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Using Eye-Tracking Data to Evaluate Medicine Information Leaflets On-Screen

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Abstract

Medicine information leaflets provide required information to the patient about the prescribed or non-prescribed medicines. The hard copy leaflets that come along with medicine packages may vary in size and content of the information provided. Although there may be different standards and regulations in different countries, several companies also provide the digital copies of medicine information leaflets on-line. However, there may be differences between the printed and digital copies in terms of layout design and context. In the technology age, since several people use smart phones and computers extensively in their daily-life, it may be the quickest way to access medical information leaflet when required. Therefore, this study focuses on improving the usability and readability of medical leaflets on-screen. First, a medicine information leaflet is considered in its printed form and redesigned to improve its readability. Current digital medicine leaflet and two improved versions in terms of readability and layout are used in tests. Based on the experiments, it was illustrated that it takes shorter time for naïve users to access the right information for a well-designed medicine information leaflet on-screen.

Keywords: eye-tracker, medical information leaflets, readability, usability

Introduction

Patients may need to revise several information from the medicine leaflets such as the instruction for use, side effects etc. The development of technology and telecommunication has also influenced the use of web sites for several purposes such as e-commerce, internet newspapers, and even medicine leaflets. Although, use of printed leaflets are still common for most people, glancing medicine leaflets on-screen is becoming popular too. The new trend is to provide all or most of the leaflet content from internet.

Therefore, this study aims to focus on usability, readability, and layout design of medicine leaflets on-screen.

Studies on Medicine Leaflets

There are several studies in literature to assess printed medicine leaflets related with usability, readability, and meeting the regulations of the country. Woods (2001) analyzes the publications on the use of patient information leaflets. Dickinson et al. (2001) utilize consumer testing to determine patient information leaflets. Koo et al. (2002) propose a method to assess the usability of medicine labels by “user-testing”. Krassa et al. (2002) report on two new instruments to assess patient information leaflets provided in US community pharmacy. Mansoor and Dowse (2003) design, develop, and evaluate a simple, understandable medicine label and patient information leaflet, and aim to assess the effect of incorporating pictograms on understanding in low-literate participants. Svarstad et al. (2003) evaluate written prescription information. Bawazir et al. (2003) aim to examine public opinion in Saudi Arabia for potential changes to a more patient-oriented package insert. Raynor et al. (2005) analyze the impact of European regulations on effective use of medicines in terms of medicine leaflets. Davis et al. (2006) measure patient understanding of the instructions on each of the five prescription medication labels. Jenkings and Vaida (2007) state that inadequate drug information, such as outdated or limited references, is one of the most common causes of medication errors. Wolf et al. (2007) aim to examine the nature and cause of patients’ misunderstanding common dosage instructions on prescription drug container labels. Davis et al. (2008) test whether the use of more explicit language to describe dose and frequency of use for prescribed drugs could improve understanding for patients with limited literacy. Webb et al. (2008) enhance warning labels promoting the safe use of prescription drugs among patients, regardless of literacy level. Bailey et al. (2009) state that health literacy and language concordance should be considered when designing a better medication label. Peerson and Saunders (2009) highlight the importance of health literacy in relation to the health promotion and preventive health agenda. Goldsworth et al. (2009) examine a total of 11 warning labels, then assess participant interpretation accuracy and preferences. Mayhorn et al. (2009) aim to determine whether prescription medication sharing, a common healthcare consumer behavior, leads to adverse outcomes, including inappropriate usage, delayed care, suboptimal patient- provider relationships, and exposure to side effects. Shrank et al. (2010) propose prescription label to improve content and format. Jaya et al. (2010) present an overview of the design and development of

Australian medical inserts and discusses ‘user-testing’ as an iterative, formative process for design. Likewise, Ved (2010) critize package inserts in India. Pander Maat and Lentz (2010) assess the usability of three patient information leaflets and attempts to improve them while complying with the EU regulations. Luk and Aslani (2011) aim to identify and review tools used to evaluate consumer-oriented written medicine and health information from a document and user perspective and readability, presentation, suitability, and quality criteria were reviewed. Adepu and Swamy (2012) focus on usefulness of information leaflets. Hammerschmidt and Spinillo (2014) published an experimental study focusing on digital medical leaflets in Mobil Devices. According to the study results it is essential to consider digital medical leaflet design in terms of interactivity and navigability.

