Studying how health literacy influences attention during online information seeking

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ABSTRACT

Health literacy affects how people understand health information and, therefore, should be considered by search engines in health searches. In this work, we analyze how the level of health literacy is related to the eye movements of users searching the web for health information. We performed a user study with 30 participants that were asked to search online in the context of three work task situations defined by the authors. Their eye interactions with the Search Results Page and the Result Pages were logged using an eye-tracker and later analyzed. When searching online for health information, people with adequate health literacy spend more time and have more fixations on Search Result Pages. In this type of page, they also pay more attention to the results' hyperlink and snippet and click in more results too. In Result Pages, adequate health literacy users spend more time analyzing textual content than people with lower health literacy. We found statistical differences in terms of clicks, fixations, and time spent that could be used as a starting point for further research. That we know of, this is the first work to use an eye-tracker to explore how users with different health literacy search online for health-related information. As traditional instruments are too intrusive to be used by search engines, an automatic prediction of health literacy would be very useful for this type of system.

CCS CONCEPTS

• **Information systems~Users and interactive retrieval** • **Human-centered computing~User studies** • **Applied computing~Consumer health** • Information systems~Web searching and information discovery

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1 Introduction

Online health searches are very prevalent. Three-quarters of unwell British people now search for their symptoms online, naming the search engine Google as "Dr. Google" [30]. Around 72% of adult American Internet users search for health-related topics online, being diseases, and treatments the most common issues [9]. Previously, Susannah Fox [16] has shown that about 8 million American adults searched for at least one health topic on a typical day in August 2006.

Health literacy is the "degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions." [24, 27]. So, health literacy is an individual characteristic that affects the comprehension of health information. Search engines typically consider the diversity of people searching the web. We believe that, in health searches, health literacy should be considered when deciding which documents should be provided to each user.

Eye-tracking technology allows the study of eye interactions that users, consciously or not, have with a screen. It is used in different areas of research, and it is evolving. Apple recently acquired SensoMotoric Instruments, a company specialized in eye-tracking hardware, which indicates an interest in the integration of biosensors into daily technology.

We believe that users with different levels of health literacy have different eye interaction with Search Engine Result Pages (SERP) and individual Result Pages (RP) while conducting online health searches. Therefore, we hypothesize it might be possible to infer health literacy with these eye movement patterns. This inference

would be useful for search engines that could predict this characteristic through information collected automatically. It is important to note that health literacy is typically measured through the application of instruments. As these instruments are usually questionnaires, that wouldn't be suitable for search engines for its intrusiveness.

To study if eye movements vary with an individual's health literacy when searching online for health information, we conducted a user study. Two groups of participants were formed, with 15 people each, according to their health literacy measured using two instruments: Newest Vital Sign (NVS) and Medical Term Recognition Test (METER). Using an eye-tracker, we analyzed users' interactions with SERP and RP.

This article has six sections. After presenting the background and state of the art, we detail our methodology. The results of our analysis are shown in the "Results" section and discussed in the following section. Finally, we conclude and present lines of future work in the last part of the paper.

2 Background and state of the art

2.1 Health Literacy

According to Malloy-Weir et al. [21], about 250 definitions of health literacy appear in different articles. Ratzan et al. [28] define it as the "degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions.". Sørensen et al. [34] refer that it "concerns the knowledge and competences of persons to meet the complex demands of health in modern society".

Despite the differences, every definition includes in health literacy the competencies to access, understand, and use health-related information. Mancuso [22] analyzed existing health literacy definitions through a concept/dimensional analysis and formed a new definition: "a process that evolves over one's lifetime and encompasses the attributes of capacity, comprehension, and communication. The attributes of health literacy are integrated within and preceded by the skills, strategies, and abilities embedded within the competencies needed to attain health literacy. The outcomes of health literacy are dependent upon whether one has achieved adequate or inadequate health literacy and have the potential to influence individuals and society".

