
Shall we care about the user's feelings? Influence of Affect and Engagement on Visual Attention.

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Abstract

The present paper aims at describing the concept of how the interaction with computer devices may benefit from joint input of users emotional state and his/her eye movements characteristics. We claim that emotions regulate visual attention, changing its formal characteristics and thus in turn influence the user's behaviour. We hypothesised that during interaction with an interface, positive mood will enhance exploratory eye movements. Participants of the study completed positive or neutral mood induction procedure followed by free viewing of classical paintings on computer screen. During the whole experimental procedure, the users' eye movements as well as their brain activity were recorded. Results confirm that positive mood changes the dynamics of visual attention. When completing a computer task, people's eye movements indicate shift from ambient toward more focal attention mode. However, positive mood slows down that process, fostering visual exploration of the presented stimuli. Obtained results are discussed in the context of self-adaptive user interfaces idea suggesting that the information about the users' emotional state together with visual attention characteristics and gaze information could be used as an input channel in order to create better user experience.

Author Keywords

visual attention, affect, engagement, eye-tracking, adaptive interfaces

ACM Classification Keywords

H.5.2 [Information interfaces and presentation]: User Interfaces input devices and strategies..

General Terms

Human factors, Theory

Introduction

During interaction with computers users are flooded with tons of visual information. Some of them are more salient and some are just unnecessary interruptions. The later often induce confusion and lower user's satisfaction and productivity, e.g. [5]. Modern trends in designing user interface try to address this issue, however there is still room for innovation.

A promising direction derives from the concepts of gaze-contingent interfaces and affective computing. Those try to employ user's visual attention and affective processes as an input sources for adaptive interfaces. Most of these efforts aim at explicit use of the gaze as an alternative input source in the process of interaction with computers, e.g. eye typing systems [10], gaze tracking games, painting applications, etc. However, eye movements characteristics offer much more information about the user than just what he/she is spotting at. That implicates the need for addressing basic questions about the relation between users' individual state, i.e. emotions, visual attention and behaviour in human-computer interaction, e.g. [8] both in conceptual work as well empirical research. The present paper rises the fundamental issue of relation between emotions,

momentary engagement in the task and visual attention characteristics during human computer interaction (HCI).

The idea of bringing emotions of the user as an input for computer devices is not new, e.g. [4]. The notion important for understanding this relation is the information reduction. Emotions select the information that comes to peoples perceptual system and thus limit the options among which attention will choose. Consequently, one may say that affect directs attention toward some information and suppress those which are incongruent with current emotional state, e.g. [6]. Moreover, positive affect broadens visual field resulting in better recognition of stimuli presented in peripheral regions [19]. In the context of HCI *Broaden and Build* theory [3] claims that positive emotions enhance creative, flexible, efficient thinking, and work productivity [15].

The concept of ambient/focal attention may help to understand better relation between emotions and user's cognitive processes as well as behaviour. This concept describes two modes of visual attention during information acquisition: exploration and inspection. The ambient mode is aimed at visual field exploration (scanning the visual field). That leads to selection of a target narrow space for further, more detailed inspection [17, 7]. Research showed that at the beginning of an image inspection fixations are shorter and the following saccades tend to have higher amplitudes *ambient attention*, while after few seconds longer fixations are followed by smaller saccadic amplitudes *focal attention*, e.g. [16].

Referring to ambient/focal attention modes and *Broaden and Build* theory we hypothesise that during interaction with an interface, positive mood will promote exploratory eye movements (*ambient* mode) compared to neutral mood which will lead to more *focal* attention.



Figure 1: Example of Impressionism painting: *Le Moulin de la Galette* by Pierre-Auguste Renoir



Figure 2: Example of Bauhaus painting: *Das Unbild* by Kurt Schwitters

Additionally, we expect that the influence of affect on attention will be moderated by the momentary engagement in the task. We hypothesise that engagement will enhance the most optimal attentional mode for task completion overriding the effect of emotions.

Methodology

Participants.

Forty nine psychology students (31 male and 18 female, aged $M = 24.47$, $SD = 6.53$) took part in the experiment after signing the consent form. Six subjects were excluded from the analysis due to eye tracking system calibration problems resulting in low tracking ratio or due to procedural problems.

