Exploring the Impact on User Information Search Behaviour of Affective Design: An Eye-Tracking Study

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Abstract. Affective design has made a significant contribution to user experience and satisfaction in human-computer interaction. As an important developing research field, user-centred information search system design should benefit from the theories and approaches of affective design. It is especially beneficial to the interactive health information search, where the search tasks can give users negative emotions. This paper explores the impact of affective design on health information search behaviours in terms of online interaction, query formulation and result selection through an eye-tracking user study. Eye-tracking experiment results show that affective design has a positive impact on the user's information search behaviour. For example, the users tend to form more precise search query formulation, spend more time on the search, and explore and find more relevant results for the task, and they interact more with the affective design features on the search interface.

Keywords: Affective Design; Online Health Information Search; User Behaviour; Eye-Tracking Study.

1 Introduction

The aim of this paper is to explore the impact of affective design on health information search behaviour in terms of online interaction, search query formulation, and result selection using an eye-tracking study. The idea of affective design in Human Computer Interaction (HCI) is not new [24]. Affective design has made a significant contribution in HCI in terms of supporting users' affective needs [18]. Affective needs in design focus on the user's emotional responses rather than their functional needs [18]. Affective needs such as emotions and feelings play a vital role in information searching behaviour and are identified as the motivating factor in information search [24,25]. However, the topic of accommodating the

user's emotional needs in information search interfaces needs more attention. Users need interface designs that meet their affective needs. Previous studies have suggested that the design of the information search interface should meet the affective needs of the user as well as their information needs [1]. Affective needs can be fulfilled by providing affective design illustrations into the information search interface design that represent the emotional state of the users. The affective design idea first emerged from the field of HCI and the developing field of affective computing [29]. It has been identified in the past that emotion influences the searcher's task performance, search experience, and satisfaction during the information-seeking process. Recent research on developing an affective search system might bring a significant shift in the behaviour of online health information search. Online health information search has been rapidly growing fast during the recent years among all stakeholders [26]. About 72% and 71% of internet users search for online health information in the USA and Europe, respectively. Elderly people in China tend to use the internet for health-related searches as it is considered more convenient for them [40]. Affective design can be beneficial to interactive health information search, where the search tasks often give users negative emotions.

The importance of affective design has been highlighted by previous studies and some have argued that models of the product design that do not consider affect are essentially weakened [14]. An earlier study indicates that more adult attention is paid to affective design illustrations on cancer-related web pages as compared to simple design web pages [3]. Also, expectations of users are changing from functionality, attractiveness, ease of use, and affordability to the objects that inspire users, enhancing their lives and arousing emotions [14]. The affective needs can be fulfilled, however, not only by analysing affective factors such as thoughts, moods, and emotions, but also by providing the affective design illustrations that represent the emotional state of the individuals. Affective interface designs are capable of eliciting the user's emotional experiences while interacting with interfaces [21]. Therefore, we propose an affective search interface design in this paper, which is developed by introducing a positive psychology theory called the Authentic Theory of Happiness by Martin Seligman [37] into interface design factors to improve positive emotional information search experience. This was accomplished by utilising two approaches to improve the design of the search interface to promote positive emotions. The first is based on the modification of an object's aesthetic appearance or interface; the latter focuses on promoting fluent and engaging interactions [38]. Isen [16] proved that minor positive affect improves problem-solving, creativity, and decision making. There has also been a rapid growth in research concerning affective and pleasurable designs to improve user behaviour and engagement [13].

Affective design can inspire individuals and help to improve their motivation and attention to the search for information. However, there is a lack of study and analysis on how the design of the search system affects the user's information search behaviour and experiences during the online search for health information. Information search behaviour is a diverse research topic that includes multiple

factors associated with the individuals during the search for information that can be affected and investigated. Precise quantification of online health information search activity can be difficult due to the complexity and diversity of information needs and search behaviour. This is why we have incorporated an eye-tracking device to track online interactions, search query formulation, and result selection during online health information search. Online interactions can be captured by using the eye-tracking device, which can investigate various measures, such as time spent, revisits, number of clicks, revisitors, Time to First Fixation (TTFF), ratios, and fixation counts. This study aims to explore the effect of affective search design on online health information searching behaviours.