Studies on Eye-Tracker for Usability

Eye tracking is the process of measuring either the point of gaze (where one is looking) or the motion of an eye relative to the head. An eye tracker is a device for measuring eye positions and eye movement. Applications of eye tracking technologies include web usability, advertising, sponsorship, package design, and automotive engineering. In general, commercial eye tracking studies function by presenting a target stimulus to a sample of consumers while an eye tracker is used to record the activity of the eye. Examples of target stimuli may include websites, television programs, sporting events, films, commercials, magazines, newspapers, packages, shelf displays, consumer systems (ATMs, checkout systems, kiosks), and software. The resulting data can be statistically analyzed and graphically rendered to provide evidence of specific visual patterns. By examining fixations, saccades, pupil dilation, blinks and a variety of other behaviors researchers can determine a great deal about the effectiveness of a given medium or product.

Salvucci and Anderson (2001) state that eye movements provide informative data to analyze human cognition and there is the link between eye movements and visual attention. Another reason for the popularity of eye movements as data is the fine temporal grain size that they represent. Today’s eye-trackers can typically sample eye movements at a rate of 50 to1000Hz, or once every 1 to 20 msec. This fine grain size allows researchers to analyze human behavior at a level of detail unachievable with more common types of data. Paterson et al. (2008) investigated effects of sentence structures on reading performances. They used an eye tracker in an experiment including different sentences with different phrases and words to evaluate participants’ reading performances. In an eye-tracking study of Fleetwood and Byrne (2006), it was illustrated that participants rarely refixated icons that they had previously examined and that participants used an efficient search strategy of examining distractor icons nearest to their current point of gaze. Halverson and Jornof (2011) provide a modeling that aims to answer the four questions of active vision such as, What can be perceived in a fixation?, When do the eyes move?, Where do the eyes move?, What information is integrated between eye movements?. Manson et al. (2012) used an eye tracker for their experiment which aims investigating web-based maps' usability via eye tracker metrics and mouse movements. Gidlöf et al. (2012) identified that most of the teenagers don't perceive online advertisements while they are surfing on internet. They conducted an experiment via an eye tracker to reveal the results of the study. Dong et al. (2014) conducted an experimental study including a remote eye tracker to search how usable an animated map is. They approached the usability of traffic maps in terms of some visual variables such as color, size, and frequency. Sharma and Dubey (2014) explain some eye tracker metrics which are used in usability studies. Fixations, saccades, eye gazes, pupil size, blink rate, and scan path are defines and a literature review is also presented in their study. However, based on the accessible literature, it can be claimed that eye-tracking is used to assess neither printed nor on-screen medical leaflets.

Based on the best knowledge, it can be claimed that medical leaflets on-screen is not studied in the literature. Further, there is no study using eye-tracker to collect data to assess the ease and duration of navigation for the information. This paper is structured as follows: second section provides general information on the studies that utilize eye-tracker for usability assessment. Third section summarizes the proposed study to assess medicine information leaflets on-screen. Last section concludes the study and provides directions for future studies.

Method

Medicine leaflets are the paper inserts available in a medicine package. Their size may vary depending on the package dimensions and paper quality. The required information usually is provided under headlines. However, there may not be a standard for the sequence and the content of the subsections. Patients may need to turn the pages, search the leaflet, and spend time to access the information they are looking for. On the other hand, if a medicine leaflet is well designed and the fonts are large enough to read, also the terms are easy to understand, one can quickly reach the information whether medicine leaflet is printed or on-screen.

