In the mood for change:
The influence of mood on change blindness


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ABSTRACT

Previous research addressed the role of human cognition in change blindness, but not yet the influence of mood on change blindness. The levels-of-focus hypothesis and attentional flexibility research support the hypothesis that a positive mood enhances detection of peripheral changes in a change blindness task. The conducted study revealed increased performance on peripheral changes for participants in a positive mood. Although the hypothesis that a positive mood leads to a broader *visual* attention focus or higher *visual* attentional flexibility was not supported, the results suggest that people in a positive mood rely more on the process of visual sensing.

Keywords

change blindness, mood, visual attention, visual sensing

INTRODUCTION

It is essential that significant changes in the environment are being noticed by observers. Unfortunately, human beings are not perfect in detecting such changes. The inability to notice important changes in the environment, when there is a brief interruption between two consecutive visual images, is called *change blindness* (e.g., Simons & Ambinder, 2005a). The interruption could be an eye blink, or for example mud splashes disturbing the view for a split second. Change blindness is not just an artifact of the visual system; it is also found for tactile perception and auditory perception (e.g., Gallace, Tan, & Spence, 2006).

A large amount of previous research on the inability to detect changes under certain circumstances has focused on visual mechanisms, investigating the underlying perceptual mechanisms of this phenomenon (e.g., Rensink, O'Regan, & Clark, 1997;

Rensink, 2002). We build on this research and focus on how *human factors* influence the (in)ability to detect changes. Often, large amounts of information presented on displays have to be processed (for example by flight controllers) in order to make a correct decision. In this context, it is of high importance that changes are detected timely and correctly. In the present study, a human factor that is notorious for influencing behaviour in everyday situations, namely mood, is being investigated in a study on change blindness.

Mood and change blindness

A person's mood is an affective state, which is diffuse, not linked to specific stimuli and which is relatively long lasting (e.g., Frijda, 1986; Russell, 2003). Schwarz (2002) states that mood, being a diffuse affect, serves as a source of information about the state of the environment. A negative mood lets the person in question believe that the situation or environment is problematic. A positive mood lets someone believe that the situation is benign. Therefore, mood can determine the cognitive processing style that is being used in a particular situation. People in a negative mood are more precise, judge more carefully and deliberately, and perform better at analytical reasoning tasks. People in a positive mood, on the other hand, engage in an intuitive, heuristic, top-down processing style (Schwarz, 2002). Additionally, a person's mood can guide what type of information is noticed: people in a negative mood are more likely to focus on local information whereas people in a positive mood are more likely to focus on global information. This difference in focus in different mood states is called the levels-of-focus hypothesis (Clore, Wyer, Dienes, Gasper, Gohm, & Isbell, 2001, see also Gasper & Clore, 2002).

Although the influence of mood on change blindness has not yet been addressed in previous research, some studies have been conducted that investigated the role of human cognition in the context of change blindness. (e.g., Llamas & Koole, 2003; Werner & Thies, 2000). Also relevant in the context of change blindness is Rensink's (2004) suggestion of the existence of an underlying intuitive process, referred to as visual sensing. According to Rensink, people might have the ability to 'feel' (or sense) the presence of a change even though they lack the conscious visual experience of that change. Rensink argues that sensing is not simply a precursor or weakened form of seeing; he stresses that sensing and seeing do not correspond to different thresholds for detecting changes, but are based on different processes.

Yet other studies addressed cognitive processing style and visual attention (e.g., Smilek, Enns, Eastwood, & Merikle, 2006; Rowe, Hirsch, & Anderson, 2006). However, these studies did not specifically address change blindness.

Gasper et al.'s (2002) findings that people in a negative mood focus on local information whereas people in a positive mood focus on global information, support the idea that the level of focus also depends on a person's mood when perceiving the *environment*. The levels-of-focus hypothesis can also be considered in line with Friedman and Förster's (2005) theory of attentional flexibility. According to this theory, a person in a positive mood is better able to shift attention than someone in a negative mood. This enhanced attentional flexibility in people with a positive mood could very likely result in a global focus of attention, enabling the person to shift attention across a broader area. When attentional flexibility is impaired, someone is less able to shift attention and is therefore very likely to have a narrow focus of attention. The levels-of-focus hypothesis and the attentional flexibility hypothesis support the idea that mood influences visual perception. In this study, it is investigated whether people in a positive mood are better at shifting their *visual* attention and/or have a broader *visual* focus of attention than people in a negative mood, with respect to change blindness.