2 Related Work

The affective design approach is an idea to bridge the gap and enhance the interaction between human and technology [4]. In any affective human-computer interaction, information is communicated by the user in a natural and comfortable way which further helps to strengthen the interaction [34]. Previously, an affective design approach to cancer-related information search has been adapted to improve website satisfaction for older adults [3]. However, affective design has not been investigated in information search engines for its effect on the individual's online health information search behaviour. Online health information search has become one of the extensively researched topics in previous years. The relationship between patients and doctors is recorded as being positive as patients are well-informed of their health conditions and tend to have better reaction to treatments. Also, it has the potential to reduce health care cost and pressure on hospitals [27]. Several studies have investigated the characteristics and behaviours of individuals searching online for health issues. Such characteristics and behaviours are various variables that can influence efficiency of searching for information. Information search behaviour consists of several factors affecting user actions when searching for online information. Factors include age, gender, education level, website types (professional or non-professional), health topics searched [41], online interactions, search query formulation, and uniform resource locators (URLs) [31], ability to access the internet, ability to access online health information, and responses to internet searches [17], use of health resources, libraries, and deterrents [6], search experience, attitude towards the quality of health information available, trust of information quality [33], information needs and preferences [23], and many other health information behaviours.

The need for an affective design interface for online health information search has been found to be a research gap by investigating the literature as discussed in the previous paragraph. However, a previous study showed that interface design factors have a significant impact on individual emotions and quality perception. Information seeking is entirely related to human decision making, and human emotions influence decision making, and affect attention and memory [38].

Therefore, design based on human emotions and affect can affect overall user experiences [38]. Affective design based on the emotional elements and design factors has emerged to promote positive emotions and experiences [10]. There are two main approaches to apply affective design to promote positive experiences. The first approach is based on the modification of aesthetic appearance and interface. While, the latter focuses on promoting engaging interactions [38]. These two approaches are applicable to technology design. The first approach focuses on the importance of emotional aspects as a drivers of market success and active use of technologies [8]. An individual show more attention towards interfaces that include the combination of fascination, pleasant surprise, and desire [8]. Another study in multimedia learning showed that integrating emotional stimuli such as face-like shapes or vibrant colours into interface design helps elicit positive emotions in improved learning [30]. In an affective design interaction, it is important to get the individual's feedback on the specific design elements that please or displease the individual, or on which elements in the interaction frustrate the individual. One of the essential methods is sensing and recognizing the affective information communicated by the individual comfortably and reliably [34]. Similarly, exploring the effect of user interface design on online information search behaviour pertaining to individuals in terms of online interaction, search query formulation, and result selection has included eye-tracking research. There is a unique contribution of eye-tracking as a method to capture direct and indirect measures of an individual's online information search behaviour. The eye-tracking methodology has been extensively followed to investigate online health information search behaviour [11,20]. Also, eye-tracking has been used to investigate the affective factors present on cancer-related websites [22,3]. Eye-tracking has a long history in HCI and virtual reality to measure visual attention [9]. Eye-tracking data provides objective data for the interface design elements.

3   Experiment Setup

The aim of this study is achieved using two search designs shown in Figure 1 for experiment 1 and Figure 2 for experiment 2 by performing three search tasks to analyse the behaviour of the individual by comparing the outcomes of two eye-tracking experiments and self-reporting studies. Affective architecture of search systems involves affective diagrams and design elements by implementing the aforementioned Authentic Theory of Happiness [37]. This work is the continuation of the research based on positive design, positive emotion, improving positive emotional health information search experience, and well-being, which requires the implementation of positive psychology theory into search interface design elements.

