

Cross-Cultural Investigation of Eye-Gaze Patterns for E-Learning Content Optimization

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Abstract

E-Learning in developing countries is still in a marginal state, mainly because of the cost of its introduction, and the lack of human resources to maintain the system. But the situation has changed and the price of the e-learning device has become affordable. So far, a large part of educational material is simply imported from developed countries. Because of this situation, the learners are confronted with diverse challenges. Poor availability of educational material for early age children, the need to use and learn two or more languages, and a strong oral tradition make the situation more difficult. To alleviate this issue, the optimisation of educational material is a necessity. E-Learning material are easy to customise compared to books. But the customisation must be done in an appropriate manner according to the culture of target users. Using eye tracking technology enables a deeper cultural analysis on e-learning materials to optimise its efficiency. Eye tracker captures the reaction around the border of consciousness and it reflects the subject's background culture much more than his/her intentional choice. This technology is widely used in web design, marketing, psychological research and cognitive linguistics. This research focuses on the analysis of how people of different cultural background interact with various contents of e-learning material such as, text, image, graphics, symbols and colors. The result of each test will provide important data to help with designing appropriate e-learning material for each country.

Keywords: e-learning, culture, eye tracking

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Introduction

Education is the most important sector in development. E-learning is a prominent solution to overcome the limitations in developing countries. But the reality is, many e-learning projects fail. There are factors which lead the projects' failures; the nature of the project, management failures and human resource failures.

Technology driven projects are easy to fail, and often make the users say "We prefer traditional materials/methods". There are e-learning projects which face fierce contestations of the teachers, because the teachers feel threatened. Because of the number of failures and difficulties, fund providers started to avoid the e-learning project. The most important part of e-learning project is the quality of contents. Another important factor is the quality of learning interface. These two factors are interrelated and indissociable. E-learning is more human science than computer science, since the aim of e-learning is to make the humans learn. So e-learning must tackle with the human complexity, and the core technology is the interface design. Interface design is how to make the accurate user perception by the stimulus created by the computers. It is also called User Experience (UX).

Despite its importance, interface design is often underestimated. Because the good design is clear, transparent and invisible to most of the users. We don't know how the students of the target culture interact with various e-learning materials. What kind of contents they are attracted, what is the best position of contents, what is their color preference, etc.

The aim of this research is to establish a method to analyze the gaze patterns on e-learning materials using eyetracking technology. E-learning materials are composed by various elements. Text, graphic, colors, photographs, illustrations, videos and sounds. Some are static, some are dynamic and some are interactive. According to the learning objective and the instruction type, appropriate media types must be chosen in order to compose an optimised material.

Literature review

Eye tracking technology is vastly used in marketing and web design field. Nielsen J. and Pernice K. explored the web usability using eye tracker in their book titled "Eye-tracking Web Usability" published in 2009. This book is considered as a reference for the studies of eyetracking.

According to the vast literature review (Educational Research Review 10, 2013) by Meng-Lung Lai et al. on the use of eye-tracking for learning research, eye-tracking is a recent technology and its use is increased from 2009. They listed 77 academic papers in the field of language learning, perception, conceptual development, psychology and sociology, and built a framework between eye-movement and learning.

There are several researches on the eye-gaze difference in multi cultural settings, but they are usually limited between Americans or Canadians (often referred as "westerners") and Japanese or Chinese (often referred as "Asians"). (Boland J. et al., 2008, Griffiths L., Chen Z., 2007, Lu Z. et al. 2008) But Ron Scollon et al. pointed out in the book "Intercultural Communication, A Discourse Approach" (Third Edition,

2012) that this binary comparison between “westerners” and “Asians” are too simplified and the result can be erroneous.

Marcos M.C. et al. conducted a research on Cultural Difference on Seeking Information: An Eye-Tracking Study (2013), between Middle Eastern and Western Europeans about the interaction with search engine result pages.

Peeters M. wrote a thesis on Consumers’ information needs on e-commerce websites, A cross-cultural eye tracking study. This study geographically targeted Western Europe, Columbia and South Africa. This study is similar to our research but the geographical target zone is different and our goal is focused to contribute the development of e-learning contents.

Despite the considerable number of research done, there is no specific study for the use of eye tracking technology for e-learning in developing countries.