The assessment of health literacy is done with instruments that are based on word recognition or pronunciation: Medical Term Recognition Test (METER) Rapid Estimate of Adult Literacy in Medicine (REALM), Short Assessment of Health Literacy for Spanish-speaking Adults (SAHLSA); or numeracy and reading comprehension: Newest Vital Sign (NVS), Test of Functional Health Literacy in Adults (TOFHLA).

METER is an English language open use instrument based on REALM, consisting of a list of medical words and made-up non-words that sound like real medical terms [29]. It is self-administered, and it takes on average two minutes to complete. NVS is a nutrition label that is accompanied by six questions and requires 3 minutes for administration [35].

The impact of health literacy is felt at the individual and society level, and the significance of this impact is making health literacy a target of attention in research.

2.2 Tracking eye movements

Eye-tracking technology allows the track of eye movements as well as the response of the eyes to the various stimulus [32, 36]. Many fields use the eye tracker technology that was pioneered in reading research [15]. There are three types of eye-tracker devices: glasses, a loose device, or an eye tracker attached to a monitor [11].

The gaze position is an essential aspect when researchers are studying the eye movement. The gaze is the externally-observable indicator of human visual attention, being the gaze position the point where the eye is looking, and many tried to record it since the late eighteenth century [14].

Many patterns of ocular movement [32, 36] can be analyzed. The most common are the ones presented in Table 1.

Table 1 – Main Eye Movements

Eye Movement	Description
Fixations	Very low-velocity movements that correspond to the test person staring at a particular point. Fixation "is a variety of motions which are generally less than 1 degree in amplitude and occur during attempted steady fixation on a target", according to Young & Sheena [36].
Pursuit	This movement can be perceived when the eyes follow a moving target in the environment, trying to fix that target on the retina. This movement is done smoothly. However, when the eye "loses" the target, it will perform "catch-up saccades", which, according to Robinson [31], are rapid eye movements to reacquire the target,.
Saccades	Rapid eye movements the eye makes while jumping from point to point in the stimulus, being triggered by displaying fixation targets at defined times within the stimulus. They are voluntary and have very high initial acceleration and final deceleration.
Gaze Path	The path followed by the eye while studying a stimulus. The gaze path can be thought of as the chronological ordering of fixations and saccades when analyzing a screen.

2.3 Eye-tracking studies on specific health literacy groups

Eye-tracking is becoming popular in the context of information retrieval due to its ability to analyze how users view the information provided in a SERP [12, 19, 26]. It complements traditional methods that study information retrieval behavior based on results the user has selected, such as server log data. Previous works have also used it to assess/inform the design of search interfaces [7, 8, 10, 33]. Gwidzka et al. [13] examine in detail the contribution of eye-tracking in the study of health information-seeking behavior.

There is a lack of studies focusing on eye-interactions on specific health literacy groups. Not being particular to health literacy, people with limited literacy have different attention patterns. They generally read more slowly and reread words or elements to make sure not to miss important information, but they are also known for skipping parts of the text or start reading in the middle of a paragraph [6]. When navigating, these users tend to get being distracted by other webpage elements (like links and icons) [6], navigate linearly and frequently backtrack [18], choose the first answer without checking if it's correct [6, 18]. When searching, they are more likely to give up if they can't find information quickly [18] and tend to only click 1 or 2 links in the search results [3].

There are not many studies focusing on the eye-interaction differences between levels of health literacy. One of the studies investigates how health literacy influences attention to text and illustrations in online health information, and whether the focus is related to recall. Authors used eye-tracking to record attention patterns on a web page. They concluded that concentration on illustrations is positively related to recall in people with limited health literacy, and attention to text increases recall in the adequate health literacy group [23]. These results corroborate previous works that concluded that illustrated health information is better than non-illustrated information [2]. The other study, by Mackert et al. [20], analyzed how health literacy influences the way people look at nutrition labels. Participant's health literacy was measured with the assistance of Newest Vital Sign (NVS). The study concludes that people with limited health literacy skills did not spend a lot of time looking at relevant information, spending more time viewing nonrelevant information.

However, none of these studies have provided valuable insights into how people with different levels of health literacy pay attention to SERP and result pages followed from SERP. We, therefore, explore the following research question: "How does health literacy affect attention on SERP and Result Pages of users searching online?".

