:41	40
E2	4:17	3:22	0:55	21
P1	3:36	2:46	0:50	23
P2	5:25	4:09	1:16	23
P3	5:27	2:55	2:32	46
P4	5:05	3:15	1:50	36
Average				(20-50)%

As shown in **Fig. 15**, all the participants found the content area in fixation no. 1 on Layout 2, which was much faster than on Layout 0 (fixation no. 2 to no. 22). This is because the center area is the first area a user will look at when they open a web page. This area is also determined as an important area to place important objects. According to Spool *et al*. (1997), users may start viewing the page in the center and only examine the very top and bottom of the page after they determine what they want is not located in the center. In the interviews conducted in this study, the content area was rated as extremely important for an informational website (**Table 3**). This means that the content area is placed in good location on Layout 2.

As shown in **Fig. 16**, all the participants except E2 found the advertisement faster on Layout 0 (fixation no. 1 or no. 2 only) than on Layout 2 (fixation no. 5 to no. 13). On Layout 0, the advertisement is placed in the center and on Layout 2 it is placed on the right side of the page. As mentioned above, the central area is normally the first area to receive fixation. However, the participants rated the advertisement object as unimportant or less important for an informational website (**Table 4**). Therefore, it is concluded that it is more suitable to place the content object rather than the advertisement object in the center.

Table 5 presents a summary of the total time taken by the participants to complete the tasks. On Layout 2, the efficiency of performing the tasks was 20-50% better than on Layout 0. This indicates that placing the web objects in the expected locations will enable the users to find the information more efficiently and will better facilitate the users' orientation compared to web objects that are not placed in conformance with users' expectations.

5. DISCUSSION AND FUTURE RESEARCH

The analysis of the number of fixations and the time taken to complete the tasks showed that using Layout 2 was more efficient than on Layout 0. This confirms the validity of the ASEAN mental model pattern for Malaysian preferences. Users were satisfied with the layout, which conformed to their expectations in the mental models.

In future work, this study will investigate the users' intentions to revisit the website. In addition, a larger number of participants from ASEAN countries will be used since the mental models have been developed for ASEAN focus groups. This may lead to more useful and accurate data on multicultural users and sustainable web user-centered interfaces. Liu *et al*. (2011) stated that individuals of different cultures might have unique ways of processing verbal and visual information because of the different rules and symbols associated with both the written and spoken word. Therefore, further eye-tracking studies are required to assess whether cultural differences and country-level factors have an impact on the web objects location based on users' mental model pattern.

The research reported in this study demonstrates that an eye tracker can be effectively used to measure the amount of time users spend looking at different objects on a web page. The results obtained from such a technique can be used to improve the user's accuracy in finding objects on a website. To further develop this eye tracking research, a comprehensive study on all ten web objects utilising not only gaze plots but also other analytical methods such as heat maps and areas of interest will be conducted to describe the users' attraction areas and their behaviors.

To conclude, the hypothesis that the placement of web objects in more typical locations will facilitate and speed up users' orientation is confirmed. The knowledge about expected object locations can be used to support design decisions. Finally, the results obtained in this study indicate that there are benefits to designing certain types of web pages according to expectations, thereby facilitating orientation. Web designers should consider user expectations about web object placement when developing websites, especially user-centered and standardised websites.

6. REFERENCES

Aslina, B. and J. Azizah, 2013. Cultural adaptivity for sustainable user interface: Investigating user expectation on ASEAN countries. Proceeding of the International Conference on Future Trends in Computing and Communication Engineering, (CCE’ 13), pp: 45-49.

Bernard, M.L., 2000. Examining user expectations of the location of web objects. ITG Internetworking.

Bernard, M., 2001. User Expectations for the Location of Web Objects. Wichita State University.

Bernard, M., 2002. Examining user expectations for the location of common e-commerce web objects. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, (SAM’ 02), pp: 1356-1360. DOI: 10.1177/154193120304701108

Bernard, M. and A. Sheshadri, 2004. Preliminary examination of global expectations of users’ mental models for ecommerce web layouts. Usability News.

Biederman, I., R. Mezzanotte and J.C. Rabinowitz, 1982. Scene perception: Detecting and judging objects undergoing relational violations. Cognitive Psychol., 14: 143- 177. DOI: 10.1016/0010-0285(82)90007-X

Biederman, J., M.C. Monuteaux, E. Mick, T. Spencer and T.E. Wilens *et al*., 2006. Young adult outcome of attention deficit hyperactivity disorder: a controlled 10-year follow-up study. Psychol. Med. DOI: 10.1017/S0033291705006410

Davenport, J. and M. Potter, 2004. Scene consistency in object and background perception. Psychol. Sci., 15: 559-564. DOI: 10.1111/j.0956-7976.2004.00719

Dujovne, L.E. and J.D. Velasquez, 2009. Design and implementation of a methodology for identifying website keyobjects. Proceedings of the 13th International Conference on Knowledge-Based and Intelligent Information and Engineering Systems, (IES’ 04), Springer-Verlag, Berlin, Heidelberg, pp: 301-308.