The present study

In change blindness, attention is crucial (e.g., Rensink et al., 1997; Simons & Rensink, 2005b). When someone pays attention to the changing area, one is likely to see the change. A method to counteract change blindness is the priming of the changing area (e.g., Tse, Sheinberg, & Logothesis, 2003). Changes that appear in a primed location (i.e., central or congruent changes) will be detected more easily. However, when a change does not appear in the primed location but in the periphery (i.e., peripheral or incongruent changes), attention needs to be shifted. An eye tracker is a suitable measuring apparatus to gain more insight in the process of visual attention during a change blindness task.[1] First of all, an eye tracker gives reliable information about whether participants indeed direct their gaze at the prime. Secondly, results from the eye track data could indicate whether people have a broader focus in a positive mood. Finally, attentional flexibility can be measured by investigating saccades[2]. It is expected that people in a positive mood are more likely to shift their attention away from the prime and scan the picture in search for a change, resulting in more saccades. In addition, visual sensing will be investigated in the present study by the use of participants' confidence levels about their performance on the change blindness task.

To recapitulate, it is hypothesized that people in a positive mood are better at detecting peripheral changes compared to people in a negative mood, and that this performance corresponds with a broader attention focus and more saccades for people in a positive mood[3].

METHODS

Participants and design

Participants were 54 Dutch-speaking students from the Radboud University Nijmegen, Netherlands, 18 male and 36 female. Their age ranged from 18 to 27 years (M = 21.42, SD = 2.32). They received either 6 Euros or course credits. The study was set up as a two (positive vs. negative mood) by two (central vs. peripheral changes) design. Participants were randomly assigned to one of the two mood conditions.

Procedure and materials

The stimuli from the change blindness task were displayed at a resolution of 1024 x 768 pixels. The display monitor refresh rate was set at 100 Hz. Eye movements were monitored using an Iviewx eye tracker (Sensomotoric Instruments, Berlin, Germany). The eye tracker was calibrated to the projection screen through the use of a regularly spaced 12-point grid. Eye position was sampled at a rate of 500 Hz. Button presses were collected using a keyboard. The computer controlled the experiment by a program written in Delphi (version 7.0.1., Borland Software Cooperation, Cupertino).

Participants were placed behind the eye tracker. All instructions and stimuli were presented in Dutch. Participants were told the study was about visual perception. Participants were asked to take place on an in height adjustable chair behind the eye tracker and were given the opportunity to sit comfortable and at the same time move as little as possible. The eye tracker was adjusted so that recording could start.

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[1] In the present study it is assumed that the point of regard corresponds reliably with the focus of attention (e.g., Kowler, Anderson, Dosher, & Blaser, 1995; Deubel & Schneider, 1996).

[2] Saccades are quick and simultaneous movements of both eyes in a certain direction and serve as a mechanism for fixation (Cassin & Solomon, 1990).

[3] See Rondeel (2007) for a full report on the conducted study.

The mood manipulation consisted of a sad or a happy video fragment of about 6 minutes: for the negative mood manipulation a scene from Sophie's Choice, and for the positive mood manipulation a scene from Jungle Book (e.g., Beukeboom & Semin, 2005). At the end of the experiment, participants were given five true-false statements about the video fragment to enhance cover story credibility.

The change blindness task in the present study consisted of abstract pictures in which a change was created using Inkscape (version 0.45, Free Software Foundation, Inc., Boston). See Figure 1.

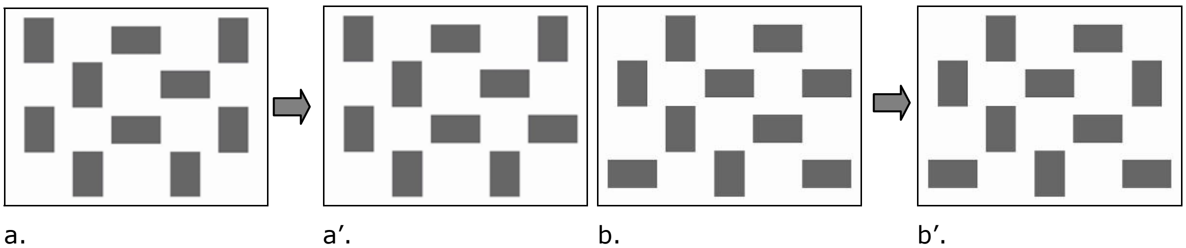

Figure 1. Two random examples of pictures in the change blindness task, consisting of ten grey rectangles (a, b). In the changed picture the direction of one of the rectangles was changed (a′, b′). In the sequence a → a′ the direction of the eighth rectangle changed from vertical to horizontal; in the sequence b → b′ the direction of the fifth rectangle changed from vertical to horizontal.

For the change blindness task in the present study, a forced choice detection paradigm was used. An original image and a modified image were displayed consecutively, with a grey blank field placed between the two images. The original image was shown for 1000 ms, then the grey blank field was shown for 100 ms and consecutively the modified image was shown for up to 4000 ms, see Figure 2.