3 Methodology

3.1 Experimental Design

We conducted a controlled, within-subject user study with 30 participants (16 males), who were asked to search for health-related information on the web. The Ethics Committee of the University of Porto approved this study.

Participants have different educational levels, from high school level to a Ph.D., and ages between 18 and 59 years. Participants were divided into two groups according to their health literacy (HL): adequate (AHL) or inadequate (IHL). The AHL group was constituted by 15 participants with ages between 21 and 49 years old and educational levels between Graduation and Ph.D. The IHL participants were aged between 18 and 59 and had levels of graduation from a secondary level to a master's degree. We recruited participants using the mailing lists of the University of Porto and through direct contact.

We pre-screened our participants for (a) level of health literacy and (b) previous experience in searching for information online (to assure users were capable of performing the task).

3.2 Health Literacy Assessment

To assess health literacy, we combined two instruments: METER that determines literacy based on word recognition or pronunciation and NVS that does it through numeracy skills and reading comprehension. This combination allows us to test health literacy in a more encompassing perspective. We chose these instruments for their quick administration and the existence of adapted versions in the native language of the participants.

METER, based on 40 words and 30 non-words recognition, was applied through a questionnaire. We used the cut-offs suggested by the adapted version of METER [24] to categorize health literacy as inadequate or adequate. In NVS, an ice cream nutrition label is given to review, and six questions are asked about it. We applied its adapted version [25] and considered that users with a high likelihood or possible limited literacy were users with inadequate literacy.

Users who were considered to have inadequate health literacy in both tests were assigned to the IHL group, and users that had adequate health literacy in both tests were assigned to the AHL group. To maximize the differences between both groups, we excluded users who scored differently in both tests.

3.3 Task Description and Assignment

We created three work task situations, that is, cover stories describing hypothetical health situations as suggested by Borlund [4]. All the tasks were related to cardiovascular disease as this is a prevalent problem in Portugal and simultaneously, a topic in which people have little knowledge [1]. For making the information-need more realistic, participants were asked to find useful information for helping a family member. The definition of the situations was informed by work about cardiovascular disease in Portugal [1]. It was done with the help of a medical doctor that also revised them to make them as realistic as possible. The prompts for each task are:

T1. You arrived home and your mother (aged 60) is with her mouth slightly to the side. She also says that she is having difficulty speaking. What should you do regarding your mother's complaints?

T2. Your brother, a young adult of 26 years, measured his blood pressure and found that his values were 142 mmHg and 90 mmHg (systolic and diastolic pressure, respectively). What health problems can result from this condition?

T3. Your aunt (65 years old) is complaining that she was suddenly ill-disposed, nauseous, with a tightness in her chest and has cold sweats. What can it be, and how can you help her?

For each task, the authors, in collaboration with the medical doctor, formulated the search query. In this process, we assured that the information need was not completely answered in one of the initial results retrieved by Google. To ensure similar levels of difficulty between tasks, we also assured that all queries had at least a document with the answer in the first SERP. For T1, the English translation of the query was *mouth to side difficulty speaking*, for T2, *142 mmHg 90mmHg blood pressure problems,* and for T3 was *chest pain nausea cold sweats*. Queries were inserted in the Portuguese language.

For task assignment, we have used the Latin Square Design [5, 17] to ensure that results aren't dependent on the order by which the tasks are performed. The use of this model resulted in the sequence of tasks of Table 2 and then repeated from participant 7 to participant 30.

Table 2 – Latin Square Design for the first 6 participants

Participant	First task	Second task	Third task
P1	T1	T2	T3
P2	T1	T3	T2
P3	T2	T1	T3
P4	T2	T3	T1
P5	T3	T2	T1
P6	T3	T1	T2

In Table 2, we see that the participant with ID P1 performed the Task 1 in the first place, then the Task 2 and finally the Task 3, while participant with ID P2 completed the Task 1, then the Task 3 and later the Task 2.