An affective search interface is divided into three parts according to the three orientations of authentic theory of happiness. 1) Engagement, in a positive affect interface has been defined as the "flow", a state of concentration and total

absorption in an activity [19]. We defined the idea of an engagement section at the left-hand-side of a search system design marked as A in Figure 4 (experiments 1 and 2, respectively, and in what follows), where users are asked to write down the list of the information or search they want to do during a session or a day. 2) Pleasure, the right-hand side of the affective search design is defined as the pleasure section marked as C in Figure 4, which is based on: a) images, b) aesthetics/art, and c) pleasant text. Studies in multimedia learning [39,30] showed that embedding emotional stimuli (e.g., face-like shapes, vibrant colours, aesthetics, pleasant text) into interfaces elicited positive emotions in learners and improved learning outcomes. Also, the combination of pleasant surprise, fascination, and desire helps to generate positive emotions [8]. 3) Meaningful, the middle section of the positive information search system design is designated as a meaningful section marked as B in Figures 4 that uses the Bing API to provide the search information, which provides users the facility to write queries that fulfil the common meaning of the information search design.

Search tasks are explicitly designed to analyse knowledge search activity of the participants in three scenarios followed by the previous works based on finding the health information search tasks [2,12,35]. Task 1 type Easy/Simple, related to finding general online information that helps participants to relax and make them happy such as "find a restaurant of your choice for a free meal". Task 2, type Neutral, is related to finding information about "medicines to quit smoking" and to "find a diet plan for diabetics". Task 3, type Complex, requires participants to find information related to "their health problems" and to "find information about lung cancer". Experiments began with the consent form and demographic forms in which the entire experiment process was clarified. For the evaluations of the two systems we gathered the same kinds of data. Each experiment took approximately 30 minutes to complete. Therefore, each participant took 60 minutes to complete the two experiments [28]. Eye-tracking and screen recording were used to capture the search process of the participants in both experiments.

The research approach used to explore the impact of health information search behaviour includes obtaining visual attention using eye-tracking similar to previous research conducted to explore the behaviour of online health information search [28,9,11]. As this paper is the continuation of emotion detection research, a complete methodology is previously defined in a review based on wearable sensors [36].

Here, the self-reporting questionnaires rely on simply asking participants to complete the questionnaire and answer questions based on their information search experience. In this study, we used close-ended questions on a 5-point Likert-scale to ask people to choose from 1–5 balanced responses. Questions were based on demographics, computer usage experience, search experience, online health search experience, preferences for online health information search, trust in online health information, preferences to visit a doctor before and after finding online health information, and personal judgements based on online information search.
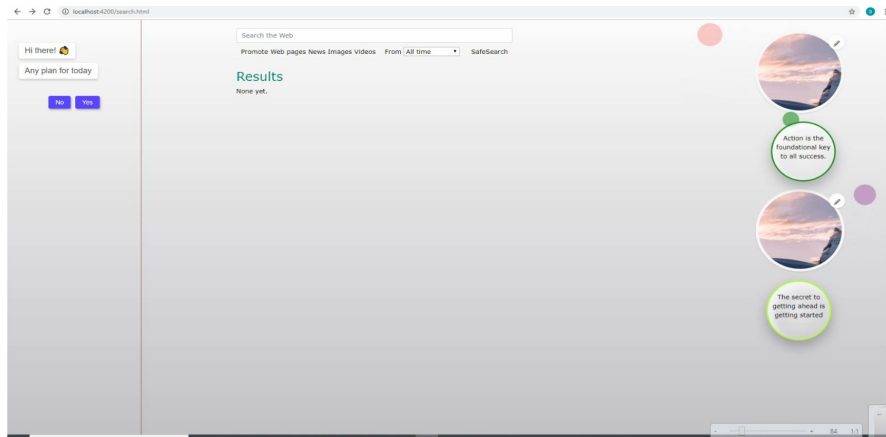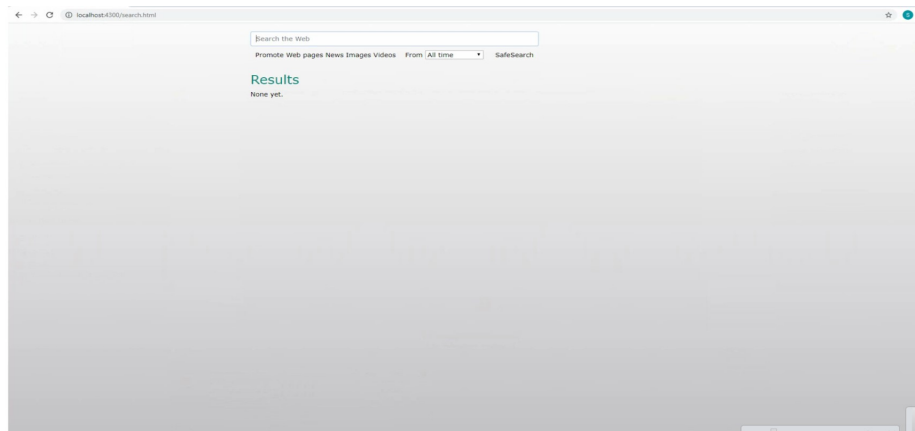
Fig.1. (a) Affective Search System Design