Procedure and stimuli

Before experimental procedure, the calibration of eye tracking device and fitting of EEG headset were executed. During the whole procedure eye movements and brain activity data were recorded. The whole procedure took approximately 20 minutes to complete.

The procedure consisted of two stages: mood induction and free viewing of art paintings on the computer screen. Mood induction followed the procedure proposed by Velten [18]. Participants were randomly assigned to one of the experimental conditions: positive mood or neutral mood. Participants in both condition were presented 20 positive or emotionally neutral sentences. Each sentence was presented for 12 seconds on the computer screen. The participants' task was to read all sentences and find for each of them relevant situations from their own life. During reading, classical music pieces, emotionally consistent with sentences, were played [12, 13].

The free viewing task consisted of presentation of pictures of six famous paintings (Impressionism and Bauhaus style)

in two series. After each series participants were doing puzzles with one of the pictures seen. The order of stimuli presentation was randomized. Each stimulus was presented for 30 seconds in full-screen mode. Examples of used pictures are presented in the Figures 1 and 2.

Apparatus.

All stimuli were presented on a computer monitor (1680 × 1050 resolution; 22-inch LCD, 60 Hz refresh rate) running with standard PC computer. Eye movements were recorded at 120 Hz with an SMI eye tracking system. SMIs Experiment Center software was used to present stimuli and to synchronize with recorded eye movements. SMIs BeGaze software was used for fixations and saccades detection with a velocity based algorithm. The peak velocity threshold was set to 40 deg / sec, the minimum saccade duration was set to 22 ms., and the minimum fixation duration was set to 50 ms. During the experiment, brain activity of the participants was also recorded, using Emotiv EPOC headset.

Experimental design. Dependent and independent variables

The experimental design was mixed factorial. The main independent variable was constituted by experimental condition (positive vs. neutral mood). The main within-subjects factor was the time of stimuli (30 sec) divided into 6 equal portions each 5 second. One of the newest approaches is to infer about the user's engagement from the brain activity from EEG signal [2, 1] Engagement in the free viewing task, recorded by Emotive EPOC EEG was treated as continuous independent variable. Ambient-focal attention coefficient reflecting the relation between current fixation duration and next saccade amplitude [7, 9] was the main dependent variable.

Results

The statistical analyses of collected data were conducted using *R* language [11]. Data analyses focus on two types of effects: the group differences in dynamics of ambient/focal attention, and moderating role of personal, momentary engagement on relation between eye-movement characteristics and emotional state. To test the hypotheses, mixed-design analysis of variance was conducted and multiple regression analyses were performed.

Emotions and visual attention mode

The first hypothesis posited that affect influences visual attention mode. We claimed that people in positive mood exhibit more exploratory eye movements (ambient mode of visual attention) compared to users in neutral emotional state. To test this hypothesis a mixed-design analysis of variance was conducted. Experimental condition (positive vs. neutral mood group) was treated as the between-subjects fix factor and time spent with the picture was treated as a within-subject independent variable. The whole time of picture presentation ($t = 30s.$) was collapsed into 6 groups each 5 second length. The dependent variable in this analysis was a focal/ambient attention coefficient.

Consistently with the hypothesis the analysis revealed statistical significant effect of interaction between time and experimental condition, $F(5, 205) = 2.83, p < 0.02, \eta_p^2 = 0.049$ (see Figure 3).

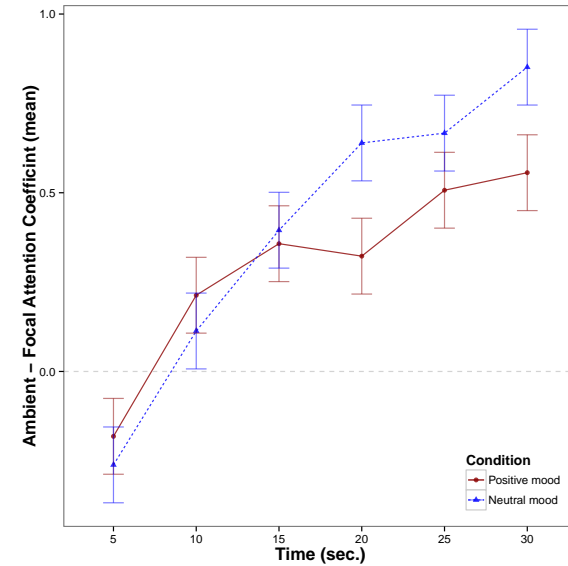


Figure 3: The interaction effect of task duration and mood on focal-ambient attention coefficient.