3.4 Apparatus

The three search tasks were done in a controlled environment, i.e., in pages manipulated (or replicated) to look like the original pages but without links to external pages, except for the hyperlink of the result on the SERP, in such a way that free navigation wasn't possible. In total, we manipulated 33 pages (3 SERP and 10 result pages for each SERP).

For each manipulated page, we defined its Areas of Interest (AOI) with the "SMI BeGaze 3.6.52" software. The AOI allow us to differentiate elements of the pages and facilitates posterior analysis. Figure 1 shows an example of a Result Page with marked AOIs.

Figure 1 - Examples of AOI defined in a Result Page. Each color represents a different type of AOI.

In Table 3, it's possible to see the AOIs defined for SERPs and in Table 4, the ones set for the Result pages.

Table 3 – Areas of Interest defined for SERP

Name	Description
Google Logo	Logo present on SERP pages
Navigation Bar	Tabs of Images, Maps, among others present in SERP
Search Bar	Search bar of the SERP
Nr of Results	Number of results obtained
Results Title	Title of each result
Results Link	Link of each result
Results Snippet	The snippet of each result
Related Results	Results with queries similar to the query entered
More Results	Section of the next SERP pages
Location	Information of the Location in SERP
More Navigation	The bottom part of SERP where help, privacy, and terms appear

Eye gaze was captured using an "SMI RED250mobile" eye tracker.

3.4 Procedure

Each experimental session started with an explanation of the research goals and process, clarifying doubts presented by the participants. Then, we gave the informed consent to the participant for him to sign, agreeing with the participation. We also gave a prequestionnaire soliciting demographic information to participants. Next, the participants performed a training task to familiarize themselves with the eye-tracking device and with the

study procedure. After training, participants started with the three main search tasks, all conducted on Internet Explorer.

Table 4 – Areas of Interest defined for Result Pages

Name	Description
Comments	The comment section of the page
Contacts	The contact section of the page (emails of contact and related information)
Images/Multimedia	Images and contents of Multimedia
Info Article and Author	Information about who wrote the article or the website page
Page Information	Copyrights, disclaimers, among others
Image Subtitle	The subtitle of the image
Login	Login area of the page (all login related fields)
Logo	Logos on the website
Navigation	Navigation tabs from the website
Other Contents Site	Links and content that links to other articles or pages
Search	Search bar of the website
Publicity	Publicity items
Social Networks	Social networks icons and references
Text	Text items (section of content of the page)
Highlighted Text	Text that is evidenced (e.g., bold text, more prominent than other text)
Title	Titles present on the website

For each task, we provided the participant with a written description of the task and a paper for writing the answer. Participants were then presented with the manipulated SERP page for that particular task. There were no time limits between tasks, and there was a short break between each task to prevent fatigue.

The experiment took place in a Research Lab from the Faculty of Psychology and Education Sciences of the University of Porto[1]. This Lab has two rooms, and participants conducted their tasks in one of the places while the researcher was in the other room.

3.4 Data Analysis

We compared both groups in terms of eye interactions with two types of pages: SERP and individual result pages, that is, content pages accessed through the SERP. In both types of pages, groups were compared regarding the number and duration of fixations (total number of fixations and number of seconds fixating each AOI), and time spent on pages (number of seconds). In SERP, we have also compared the number of fixations in the title, link, and snippet; the number of results users looked at before clicking on a result; and the number of clicks per SERP.

[1] More info at https://www.fpce.up.pt/sexlab/eng/about.html

Given the independence of the samples, we compared the means of the above variables between groups using two independent samples tests. In most cases, we used the non-parametric Mann-Whitney test because the normal distribution of the samples, one of the assumptions of the parametric Student's t-test, was not verified. We only applied the parametric test in 3 comparisons on result pages: total time spent there, time fixating images, and time fixating other content. To analyze the normality of the distributions, we used the Shapiro-Wilk test. All tests were unilateral.

When reporting our results, we use * to indicate results significant at a α=0.05 and ** to indicate results significant at a α=0.01.

4 Results

4.1 SERP Behavior Analysis

This subsection presents the results of the comparison of users' interactions with SERP by health literacy group. Table 5 summarizes these results for all the metrics except the ones related to the AOI.