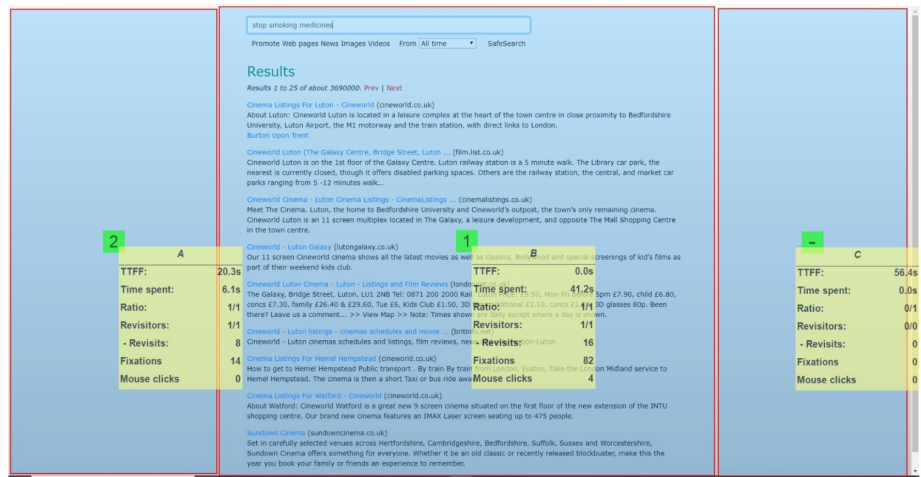

Fig.2. (b) Baseline search system design

Fig.3. Dividing baseline design interface in three parts A, B, and C for eye-tracking measure capture
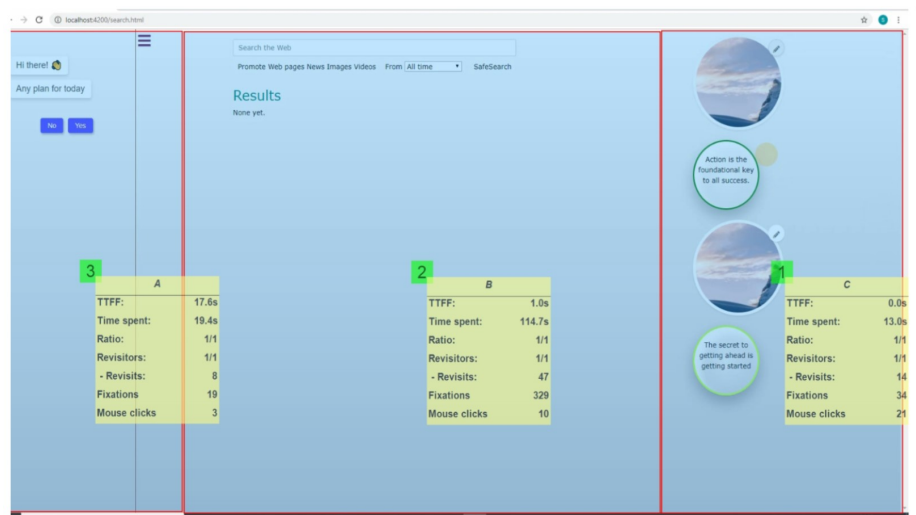

Fig.4. Dividing affective design interface in three parts A, B, and C for eye-tracking measure capture

4 Results and Discussion

The results from eye-tracking and the self-reporting questionnaire show the data of 25 students from a UK university from different departments including 17 male and 8 female students ages 21–35 with the education level of Bachelor, Masters and PhD degrees. All the participants were aware of the search engine, finding specific information, and interacting with search engines daily. The results were: 40% of participants were very confident in finding online health information; whereas, 52% of students were very confident in finding health-related information before visiting a general physician (GP); 60% of them liked to make personal judgments based on online health information available; 60% of participants felt neutral while searching for online health information, 20% excited, and 20% worried.

4.1 Online Interaction

The results depicting online interaction behaviour are captured using eye-tracking measures. Eye-tracking research allows for identifying further information processing measures [28]. These measures are the indicators for interface design elements. The result of the comparison of eye-tracking data shows that 52% of participants think that the affective design has helped them to stay focused on all three tasks compared to the baseline design. An example of one participant for two sets of experiments is depicted here to understand this claim. Table 1 depicts the online interaction behaviour of one participant obtained from eye-tracking measures as shown in Figure 6. Table 1 displays the values for the three tasks and further demonstrates the eye-tracking measures for three areas of interest for each task for affective design. AOI is the area of interest; to get the eye-tracking data for both affective and baseline interfaces, both interfaces were divided into three areas of interest named as A, B, and C called AOI1, AOI2, and AOI3, respectively, to obtain the whole eye-gaze map.