The *post hoc* comparisons between means in both conditions run separately for each period of time showed that significant difference occurred for the 4th period, $t(36.22) = 3.05, p < 0.01$, meaning that participants in positive mood condition exhibited less focal eye movements ($M = 0.32, SD = 0.28$) than those in neutral mood condition ($M = 0.64, SD = 0.40$). For the 6th period the difference reached statistical tendency level, $t(36.22) = 1.86, p = 0.071$, again positive condition participants were lower on focal-ambient coefficient ($M = 0.55, SD = 0.38$) than neutral mood group ($M = 0.85, SD = 0.64$). The rest of pairwise comparisons were not significant. To understand the interaction term better, we conducted simple main effects

analysis separately for positive and neutral experimental condition. For positive experimental condition the analysis revealed statistically significant effect, $F(5, 95) = 19.88, p < 0.001, \eta_p^2 = 0.387$. For neutral mood condition the simple main effect was also statistically significant, $F(5, 110) = 22.94, p < 0.001, \eta_p^2 = 0.462$. The comparison of both effects partial η^2 coefficients shows that the effect for neutral condition is stronger, which suggests that the shift from ambient to focal attention mode for participants in this condition is more pronounced.

The analysis also showed significant main effect of time, $F(5, 205) = 31.49, p < 0.001, \eta_p^2 = 0.366$ (see Figure 4).

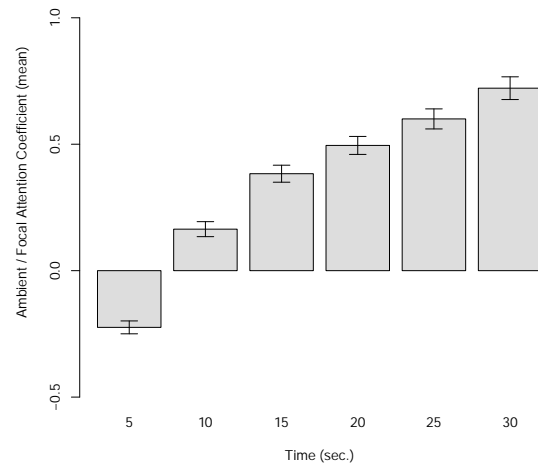


Figure 4: The main effect of task duration on focal–ambient attention coefficient.

Post hoc analyses indicated that the mean ambient/focal attention coefficient significantly increases with time stabilizing at the last 10 seconds. See table 1 for detailed descriptive statistics in each time period and significance of differences indicators.

Period	Time	<i>M</i>	<i>SD</i>	<i>p</i> < 0.01
1	5 sec.	-0.22	0.24	2,3,4,5,6
2	10 sec.	0.15	0.28	1,3,4,5,6
3	15 sec.	0.37	0.30	1,2,5,6
4	20 sec.	0.49	0.37	1,2,6
5	25 sec.	0.59	0.43	1,2,3
6	30 sec.	0.71	0.55	1,2,3,4

Table 1: Descriptive statistics and differences significance for each time period on focal–ambient attention coefficient.

The main effect of experimental condition reached only statistical tendency level, $F(1, 41) = 3.45, p = 0.7, \eta_p^2 = 0.02$. However, the pattern of means difference was consistent with the hypothesis. Participants in the positive mood condition exhibited slightly more ambient eye movements ($M = 0.29, SD = 0.19$) than participants in neutral mood ($M = 0.40, SD = 0.17$).

To sum up obtained effects, users in positive mood exhibit slightly less focal attention during exploring complex stimuli presented on the computer screen compared to neutral mood situation. More interestingly, the general phenomenon of attentional mode shift from ambient towards focal with the time course of the task is quantified by users emotional state. All participants' eye movement patterns indicated that their attention shifts

from ambient, in the first 5-second period, toward more focal mode, however, from the midpoint of task duration, people in positive mood exhibit slightly more exploratory eye movements than those in neutral mood condition.