Foulsham, T. and G. Underwood, 2008. What can saliency models predict about eye movements? Spatial and sequential aspects of fixations during encoding and recognition. J. Vis. DOI: 10.1167/8.2.6

Leuthold, S., P. Schmutz, J.A. Bargas-avila, A.N. Tuch and K. Opwis, 2011. Vertical versus dynamic menus on the world wide web: Eye tracking study measuring the influence of menu design and task complexity on user performance and subjective preference. Comput. Human Behav., 27: 459-472. DOI: 10.1016/j.chb.2010.09.009

Lindgaard, G., G. Dudek, G. Fernandes and J. Brown, 2006. Attention web designers: you have 50 milliseconds to make a good first impression!. Behav. Inform. Tech., 25: 115- 126. DOI: 10.1080/01449290500330448

Liu, H., M. Lai and H. Chuang, 2011. Using eye-tracking technology to investigate the redundant effect of multimedia web pages on viewers’ cognitive processes. Comput. Human Behav., 27: 2410-2417. DOI: 10.1016/j.chb.2011.06.012

Norman, D., 1983. Some Observations on Mental Models. In: Mental Models, Gentner, D. and A. Stevens (Eds.), Lea, pp: 7-14.

Nurul-Hidayah, M.Z., A.R. Fariza-Hanis, J. Azizah and Z. Mohd-Firdaus, 2011. Eye tracking in educational games environment: Evaluating user interface design through eye tracking patterns. Proceedings of the 2nd International Conference on Visual Informatics: Sustaining Research and Innovations, Nov. 9-11, Springer, Selangor, Malaysia, pp: 64-73. DOI: 10.1007/978-3-642-25200-6_7

Oulasvirta, A., 2004. Task demands and memory in web interaction: A levels of processing approach. Interact. Comput., 16: 217-241. DOI: 10.1016/j.intcom.2003.12.004

Oulasvirta, A., L. Karkkarinen and J. Laarni, 2005. Expectations and memory in link search. Comput. Human Behav., 21: 773-789. DOI: 10.1016/j.chb.2004.02.018

Palmer, S.E., 1975. Visual Perception and World Knowledge: Notes on a Model of Sensory-Cognitive Interaction. In: Explorations in Cognition, Nonnan, D.A. (Ed.), W.H.Freeman and Co Ltd, ISBN-10: 0716707365, pp: 279-307.

Pan, B., H.A. Hembrooke, G.K. Gay, L.A. Granka and M.K. Feusner *et al*., 2004. The determinants of web page viewing behavior: An eye-tracking study. Proceedings of the Symposium on Eye Tracking Research and Applications, Mar. 22-24, ACM., New York, pp: 147-154. DOI: 10.1145/968363.968391

Rayner, K., 1998. Eye movements in reading and information processing: 20 years of research. Psychol. Bull., 124: 372-422. DOI: 10.1037/0033-2909.124.3.372

Roth, S., P. Schmutz, S. Pauwels, J. Bargas-Avila and K. Opwis, 2010. Mental models for web objects: where do users expect to find the most frequent objects in online shops, news portals and company web pages? Interact. Comput., 22: 140-152. DOI: 10.1016/j.intcom.2009.10.004

Roth, S. P., A.N. Tuch, E.D. Mekler, J.A. Bargas-avila and K. Opwis, 2012. Location matters, especially for non-salient Features-an eye-tracking study on the effects of web object placement on different types of websites. J. Human Comput. Stud., 71: 228-235. DOI: 10.1016/j.ijhcs.2012.09.001

Rouse, W.B. and N.M. Morris, 1986. On looking into the black box: Prospects and limits in the search for mental models. Psychol. Bull., 100: 349-363. DOI: 10.1037/0033-2909.100.3.349

Shaikh, A.D. and K. Lenz, 2006. Where's the search? Re-examining user expectations of web objects. Usability News.

Spool, J.M., T. Scanlon, W. Schroeder, C. Snyder, T. DeAngelo, 1997. Web Site Usability: A Designer's Guide. 1st Edn., Morgan Kaufmann Publishers, ISBN-10: 155860569X, pp: 176.

Tuch, A.N., J.A. Bargas-avila, K. Opwis and F.H. Wilhelm, 2009. Visual complexity of websites: Effects on users' experience, physiology, performance and memory. J. Human Comput. Stud., 67: 703-715. DOI: 10.1016/j.ijhcs.2009.04.002

Underwood, G. and R. Radach, 1998. Eye Guidance and Visual Information Processing: Reading, Visual Search, Picture Perception and Driving. In: Eye Guidance in Reading and Scene Perception, Underwood, G. (Ed.), Elsevier, Oxford, England, ISBN-10: 0080506232, pp: 1-28.

Vasantha, R.N. and N.S. Harinarayana, 2011. Identifying the location of web objects: A study of library web sites. Proceedings of the 8th International Caliber, (IG' 11), Goa University, pp: 28-39.

Velásquez, J.D., 2013. Combining eye-tracking technologies with web usage mining for identifying Website Keyobjects. Eng. Applic. Artificial Intell., 26: 1469-1478. DOI: 10.1016/j.engappai.2013.01.003

Vertegaal, R. and Y. Ding, 2002. Explaining effects of eye gaze on mediated group conversations:: Amount or synchronization? Proceedings of the 2002 ACM conference on Computer supported cooperative work, Nov. 16-20, ACM Press, New Orleans, pp: 41-48. DOI: 10.1145/587078.587085

Yom, M. and T. Wilhelm, 2004. WOOS-Ein Messinstrument Für Die Wahrgenommene Orientierung in Online-Shops. In: Mensch and Computer 2004: Allgegenwärtige Interaktion, Mensch and Computer, Keil-Slawik, R., H. Selke and G. Szwillus (Eds.), Oldenbourg Wissenschaftsverlag, ISBN-10: 3486576240, pp: 43-53.

Zhang, P., R. Small, G. Von Dran and S. Barcellos, 2002. Websites that satisfy users: A theoretical framework for web user interface design and evaluation. Proceedings of the 32nd Annual Hawaii International Conference on Systems Sciences, Jan. 5-8, IEEE Xplore Press, Maui, HI, USA. DOI: 10.1109/HICSS.1999.772668