Affective Search Design									
Participant1 Experiment1	Task 1			Task 2			Task3		
	A (AOI1)	B (AOI2)	C (AOI3)	A (AOI1)	B (AOI2)	C (AOI3)	A (AOI1)	B (AOI2)	C (AOI3)
TTFF	17.6s	1.0s	0.0s	13.7s	0.0	18.7	17.6s	1.0s	0.0s
Time Spent	20ss	120.7s	15	11.8s	71.5s	1.72s	19.4s	114.7s	13.0s
Ratio	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
Revisitors	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
Revisits	10	58	20	22	40	10	8	47	14
Fixation Count	23	458	46	38	212	17	19	329	34
Mouse Click	6	22	25	10	22	8	3	10	21

Table 1. Eye-tracking data of one participant for affective design showing eye-tracking measures to analyse online interaction

Thus, for the baseline design, Table 2 displays the same eye-tracking measures of the same individual as shown in Table 1. The time to first fixation (TTFF) demonstrates the time for a stimulus to draw the attention of the eyes. The timer for this metric stops when the participant fixates on the specific AOI. A lower TTFF value would, therefore, be considered effective at gaining interest from the participants [5]. That indicates the participant's interest in affective design. The time spent engaging with the affective search design is more than with the baseline design. If we observe the time spent by all individuals on specified sections, we identified that each individual spent significant time with the affective design, indicating their interest in interacting with this specific design. The ratios and the revisitors display the affective feature benefit of 1/1, indicating the ratios of revisiting each area of interest. The number of fixations in eye-tracking is the gaze point maintained for a duration; it becomes a fixation. The time in which eyes lock one position is a visit. The number of fixations and visits are the most common measures in an eye-tracking study to identify visual attention [28,15,7,32]. The fixation count in this study is the number of fixation count per area of interest (AOI) visited. Similarly, values for the number of fixation counts for A, B, and C for three tasks are higher observed in Table 1 for the affective design as compared to