Methodology

Kobe Institute of Computing has an international environment, its students are composed of Asian and African countries. Since the aim of this research is to clarify the difference of gaze patterns caused by cultural difference, this environment can be an appropriate situation.

Test A consists on general observation of eye gaze pattern of interaction with various elements of e-learning materials. We prepared 15 images on different themes. Eye tracker test total time is 3 minutes and 35 seconds.

Test B is more focused on composite e-learning materials, and the aim of the test is see the level of understanding using the different kind of informations and representations. The post-test questionnaire contains some questions about the contents of the materials. Participants are instructed this procedure before the eye-tracking test. Test time is 4 minutes and 57 seconds.

Participants:

	Test A		Test B	
	Male	Female	Male	Female
Nationality				
Afghanistan	4	0	5	0
Japan	1	1	1	1
Tanzania	0	0	0	1

Hardware configuration:

Monitor: 19 inches and a display resolution of 1,280 × 1,024

Eyetracker: The Eyetribe ET1000 Batch 2014-04

Software configuration: Eye gaze recorder: Eyeproof recording suite

Testing Materials

Test A1: Color Dots (5 Seconds)

We prepared an image with 15 circles of different colors. I used 12 standard colors based on CMYK model. I added 25%, 50% and 75% grey. I chose circle because it does not have any particular bias which guides the movement of the eye. I scattered randomly the 15 color circles on a white background.

Test A2: Color Hex (5 Seconds)

We created a hatch of black hexagons and put 4 different color associations. These associations are inspired by the national flags. Blue-White-Red is from the french flag, Green-White-Red is from italian and afghan flag, Red-Yellow-green is very common color scheme on african countries, Red-Yellow-Light Blue is from Rwandan flag.

Test A3: Kryptonian Text (5 Seconds)

The aim of this test is to see the unintentional orientation of the gaze. But normal text which the subjects are used to see, there's preset direction to read it. So the character set should be something that the subjects have never seen. The character set we used is called "Krypton font" of a fictional language created for "Superman".

Test A4: Emoji (8 Seconds)

Emoji is an expression of text represented by graphic symbols. It is widely used now among young people. This mode of text communication is not a conventional, and it can be considered as a new method of communication. The aim of the test is to see how the subjects interact with these graphic symbols.

Test A5: Cartoon (6 Seconds)

Cartoon is a mixture of two method of communications; text and image. The aim of this test is to see the interaction of subjects to this mixed communication methods.

Test A6: Hypertext (15 Seconds)

Hypertext is a basic style of web contents. The aim of this test is to analyse the standard pattern of the subjects with the standard web contents.

Test A7: Diagram (10 Seconds)

Diagram is a graphical representation of cause-effect text contents. The graphical attributes (form, color etc) have very little connection with the semantic information of the whole diagram. The aim of this test is to analyse if the participant will follow the logical connections or they will see the image randomly.

Test A8: Text Graphic Composite Document (10 Seconds)

This type of content is also very common in academic document and e-learning material. Actually there are several combinations of different kind of contents. This time I used the combination of bar graphs and text. The aim of this test is to analyse another standard pattern of the subjects with standard academic document.

Test A9: Table (15 Seconds)

Table is an another representations of cause-effect text contents. There's less importance of graphical features compared to diagram. But it has a predefinition of the

order of the contents. The contents on the left top is a privileged position, and the user can read the table horizontally or vertically according to user's preference.

Test A10-13: Moodle Experience (4 Different Images)

This test contains 4 different images of a very common MOOC platform. The aim of this test is to compare the gazing pattern on different pages and to analyse the optimised pattern of contents disposition.

Test A10: Moodle Main Page (15 Seconds)

Moodle is a very widely used open source e-learning solution. Moodle is very flexible and we can customise it easily. This image is the Moodle page after login process. This is the most basic and simple page disposition pattern. The contents is limited to text.

Test A11: Moodle Class Contents Page (15 Seconds)

This image is common Moodle class main page. There are much more text contents compared to Moodle main page, but there is no graphic contents.

Test A12: Coursera Class Contents Page (15 Seconds)

Coursera is a common MOOC platform. Coursera main page is much more media rich and colorful, but the standard class page is very similar to Moodle class content page. There are some graphical objects placed in this page.