Compared to printed medicine leaflets, medical leaflets on-screen can provide one or more of the listed advantages:

- Capacity: restricting constraints in any printed medicine leaflet related with page or column limit may be eliminated,
- Flexibility: illustrative drawings or signs can also be provided,
- Immediacy: an on-screen leaflet can be accessed and shared at the web environment,
- Permanence: the on-screen leaflet are kept at the electronic environment and the information is assumed to be permanent unless they are deleted while printed medicine leaflets can easily be damaged.

Experimental Design

Ten graduate students (five female) were recruited for the experiment. All the partipants are Turkish citiziens and between 20-28 years of age.

For the purpose of the study, the ease of reading and searching for information is related with Task Duration, Number of Fixations, and Duration of Fixation. Medicine leaflets as pdf formats are provided to the user on a laptop. Tobii X2-60 screen-based eye-tracker represented in Figure 1 is used during the tests. The device's sampling rate is 60 Hz and Tobii Studio software was used to analyze the results.

Figure 1. Eye-tracker used in the study

A well-known brand worldwide that is used for allergies is considered. The printed leaflet was obtained from the medicine package. However, there were several versions of the medicine leaflets for on-screen designs; having various number of pages with different content in different languages.

LD1: A Turkish version of a medicine leaflet was downloaded to the laptop as a pdf file. This is called the original leaflet and referred as LD1 throughout the paper.

LD2: The original leaflet design LD1 is improved in terms of readability based on current studies in the literature. DuBay (2004) state that reading ease is influenced by four basic elements such as content (prepositions, organization, and coherence), style (semantic and syntactic elements), structure (chapters, headings, and navigation), and design (typography, format, and illustrations). There are a number of studies that investigate the readability of medicine leaflets such as; Spadaro et al. (1980) assess readability of medical leaflets, Mary et al. (1999) use an assessment tool to evaluate patient medication leaflets.

Ulutas and Ozkan (2014) investigate how information is presented in several medical leaflets. To improve usability, factors to be considered are defined and assessed by a survey. A case study is provided to compare the current printed package insert and the redesigned one. Ozkan and Ulutas (2014) provide a leaflet evaluation score (LES) based on printed medicine leaflet size and the area of the critical information. A number of commercially available leaflets for syrup, tablet, pomade, and drop are randomly selected and their LES is calculated. Then, an ideal leaflet design for a syrup is introduced based on the criteria in concern. The video records are separately used to calculate the duration when 30 students tried to access the predefined information from leaflets with the lowest LES and the ideal design in terms of readability. Further, a statistical analysis is held to assess how medicine leaflet design affects leaflet usability. This study is based on the medicine leaflet design proposed in Ozkan and Ulutas (2014).

$$LES = \frac{\sum_{i=1}^{n} w_i \times x_i}{\sum_{j=1}^{m} v_j \times y_j} \tag{1}$$

where,

- w_i: weight of the i^{th} desired factor
- v_j: weight of the j^{th} undesired factor
- x_i: value of the i^{th} desired factor
- y_i: value of the j^{th} undesired factor

LD3: LD2 is improved in terms of layout design and this version is named as LD3 throughout the paper.

Although, -theoretically- unlimited page length may be considered as an advantage for an on-screen medicine leaflet, it may not be easy for users to access to the required information in a reasonable time. To be fair, same font type is used for the improved leaflet designs with the original design. However, the font size of body texts that contain information relevant to tasks slightly differ. One should keep in mind that, the user is also possible to zoom the digital leaflet that is practically not possible for a traditional paper leaflet. On the other hand while using LD3 without extra zoom, subjects don't need to scroll down since they are able to scan all the leaflet in their visual area. Table 1 summarizes the basic features of the medicine leaflets on-screen used in the study.

Table 1. Medicine leaflet features in concern

Leaflet Design	Number of pages	Number of columns	Font / Size
LD1	6	1	Calibri / 11.5
LD2	2	1	Calibri / 10
LD3	1	4	Calibri / 9.5

With eye tracking, it is possible to discover where a person looked first, second, third, and so on. Also, it is possible find out what the user considers to be the most interesting part of the screen and how long he or she looked at certain areas.