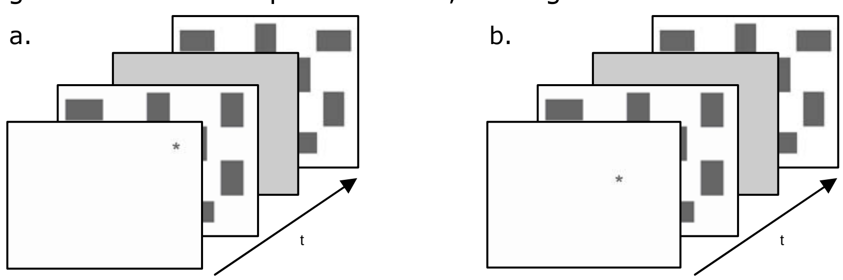

Figure 2. a. Central changes occur at the same location as the prime (the star on the first screen). b. Peripheral changes occur at a different location than the prime.

Participants were instructed to press the spacebar as soon as they detected a change. The second image disappeared as soon as the participants responded. If the participants did not detect a change, the second image stayed on screen for 4000 ms after which it disappeared and the next trial started. Furthermore, half of the changes were central changes and half of the changes were peripheral changes. The testing phase consisted of 60 trials. Participants were told that the change could occur at any random location on the screen. The pictures were viewed on a 20 inch monitor and viewing distance was approximately 50 cm. A prime was given before the start of each trial so that the participant's starting point of regard was controlled. Before the mood manipulation was administered, participants were given three practice trials. The testing phase was administered immediately after the mood manipulation. After the testing phase, participants were asked some additional questions, for example how difficult they found performing the task.

Since the aim of the study was to investigate whether mood had a different effect on participants' responses on central versus peripheral change trials, the 'type' of change had to be varied. The location of the prime was varied to draw attention to the prime in every single trial. Central changes were changes that occurred at the same location as the prime, see Figure 2a, while peripheral changes occurred at a different location than the prime, see Figure 2b. The distance of the changing rectangle to the prime was kept constant for all peripheral change trials.

After each trial, participants were asked to indicate how certain they were that they did or did not see a change on a 7-point Likert scale. Confidence levels about answers should give more insight in participants' reliance on intuition or visual sensing.

Participants were thanked and debriefed by email a few weeks later.

RESULTS

Preliminary analyses

Eight participants were eliminated from analyses, due to prior experience with the change blindness task, not adhering to the instructions properly or technical problems during the experiment. Because differences between central and peripheral change trials become diffuse for participants who do not direct their attention to the prime, percentages were calculated which presented how often participants directed their attention to the prime. To retain as many participants as possible in further analyses, while correcting as much as possible for participants who did not look at the prime, a cut-off point of 60% was chosen as the percentage of looking at the prime of the total amount of trials in the experiment. Participants who did not direct their attention to the prime in more than 60% of the trials were excluded from analyses (N = 5)[4], as well as participants for whom calibration did not succeed (N = 4). Analyses were run for 37 participants.

An effect was found of reported difficulty of doing the task on performance on the central change trials. The more difficult participants found the task, the worse their performance, $F(1,36) = 2.417$, $p = .050$, $\eta^2 = .326$. No significant effect of mood condition on reaction time was found for any of the changes, $F(1,31) = .928$, *ns*.

Mood and type of change

Hit rates for the central and peripheral changes and false alarm rates were calculated for each participant (see also Barton, Deepak, & Malik, 2003). A 2 (positive vs. negative mood) by 2 (central vs. peripheral changes) analysis of variance was conducted on the hit rates. No main effect of mood on performance on the change blindness task was found, $F(1,35) = .928$, *ns*. A significant interaction effect was found between mood and type of change, $F(1,36) = 4.643$, $p = .038$, $\eta^2 = .117$, see Figure 3. As expected, participants in the positive mood condition performed significantly better on the peripheral change trials than participants in the negative mood condition ($F(1,36) = 4.226$, $p = .046$, $\eta^2 = .109$). There was no difference in performance between participants in the negative and positive mood condition on the central change trials, $F(1,36) = .280$, *ns*.

Because the detection of the central and peripheral changes is based on a sensory process as well as a decision process, signal detection analysis was used to gain more insight in the process of change detection (see for example Stanislaw & Todorov, 1999). In the present study, delta (d') for sensitivity and beta (β) for bias to respond were calculated for each variable by using Banaji and Greenwald's method (1995). There were no significant differences for β (bias to respond) between the two conditions, $F(1,35) = .196$, *ns*. For d' (sensitivity), a significant interaction effect was found between mood and change, $F(1,35) = 4.442$, $p = .042$, $\eta^2 = .113$. Participants

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[4] Preliminary analyses showed no difference in percentage of looking at the prime between participants in the positive mood condition and participants in the negative mood condition.

in the positive mood condition had a marginal greater d' for peripheral change trials, $F(1,36) = 2.884$, $p = .092$, $\eta^2 = .079$, whereas there was no difference in d' for the central change trials between participants in the negative and positive mood condition, $F(1,36) = .458$, *ns.* See Figure 3.