Table 2 for the baseline design. Similarly, individuals' revisits and clicks on the interface sections are observed as high in Table 1 relative to Table 2. These eye-tracking measures in Table 1 and Table 2 sum up the online contact and interest among the participants depicted in three AOIs. Time spent by the user, number of clicks, revisits, ratios, and fixations were found to be as high in the design of this affective search system. However, in the baseline search system design all the factors counted as slightly low.

Heatmaps are a visualization of fixation positions over time as an overlay on a specific stimulus, as shown in Figure 5 that displays the participant's visual focus captured during (a) the affective and (b) the baseline system tests. Data from the heatmaps also show that participants wanted to engage with the affective interface, while participants only had visual focus at the baseline search bar. Eye-gaze is a summary of eye fixations and counts for the user. The eye-gaze movement for the whole search process was identified as a large number in the affective design. Example of eye-gaze summary of one participant depicted in Figure 6 for (a) affective and (b) baseline designs. These gaze points represent the basic unit of measure: one gaze point is equal to one raw sample captured by the eye tracker. The overall eye-tracking results show the behaviour of online interaction indicating that the affective design obtained more visual attention.

Baseline Search Design									
Participant1 Experiment1	Task 1			Task 2			Task3		
	A (AOI1)	B (AOI2)	C (AOI3)	A (AOI1)	B (AOI2)	C (AOI3)	A (AOI1)	B (AOI2)	C (AOI3)
TTFF	52.4s	0.0s	48.3s	20.3s	0.0	56.4s	30.8s	0.0s	30.8s
Time Spent	3.8s	70.4s	0.4s	6.1s	41.2s	0.0s	0.0s	22.3s	0.0s
Ratio	1/1	1/1	1/1	1/1	1/1	0/1	0/1	1/1	0/1
Revisitors	1/1	1/1	0/1	1/1	1/1	0/0	0/0	1/1	0/0
Revisits	10	52	0	8	16	0	0	11	0
Fixation Count	14	195	2	14	82	0	0	47	0
Mouse Click	0	43	1	0	11	0	0	10	0

Table 2. Eye-tracking data of one participant for baseline design showing eye-tracking measures to analyse online interaction
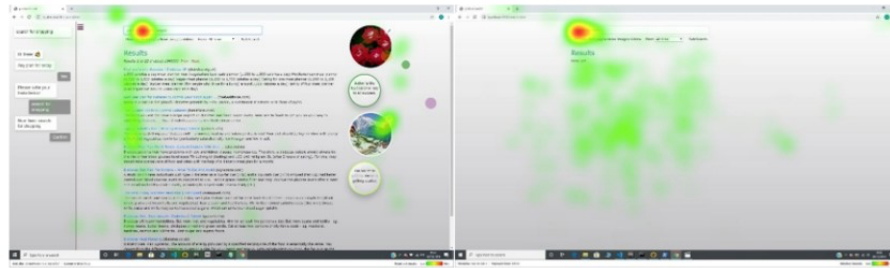
Fig.5. Heatmaps showing the visual attention of one participant for (a) affective design and (b) baseline design