Test A13: Moodle Re-Designed Main Page (10 Seconds)

We re-designed the Moodle main page to improve the usability and experience of Moodle using mainly different colors and simple graphic objects. This image will show how the gazing pattern will change with modification.

Test A14: Escher Test (8 Seconds)

Escher is famous by his "trompe oeil" paintings. This painting is 3 mirroring image of the quarter. And it contains various sub images of animals. This painting is a totally flat two dimensional image. The aim of this test is to see the interaction pattern with the different design element of this picture.

Test A15: Velasquez Text (8 Seconds)

This painting has a very complex structure, and there are elements on a various depth level. The main contents ("*Las meninas*", The girls in Portuguese) are in the middle of the contents. In front of the girls, there's a dog on the right and the back of the canvas. And behind the girls, there's the painter at the left. Also, there are 2 adults on the right. Behind these characters, there's a wall with a mirror in the middle and a doorway at the right. And there's a man in the doorway. The difference of this material is this three dimensional contents positioning. The aim of this test is to analyse the depth of gaze of the subjects.

Test B1: Text Interaction (60 Seconds)

This testing material contains only text. I chose Japanese Language as theme, because it's a common field of interest among the participants. To avoid the bias, I chose questions that Japanese participants cannot answer without reading the text.

Test B2: Text And Images (60 Seconds)

This material is a text with some related images (photographs). These photographs are a simple representation of the theme of the text, and not exactly related to the asked questions. Therefore, the image contents are simple noise as semantic information. The answers to the questions are clearly stated in the text. The theme of the text is Hanami, which is in the field of common interest of all the participants.

Test B3: Text And Logos (60 Seconds)

This material is composed by text and logos of the organisations which appears in the text. Logos contain mainly text elements which also appears clearly in the text. The question is asked about these informations, which appears in both text and image. The theme of the text is World Wide Web, and it is in the common field of common interest of all participants, but different from the former tests.

Test B4: Text And Images (60 Seconds)

This material is composed by text, images and logo. Images and logos are directly related to the contents of the text. This time, the logo does not contain text. But images are not the simple representation of the theme of the text. They have their own meanings, therefore they are semantic representations. The questions are asked about the graphical contents of the image which do NOT appear in the text, and about the graphical attributes of the image like colors and forms.

Test B5: Color Random Dots (10 Seconds)

This is the similar materials I used in the previous lab test. The difference is the timing of the test. In previous lab test it was the first test material, and it seems the participants were not ready to interact with testing materials.

Test B6: Color Circular Model Dots (10 Seconds)

This is a similar test as test 5, only the dots are arranged in circular position. Because all the elements are placed at the same distance from the middle of the screen. This difference has an importance because the arrangement of dots gives a "form" and this fact implants a particular meaning and logic to the participants. This can be affect the gaze patterns of the participants.

Test Procedures

Pre-test questionnaire is a verbal session consists on the acquisition of general informations about the participant, a screening questions about their eyes and english proficiency, a small survey about their preference and experience of media interactions. I gave them instructions about eye tracker and how to interact with the materials. I explained to them that there will be some questions about the contents of the test, after the eye-tracking test.

Eye-tracking test is the interaction with test materials using eye-tracker.



Figure 1: Eyetracker test

Post-test questionnaire is a written survey, that participants can do immediately after the eye-tracking test. The questionnaire was built using Google forms, and the results are automatically sent to Google sheets. This questionnaire is composed by some very simple questions about the contents of testing materials with multiple choice answer and check-box style answer, general impressions about the test.

Results

Test A1: Color Dots

We can see the similarity on the high concentration of gaze in the central zone of the screen. And there are few gaze on the peripheral zone. We can see a difference between Afghan students and Japanese students. The gaze pattern of Japanese students are scattered in wide range. The gaze pattern of Afghan students are rather concentrated to a small area at the center of the image.