Table 5 – Comparison of SERP Interaction by health literacy group. Average and standard deviation for each group and the significance of the differences. The highest value for each variable is shown in bold.

	AHL		IHL		p-value
	avg	sd	avg	sd	
Number of results seen before the first click	**4.76**	2.99	4.12	2.87	0.138
Clicks on SERP Results	**2.56**	1.53	1.83	1.01	0.012*
Total fixations on SERP	**226.38**	151.66	162.57	135.62	0.011*
Total time (in seconds) spent in SERP	**28.53**	20.22	21.09	17.32	0.018*
Total fixations in Results Title	**101.47**	52.82	91.5	78.44	0.192
Total fixations in Results Link	**62.33**	33.56	42.71	32.92	0.023*
Total fixations in Results Snippet	**106.6**	66.19	52.43	45.81	0.002**

4.1.1 Number of Results seen before the first click. The number of results looked at before the first click allows us to understand the importance given by people to each link present on the SERP, i.e., if they open the first link or if they try to assess which result corresponds better to the information needed. Although

participants belonging to the AHL group see more results before clicking on the first one (4.76 to 4.12, on average), this difference is not statistically significant.

4.1.2 Clicks on SERP Results (results seen by session). The number of clicked results is vital to understand if participants used more than one resource in their search or if they only looked for one result. If participants went back from the result page, they would return to the previous SERP, so, for this variable, we considered every result in which participants clicked to reach an answer. We detected a significant difference between the two groups. With an average of 2.56, the AHL group clicked in more results than the Inadequate Health Literacy (IHL) group, which had an average of 1.83 results opened. This difference corroborates the idea that people with higher health literacy want to make sure that the information they are retrieving is correct and reliable.

4.1.3 Total Fixations on SERP. Analyzing SERP behavior, with the two previous variables, we can see that participants from the AHL group paid more attention to the search, analyzing more results, and viewing more results before clicking. Corroborating this idea, we also found that the number of fixations on SERP is higher on the AHL group (226.38 fixations) than in the IHL group (162.57). This is a significant difference. Note that, for the computation of the total number of fixations on SERP, we added all the fixations in SERP for each participant.

4.1.4 Total Time (in seconds) spent in SERP. The total time each participant spent in SERP let us analyze the attention given to the SERP. Users might find useful the information provided in the SERP or might only use it to access results without paying close attention to the different elements included in the SERP. As expected from the previous results, with a mean value of 28.53 seconds spent in SERP, users belonging to the AHL group spent more time than users from the IHL group, which spent 21.09 seconds on average. This is a statistically significant difference.

4.1.5 Total Fixations on Title, Link, and Snippet on SERP. The most viewed areas on the SERP were, as expected, the title, link, and snippet of results. These are the elements that give users a brief description of what's on the result page and lets the user understand if the result is appropriate for his needs. In this context, we analyzed the number of fixations of each participant in those three areas. As reported in Table 5, participants from the AHL group showed a total number of fixations higher than participants from the IHL group for all of the three areas. It's also essential to notice that the snippet registered the most significant difference between the two groups. Participants with higher health literacy fixated, on average, more than twice as many times in that area than participants with lower health literacy (106.6 to 52.43). The number of fixations on results' links also presented a significant difference at α=0.05. These results support the evidence previously stated for the SERP page.

4.1.6 Total Duration of Fixations (in seconds) for each AOI per group. We assessed the duration of fixations by each AOI defined for SERP. As seen in Table 6, the most viewed areas in SERP are related to its content, i.e., "Results Titles", "Results Link", and "Results Snippet". We found three AOI with statistically significant differences. These AOI were "Results Link", "Results Snippet" and "Related Results". The first presented itself with an average duration of fixations of 18.46 seconds for the AHL group, while participants from the IHL group registered, on average, 12.04 seconds fixation on this AOI. Also, analyzing both groups regarding the duration of fixations on the Results Snippet, it was verified that participants with higher health literacy registered 26.25 seconds, spending much more time analyzing this AOI than participants from the IHL group, which only fixated for 12.41 seconds, in average. Furthermore, in regards to the AOI "Related Results", participants from both groups didn't spend too much time fixating on it. Yet, participants with higher health literacy spend more time analyzing it than participants with lower health literacy (1.38 seconds and 0.33 seconds, respectively). The only AOI in which IHL participants spend more time was the "More Results" one.