4.2 Search Query Formulation

The selection of search query formulation behaviour is observed using screen recording. An interesting observation during both experiments is identified as the respondent's query formulation behaviour. No single participant in the same search task wrote the same query. For example, participant 1 wrote the precise query for finding the information when engaging with the affective design for task 1, such as "restaurant name". Whereas, the same participant selected a random query to find the information when engaging with the baseline design such as "best restaurant in town". This variation of the query was also observed during task 3, which is a complex task. When asked to look for health problems related to their health, each participant wrote two separate queries on two different health issues during two experiments. For example, one participant searched for "anxiety" during experiment 1 and searched for "how to quit smoking" during experiment 2 in task 3. Another participant searched for, "headache" and "stress" which could indicate that the stress level causes headaches or vice versa. Another example is, "causes of depression" during experiment 1 and "how to quit social media", "how to use less mobile" during experiment 2.
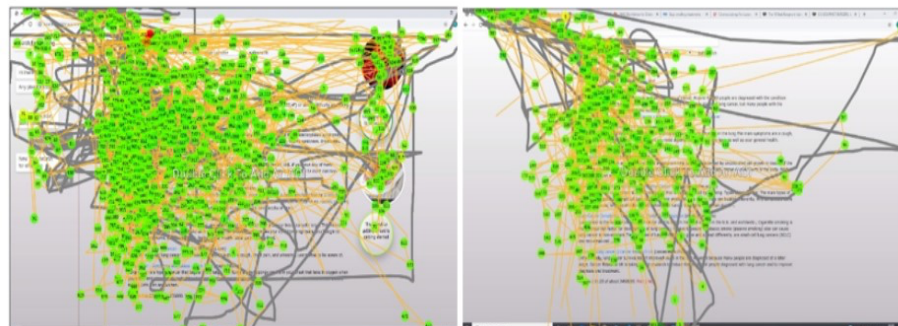

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Fig.6. Eye-gaze summary of one participant for (a) affective design and (b) baseline design

There is an implication that all participants face more than one health-related issue at a time. An online study conducted by *The Guardian* in 2018 revealed the troubling numbers of psychologically disturbed, depressed, and anxious students in the UK (The Guardian). One of four students suffer from psychological illness due to multiple factors. This study observed similar behaviour among students when observing search query formulation by participants. All the participants were looking for stress, depression, anxiety, low feeling, moody feeling, low concentration, headache, feeling angry, and sadness reasons. This is the major reason that there is a strong requirement for developers and technology companies to develop more affective designs that engage users in a positively productive way.

4.3   Result Selection

During online health information search, selection of the website is the most important aspect that needs to be examined to determine if users are reading the correct content. This behaviour is observed using screen recording. This study showed that 94% of participants clicked on the National Health Service (NHS) website during two experiments to find online health information. In two experiments their decision to click on the NHS website for the same tasks was not influenced by search design, their level of education, age, and other environmental changes. However, during two experiments their intention to search healthcare-related issues only from official and authentic websites remained intact.

5   Conclusion

In recent years, more and more searches have been made to find information relevant to health. The online search for health information is free and open to everyone at any time. There is a lack of study on identifying the impact of affective design on online health information search behaviour. Affective design is a widely discussed and researched area that integrates human emotions and feelings with the systems and design, which has been applied in HCI to make designs more user-centric. In this paper, we proposed a search system design based on affective design concepts. Furthermore, we explored and identified the impact of affective search system design on online health information search behaviours, such as online interaction, search query formulation, and result selection. Our experimental results show that the users preferred to find health-related information online before going to their GP. The eye-tracking data analysis results show that affective design has a positive impact on the user's information search behaviour in terms of online interaction and search query formulation. Positive impacts were observed such as the greater time spent, number of clicks, number of visits, revisits, time to first fixation, and ratios. Nonetheless, design,

environment, age, and experience did not influence the selection of the results. We believe that positive psychology design features can be used as stimulus in search interface design to develop positive technology for health information search. In an effort to achieve this, we plan to work on the exploration of the impact of the affective design further, based on more data tracked by different sensors, so that we will understand better the users' preferences. In the end, we hope that the positive technology we develop will not only improve the users' search experience but also their emotions/well-being during their information search process.

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