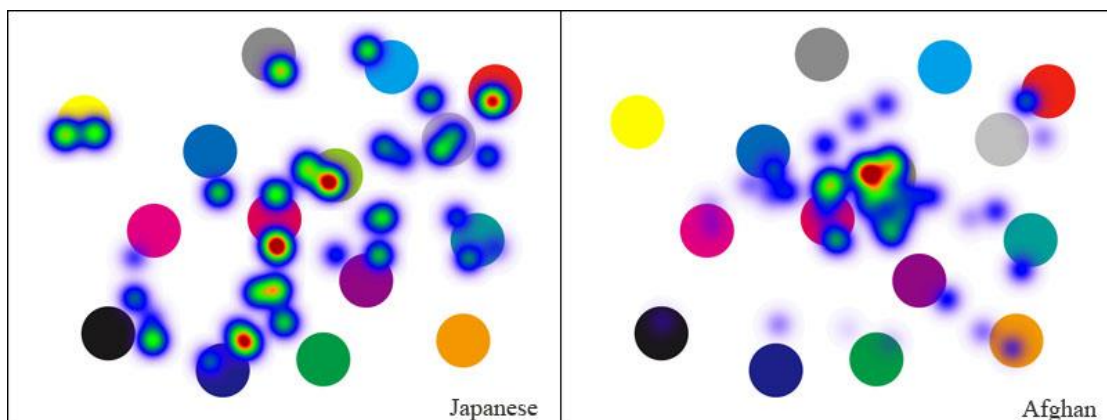


Figure 2. Gaze pattern difference between Japanese and Afghan participants

Test A2: Color Hex

Unlike the previous test, the difference is difficult to analyze. The very strong gaze concentration of the Afghan students at the center of the screen can be translated to the attraction of black color.

Test A3: Kryptonian Text

The result of this test is also very difficult to explain. Actually there are no significant difference between Afghan and Japanese participants. We hypothesize that the kryptonian text is recognized as image instead of text.

Test A4: Emoji

All the participants spend more time on decrypting the symbol & text mixed part, but Japanese participants are slightly more attracted by stamps compared to Afghan participants.

Test A5: Cartoon

We can observe 2 significant differences. Japanese participants are less attracted the text element embedded to the image, and are attracted by graphical expression. Afghan participants have more concentration on pirates flag than the pirate's face.

Test A6: Hypertext

This test present a very similar pattern on both participants.

Test A7: Diagram

This test present a very similar pattern on both participants.

Test A8: Text Graphic Composite Document

This test present a very similar pattern on both participants.

Test A9: Table

The table used for the Test A is called logframe, which shows logical connection horizontally and vertically. This was too complicated to the test. We should have made a simple table.

However the disposition of gaze pattern were different. Afghan participants present a strong horizontal movement. Japanese participants present more vertical movements.

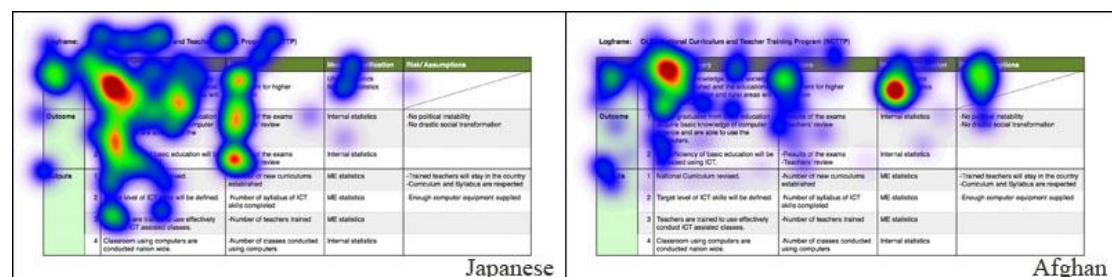


Figure 3: Eye gaze pattern on Table

Moodle Experience (4 different images)

This test contains 4 different images of a very common MOOC platform. The aim of this test is to compare the gazing pattern on different pages and to analyse the optimised pattern of contents disposition.

Test A10: Moodle Main Page/Moodle Class Contents Page

On the main page, Japanese participants concentrated the gaze on navigation pane (Left). Afghan participants' gaze pattern is similar to Contents page, making the concentration on Contents pane. On Class contents page, Japanese participants concentrated the gaze on Contents pane.

Test A11: Moodle Class Contents Page

This image is common Moodle class main page. There are much more text contents compared to Moodle main page, but there is no graphic contents.



Figure 4: Eye gaze pattern of Afghan and Japanese participants

Test A12: Coursera Class Contents Page

The pattern is similar to Moodle contents page, the significant difference is both Afghans and Japanese have certain amount of gaze on Title area.