Task Definition

Ten tasks are defined that are related with the information provided in different subsections of the leaflet. Each task include at least one question from a subsection such as side effects, dosage, medicine use in case of pregnancy etc. The tasks are not listed in the order of the subsections of the printed medicine leaflet. Table 2 provides the tasks to assess usability of the leaflets.

Table 2. Medicine leaflet usability assessment tasks

No	Task Definition
1	Please find the explanation about what to do in case of a side effect such as insomnia
2	Please find the information about maximum dosage in 24 hours for an adult
3	Please find the information about what kind of drugs should not be taken with this medicine
4	Please find the explanation about how this medicine should be stored
5	Please find the information about the aim of use of this medicine
6	Please find the explanation about use of the medicine during pregnancy
7	Please find the information about use of the medicine with alcohol
8	Please find the explanation about use of the medicine for children
9	Please find the information about if the medicine should be used on a full stomach or not
10	Please find the explanation about what to do in case of overdose of this medicine

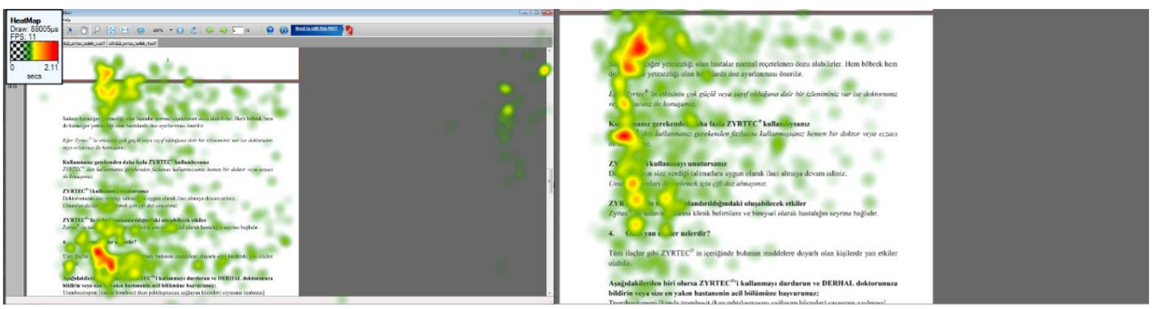
Data

10 people Table 3 provides the summary of eye-tracker data obtained from the test results of. For each Leaflet Design, Task Duration (msec), Number of Fixations, and Duration of Fixation (msec) are the data in concern.

Table 3. Mean rank for theeye-tracker data

Leaflet Design	Task Assessment	Min	Max	Mean	Std.Dev.
LD1	Task Duration	20138	395287	248263.30	103465.86
	Number of Fixations	375	862	652.30	166.01
	Duration of Fixation	47687	164654	105025.50	34224.04
LD2	Task Duration	90992	170577	127128.60	24968.53
	Number of Fixations	145	446	276.50	80.33
	Duration of Fixation	20117	82757	46449.10	16244.22
LD3	Task Duration	76599	132543	103434.30	19486.77
	Number of Fixations	64	349	226.70	77.66
	Duration of Fixation	8765	71659	38965.60	17342.55

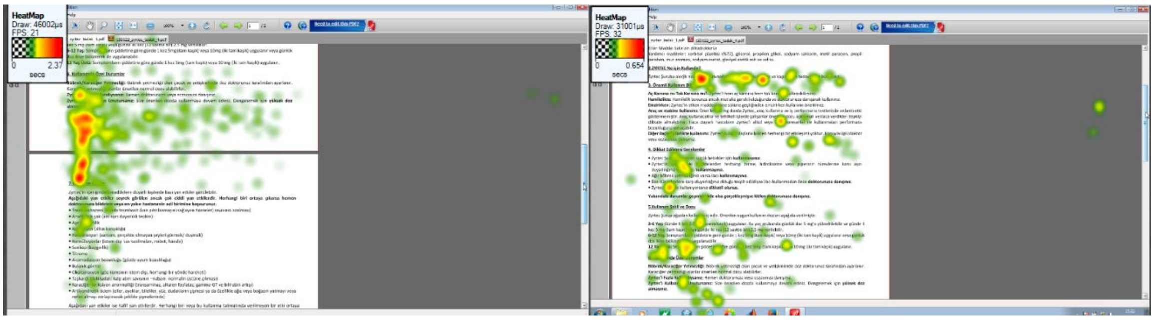
An eye tracking heat map shows the gaze duration on a page, pointing out the need for searching the information defined in task. Heat maps generated by eye-tracker for the original design (LD1) is illustrated in Figure 2. It is clear that the user needs to scroll down to search for the information if the design doesn't fit to the page properly. The green circles on the right hand side, on the grey area, that rather have small diameter state that the user may require extra time to switch within the pages.