Table 6 – Comparison of the number of seconds fixating AOI in SERP. Average and standard deviation for each group and the significance of the differences. The highest value for each variable is shown in bold.

	AHL		IHL		p-value
	avg	sd	avg	sd	
Google Logo	**0.20**	0.39	0.05	0.09	0.335
Navigation Bar	**0.51**	0.49	0.48	0.40	0.431
Search Bar	**1.42**	1.20	0.69	0.99	0.068
Nr of Results	**1.39**	2.28	1.15	0.77	0.158
Results Title	**25.91**	13.34	23.84	19.87	0.158
Results Link	**18.46**	11.25	12.04	9.45	0.045*
Results Snippet	**26.25**	18.76	12.41	11.44	0.002**
Related Results	**1.38**	2.28	0.33	0.68	0.018*
More Results	0.15	0.36	**0.17**	0.65	0.191
Location	**0.02**	0.06	0	-	0.082
More Navigation	0	-	0	-	-

4.2 Result Pages Behavior Analysis

4.2.1 Total Fixations on Result Pages. We also analyzed the number of fixations of participants from both groups on result pages. We found that participants from the AHL group have more fixations (847.11) than the participants with lower literacy (501.29). This difference is significant, as it is possible to see in Table 7.

4.2.2 Total Time Spent on Results Pages per Session (in seconds). The time participants from each group spent, on average, looking for the answer to the question presented to them was, as it is possible to see in Table 7, higher in participants of the AHL (285.03 seconds) than in IHL participants (189.12 seconds). This is a significant difference.

Table 7 – Comparison of Result Pages Interaction by health literacy group. Average and standard deviation for each group and the significance of the differences. The highest value for each variable is shown in bold.

	AHL		IHL		p-value
	avg	sd	avg	sd	
Total fixations on Result Pages	**847.11**	408.37	501.29	307.41	0.008**
Total Time Spent on Result Pages per Session	**285.03**	145.68	189.12	133.11	0.038*

4.2.3 Total duration of fixation (in seconds) for each AOI per group. Similar to the analysis performed for the SERP pages, we analyzed the result pages regarding the fixation duration in each defined AOI. We found that the most critical AOI for both groups, i.e., the most viewed areas of the result pages, were "Images/Multimedia", "Info Article and Author", "Other Contents Site", "Text", "Highlighted Text" and "Title".

As is possible to see in Table 8, "Info Article and Author", "Login", "Other Contents Site", "Text" and "Highlighted Text" AOI presented significant differences between both groups. In all of these AOI, the AHL group spent more time looking at them than the IHL group.

Although presenting non-significant differences, the only AOI where IHL participants spend more time than AHL participants were the "Images/Multimedia and "Navigation".

5 Discussion of Results

As presented in the previous section, we found six significant differences in SERP pages, all revealing more attention of the AHL group. When compared with IHL users, AHL users: (a) see more results per session, (b) spend more time, (c) have more fixations, and have longer fixations on (d) results' link, (e) snippet and (f) related results. These results support the idea that AHL users are more careful when searching online, being more prepared to check the correctness of the information, not being limited to one information source, and showing interest in related results.

The only AOI from SERP in which IHL had longer fixations was the "More Results" one, but this was not a significant difference.

Table 8 – Comparison of the number of seconds fixating each AOI in Result Pages. Average and standard deviation for each group and the significance of the differences. The highest value for each variable is shown in bold.