Test A13: Moodle Re-Designed Main Page

This re-designed interface showed a completely different gaze pattern compared to other Moodle interface and Coursera interface. Both Afghans and Japanese scanned the whole page and the gaze is distributed. Since classical Moodle page is composed by text, the eye gaze pattern becomes text reading pattern. In the other hand, modified Moodle interface is more graphical, this difference of the contents character lead to the difference of eye gaze pattern.

Test A14: Escher

The participants are attracted the joint part of the image. I can't explain the cause of this phenomenon.

Test A15: Velasquez

The heatmap shows a slightly different gaze patterns between Japanese and Afghan students. All participants looked at the main character and scanned *Las Meninas* (The girls), but Afghans have strong gaze fix on the dog in front of the girls. The Japanese are more attracted to the background like mirror and the doorway than the dog.



Figure 5: Eye gaze pattern on Velasquez

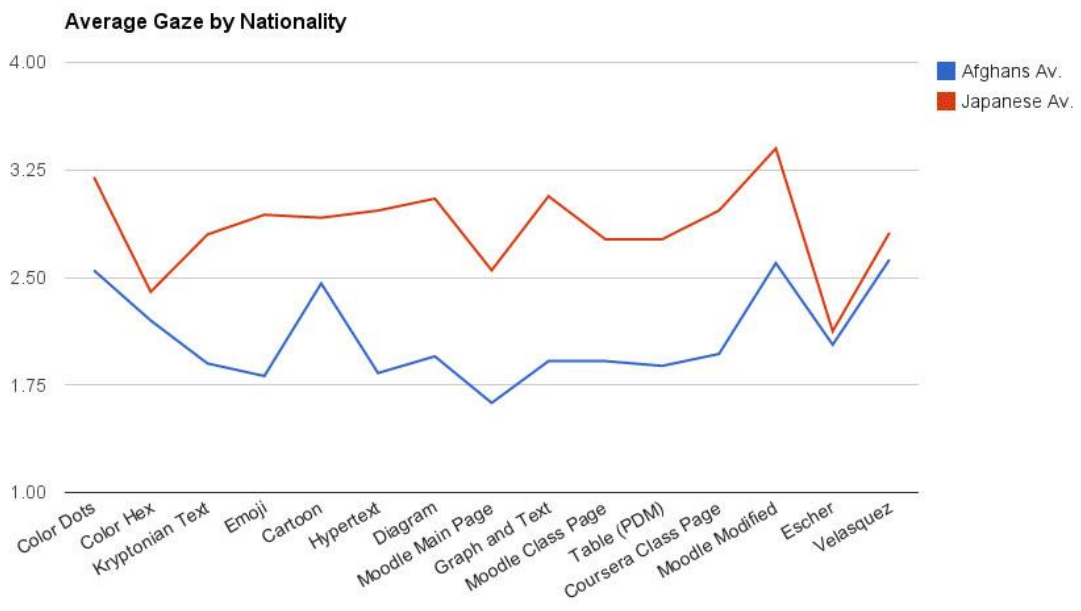


Figure 6: Gaze count

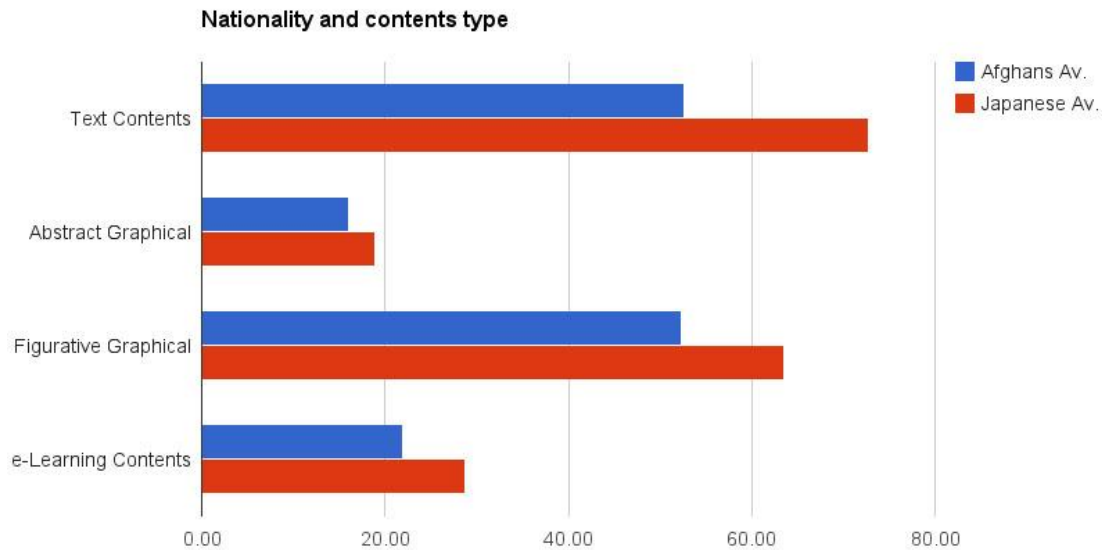


Figure 7: Gaze count by contents type and nationality

Test B1: Text Interaction

For eye tracking data, they show a standard text interaction pattern. But the results of the questionnaire show very important point of analysis. The first question was about the content of first sentence of the text, and none of the participants gave the right answer. Although almost all the participants clearly read this sentence. Maybe because I change the expression from the original text, but this result shows that the participants read the text without understanding the meaning of the text. The whole text contains 227 words. Almost all the Afghan participants read only paragraph 1, which contains 117 words, and none of them finished reading paragraph 2 which contains 115 words. This reading speed is very important, because the second question is about the contents of the second paragraph. Only one Japanese participant selected the right answer.

Test B2: Text And Images

For this material, the whole text is shorter than the Test 1, and many of the participants read the entire text (160 words). The images are placed at the bottom of the document, 3 participants did not look at the pictures. But it did not affect the results of the questionnaire since the answers are in the text and not in the images. The results are clearly better than Test 1. And it seems that all the participants understood the meaning of the questions and answers. The questions on this test is about substantive object, which can relate to the figurative images. The question on Test 1 was rather conceptual and abstract.