(a) Page 1 *(b) Page 2*

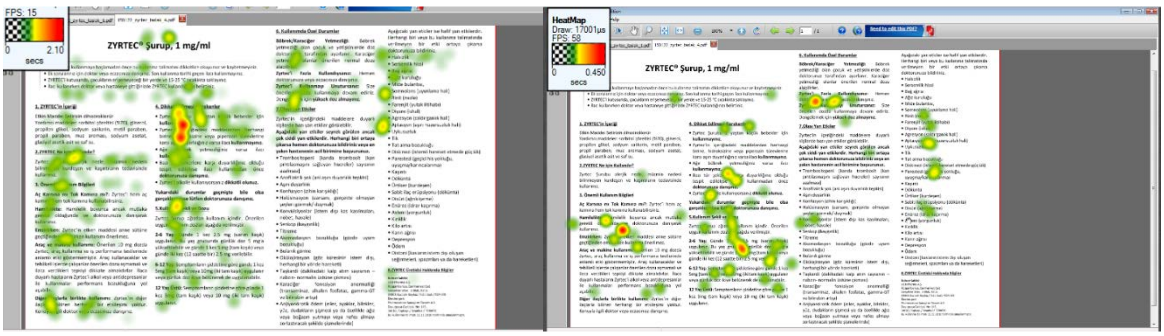
Figure 2. Duration of Fixation LD1

Many written languages use a left-to-right reading pattern. In web design conventions and reading habits, this viewing pattern has become ingrained. The heat map given in Figure 3. illustrates that people tend to look at left. Also, if the file has several pages, it takes longer to complete the given task for LD2. Figure 4. provides the heat map for LD3 that was designed as a pdf file in four columns in a single page.



(a) Page 1-2 *(b) Page 2*

Figure 3. Duration of Fixation LD2



(a) Page 1 *(b) Page 1*

Figure 4. Duration of Fixation LD3

Conclusions

In this study, medical leaflet designs of the same medicine are compared in terms of readability and usability via tasks that aim to reach critical information as fast as possible. Although use of eye tracker is a widely used method for various usability studies it is still new and promising approach for medicine leaflet design studies. After ten tasks had been completed three critical data were compared. Task Duration points the pace of the users while browsing the leaflet to find the relevant information. Number of Fixations relates to search difficulty and Duration of Fixation indicates how much time users spent while reading, understanding, and deciding processes when they thought that they caught the correct information for the relevant task. Statistical results show that LD2 and LD3 are better than the LD1 (original one) in terms of all test outputs. In addition, LD3 is one step ahead of LD2 since tasks were completed earlier with it.

It is expected that this study will be an initiator one to search usability and readability of leaflets on computers, tablets, and smartphones. The experiments in this study can also be repeated by use of other types of eye-trackers such as the eyeglass type.

This study makes an important theoretical contribution to the existing eye tracking literature by focusing on the usability and readability of medical leaflets on-screen. Results of the study provide suggestions on basic design principles of medical leaflets that can be considered in real life applications. It is expected that this study will be an initiator one to search usability and readability of leaflets on computers, tablets, and smartphones. The experiments in this study can be repeated by use of other types of eye-trackers such as the eyeglass type. However, the study has also limitations because of the costly feature of the eye-tracking technology.

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