	AHL		IHL		p-value
	avg	sd	avg	sd	
Comments	**0.41**	0.93	0.19	0.39	0.375
Contacts	0	-	0	-	-
Images/Multimedia	7.49	7.75	**9.95**	12.44	0.483
Info Article and Author	**8.28**	10.82	1.16	1.65	0.008**
Page Information	0	-	0	-	-
Image Subtitle	**0.14**	0.24	0.08	0.17	0.219
Login	**0.05**	0.11	0	-	0.042*
Logo	**0.97**	1.12	0.72	0.83	0.241
Navigation	0.64	0.60	**0.74**	1.08	0.277
Other Contents Site	**2.94**	2.45	1.31	1.48	0.004**
Search	**0.05**	0.09	0.02	0.06	0.099
Publicity	**0.19**	0.30	0.04	0.11	0.054
Social Networks	**0.56**	0.55	0.47	0.49	0.270
Text	**173.7**	98.54	101.17	76.80	0.019*
Highlighted Text	**16.10**	13.42	10.17	18.49	0.028*
Title	**25.05**	16.24	19.61	15.55	0.183

When compared with studies focused on general information literacy, our results contradict previous results that conclude that IHL users spend more time on information search tasks [6]. This might be justified by the higher likelihood of skipping parts of the text [6], of giving up if they can't find information quickly [18] and tendency to click on few links on the SERP [18]. Our results also support this last tendency.

On the result pages, we found seven significant differences, also showing more attention from the AHL group. When compared with IHL users, AHL users: (a) have more fixations, (b) spend more time, and have longer fixations on (c) the information about who wrote the article or the website page, (d) login-related fields, (e) links and content that link to other items or pages, (f) text and (g) highlighted text. These results are in line with our conclusions based on SERP, that is, are more cautious and attentive when searching for health information. Note that they pay more attention to the author and website, a typical recommendation for the evaluation of health information quality. This shows that participants with higher health literacy try to understand, to an

extent, the information they are getting is reliable, trying to know its origins. Longer fixations in the webpage's main content and external links show their greater interest and attention.

Although a non-significance difference, the only AOI from Result Pages in which IHL had longer fixations was the "Images/Multimedia" and the "Navigation" ones.

These results follow conclusions from other studies stating that inadequate information literacy users skip words or sections [6], and get distracted by elements of a website such as links and icons [6].

Summing up, it's possible to conclude that the attention of people with different health literacy differ while searching for health information online with AHL users showing more attention and being more cautious. These results are a good starting point to a deeper understanding of the influence of health literacy in peoples' eye movements when searching online for health information.

Recalling our ultimate goal of automatically detecting health literacy through eye interactions, we have to analyze how well these differences will help the prediction. The automatic detection of health literacy could be used by search engines to adjust their results to the literacy of the searchers, proving, for instance, more readable and/or illustrated information to inadequate health literacy ones. If the conclusions we have reached regarding the result pages are enough to predict health literacy, this could also be used by websites that could also adjust their contents to the reader.

6 Conclusions

The study consisted of understanding if eye movements of participants vary according to their health literacy when searching online for health information. Health literacy is becoming critical over time, which affects the impact that this study may have on society. This study used an eye tracker as a possible instrument to detect a person's health literacy avoiding the need to apply traditional instruments that measure this characteristic. Eye-tracking use has been growing and evolving in such a way that the achievement of eye movements is much more precise.

During this study, we found differences between people with different levels of health literacy. We understood that people with adequate health literacy are more careful when searching online for health information. They pay more attention to both the authors and sources of information. They also spend more time on the SERP, paying more attention to the results' snippets. On the Result Pages, they spend more time looking at the text and highlighted text.

However, we believe that there are opportunities to improve the work here presented. A limitation of this study relates to the health literacy of participants belonging to the inadequate health literacy group that, in some cases, is close to being considered as having adequate health literacy. It would be preferable to have more extreme cases. This is a challenge because participants with very inadequate health literacy might not know how to work with a computer and to search on the web, which makes it impossible for them to participate in the study.

This study is also useful for search engines to the extent that through eye patterns during a health-related search, it's possible to induce, with some level of certainty, the user's health literacy. Through the estimation of health literacy, search engines can, for example, personalize their response to users' health literacy. For instance, for inadequate health literacy users, search engines can exclude less readable contents such as scientific articles, provide more readable materials, less verbose texts or content more based on illustrations.

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