Test B3: Text and Logos

In this material, there are 3 text paragraphs, and there are related logos at the side(right-left:right) of each paragraph. Each logo contains the abbreviation of the name of organism or product, which are also shown in the text. The questions are to choose the right answer among the names of the related organisms or related products. Despite this double hint, the results of the questions are not very good. Mainly because of the reading speed, three participants read only the paragraph 1 (122 words), and none of them finished reading the entire text (238 words). The position of the text and image is somewhat confusing. The result suggest the uncertainty of abbreviations.

It is a common way to make the organization name or logo based on it, but it is very easy to be forgotten, or confused with other abbreviations.

Test B4: Text And Images

In this material, there are two text paragraphs, one logo at the right top of the document and two images at the bottom of the document. The questions are about the contents of graphic elements and the answers are not shown in the text. Since the text part is not long (157 words), all the participants finished reading the text. But 4 participants did not look at the logo, and two of them did not look at the pictures. Q7 is about the attribute (color) of the logo, and more than half of the participants selected the correct answer. Q8 is also about the attribute of the image, but this time it was about form. The object is placed in a black and white photography, and the painter (Pablo Picasso) is drawing a bull in a simple and abstract way. Less than half of participants selected the correct answer, and some participants say that they didn't know that the form was a bull. This fact needs a further analysis. The form was seen and recognized, but cannot be understood as a figure. So the failure occurred in semantic information process. On the creator side, the failure occurred in codification process.

Test B5: Color Random Dots

This is the same material I used in the Test A. We thought that the participants are confused with this material because it was the first image for the Test A. This time it was shown as fifth image and the results are similar to the results of Test A. So this "first time" bias does not exist. The gaze pattern of Afghan participants are usually condensed at the middle of the screen. In other hands, other nationalities (Japanese and Tanzanian) showed more widely spread eye gaze pattern.