The moderating role of engagement for relation between emotions and visual attention mode

We claimed that the momentary changes in the user's engagement into the task will moderate the relation between his/her emotional state and characteristics of eye movements. To test the hypothesis, we ran a multiple regression analysis with ambient-focal attention coefficient as the dependent variable and two predictors: experimental condition and momentary user's engagement, including the interaction term between both predictors. The analysis revealed that the tested model is statistically significant,

$F(3, 7583) = 8.56, p < 0.001, adjustedR^2 = 0.002$. The engagement alone influences the ambient-focal coefficient, $b = -0.59, t(7583) = 3.37, p < 0.001$, meaning that the stronger momentary engagement in the task the less focal eye movements are made. Also the effect of experimental condition was significant, $b = -0.71, t(7583) = 4.12, p < 0.001$, confirming previous analysis that people in positive mood achieved lower focal attention's scores. More interestingly, we obtained a significant interaction term of experimental condition and momentary engagement, $b = 1.02, t(7583) = 3.64, p < 0.001$ (see Figure 5).

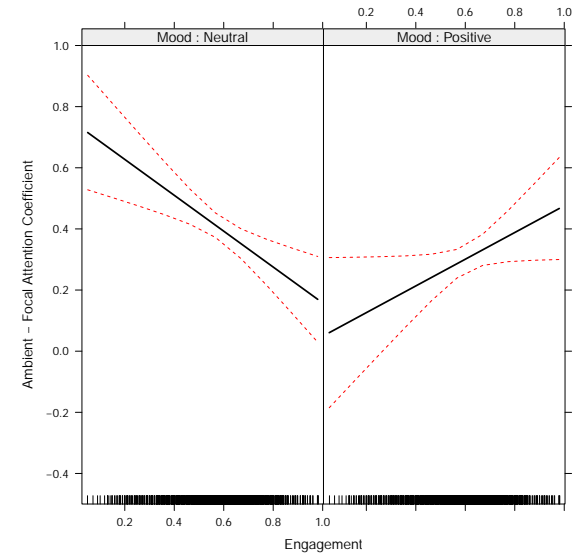


Figure 5: The interaction effect of mood and momentary engagement on focal-ambient attention coefficient.

The interaction term shows that the mood influences characteristics of visual attention when users are not engaged. While the engagement scores increases people in positive mood become more focal and those in neutral mood condition become more and more ambient.

Discussion and conclusions

Obtained study results confirm the hypotheses. Mood influences the attention mode during human computer interaction and this effect is moderated by the engagement in the task.

Transition from focal and ambient attention observed during the course of perception of the image is consistent

with the expectations. At the beginning of the examination of the painting, users glance over its whole surface. As they watch it further, they probably encounter elements that capture their attention and start to watch them more carefully. This increase in focality of attention is observed both for users in positive and neutral mood. But when we examine the time-course of the above mentioned transition between focal-ambient attention mode for users in different mood, we see that those in positive mood glance over the picture for longer and concentrate less on details towards the end of the viewing time, compared to those in neutral mood. It confirms the impact of mood on the attention characteristics. This effect is in accordance with the results from the papers showing that positive emotions increase the breadth of visual attention, e.g. [14]. What is interesting, the influence of emotions mentioned above is moderated by the users' engagement. If the users are engaged in the task, the emotions do not change the parameters of attention. This suggests that momentary engagement overrides the effect of mood on ambient/focal attention presumably forcing the users' attention to the optimal mode.

In the presented study we used a task of free viewing of art paintings. To further investigate the observed effects, it is necessary to conduct studies using different types of stimuli and tasks, similar to the ones encountered during real life human computer interaction, like web-browsing or text editing. Then, the next step would be to use the data about the users' emotional state and engagement as a continuous input for the adaptive interface systems. Such input would allow the interface to change compatibly with current attention mode (focal/ambient). Thanks to gaze information it would be possible to establish the currently seen area on the screen and change the parameters of the

surrounding interface according to the attention mode. For example, knowing the fixation point on the screen it would be possible to highlight or enlarge the focused area and make the rest of the screen less obtrusive, e.g. by dimming or disabling notifications.

Multimodal adaptive interfaces have the potential to change the way of interaction with the technology but still require both an extensive theoretical investigation and well-designed empirical research.

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