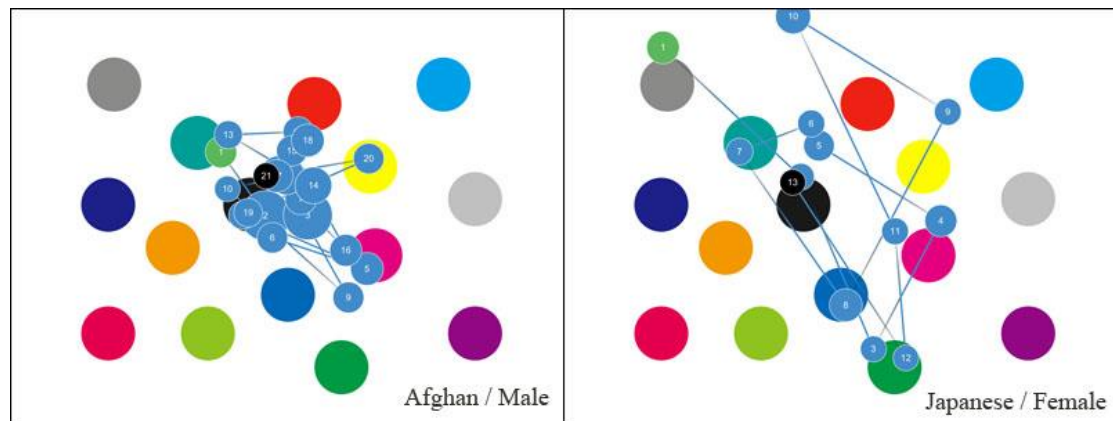


Figure 8: Male/Female gaze pattern on random color dots

Test B6: Color Circular Model Dots

The result of this test shows two interesting points. The eye gaze pattern of 5 participants show a clear circular pattern (Clockwise and anti-clockwise). It means the participants are aware of the structure of the elements. Then all the 5 participants are male. The female participants did not show this circular pattern. In other tests, I could not find any difference between male participants and female participants.

The implementation of this circular structure in e-learning material can be seen in the Sugar OS.

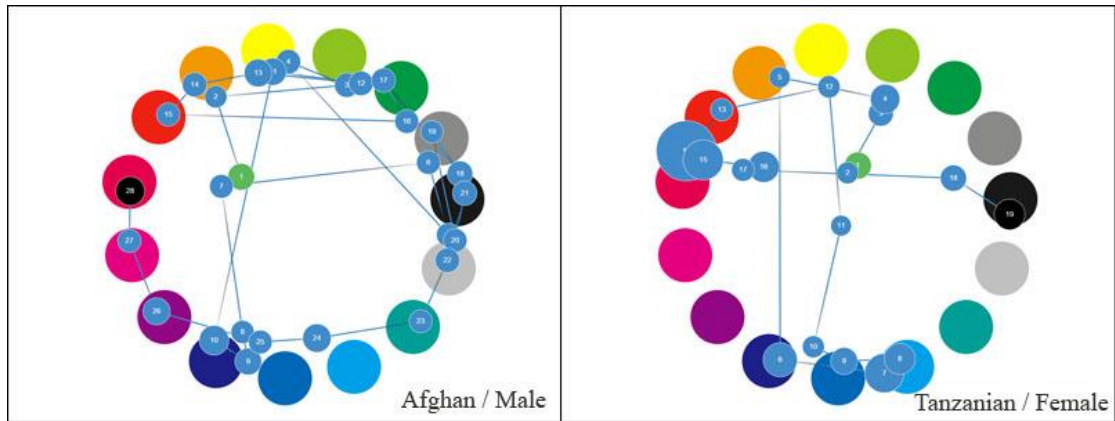


Figure 9: Male/Female gaze pattern on circular color dots

Conclusion

Our conclusion is that cross-cultural analysis of eye gaze pattern is an innovative and effective approach to optimize e-learning contents. Since this research tackle with human complexity, the approach to analyze the results is holistic. Eye gaze is easily influenced by many conditions; distraction, boredom, individual likes and dislikes. Based on these limitations, we made findings as following; (i) There are a lot of gaze pattern similarities among the different cultural groups; (ii) There is a clear gaze pattern differences between text materials and graphic materials; (iii) Afghans' gazes are concentrated at the center of the screen, compared to Japanese participants; (iv) Reading speed is a crucial factor for the text understandings; and (v) Form is a gaze guiding factor more than color, especially for male. However, this research is still in experimental stage, the data size is limited. Further research is needed to find a clear connection between gaze pattern differences and culture groups.

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