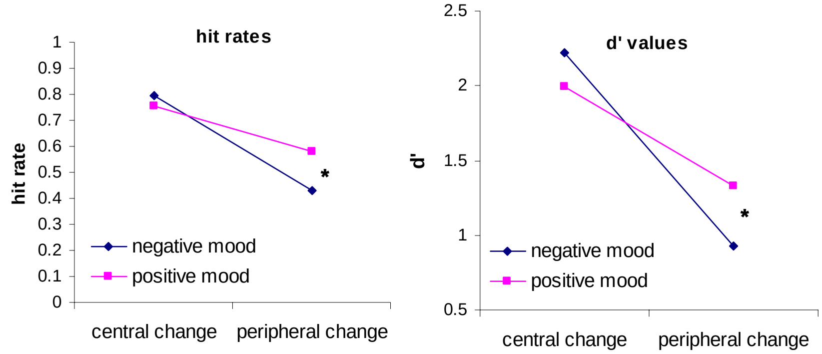

Figure 3. Left: Hit rates on the central and peripheral change trials for participants in the negative and positive mood condition. * indicates $p < 0.05$. Right: d' values for the central and peripheral change trials for participants in the negative and positive mood condition. * indicates $p = .092$. A d' value of 1 indicates sensitivity towards the stimulus of approximately 70 % (Greenwald, Nosek, & Sriram, 2006).

Confidence levels

To investigate confidence levels, a 2 (positive vs. negative mood) by 3 (central vs. peripheral vs. no changes) by 2 (response vs. no response) analysis of variance was conducted on participants' confidence levels with the last two factors as within subjects variables. No main effect of mood was found on confidence levels, $F(1,23) = 1.426$, *ns*. Results did yield a main effect of response on confidence levels, $F(1,23) = 66.751$, $p < .001$, $\eta^2 = .744$. The graph in Figure 4 shows that this is primarily due to a difference in confidence levels between responses and no responses to the central and peripheral change trials. Participants were more confident about their answer when they indicated they had detected a change (i.e., hits) compared to when they indicated not to have detected a change (i.e., misses). An interaction effect between type of change and response was found, $F(2,22) = 18.136$, $p < .001$, $\eta^2 = .622$.

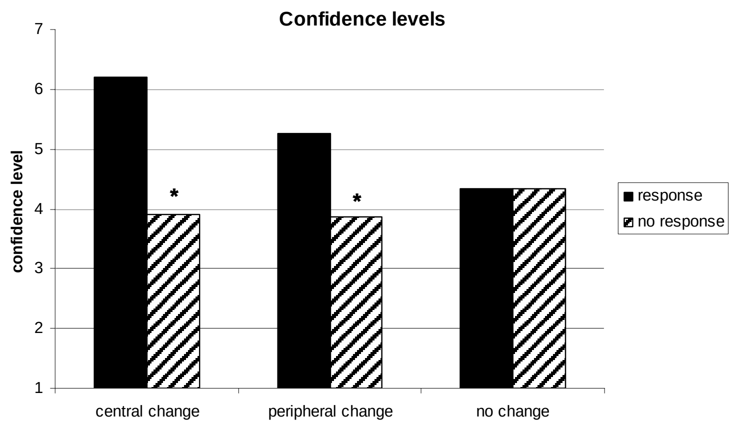

Figure 4. Observed means of confidence levels for responses to central change, peripheral change and no change trials and non responses for central change, peripheral change and no change trials. * indicates $p < .001$.

Participants were more certain about their answer when they pressed spacebar in the change trials (both central hits and peripheral hits) compared to the no change trials (i.e., false alarms), see Figure 4. This interaction effect indicates that participants are less certain that a change was absent in the peripheral and central change trials to which they had not responded (i.e., central and peripheral misses), compared to the no change trials to which they had not responded (i.e., correct rejections). This difference was slightly stronger between peripheral change trials (i.e., peripheral misses) and no change trials (i.e., correct rejections), $t(36) = -3.371$, $p = .002$, than between central change trials (i.e., central misses) and no change trials (i.e., correct rejections), $t(28) = -2.561$, $p = .016$. More in depth analyses show that differences in confidence levels between change and no change trials were present for both mood conditions[5].

Eye track results

To test the hypothesis that people in a positive mood have a broader visual attention focus compared to people in a negative mood, the distance to the change at 350 ms. before participants pressed spacebar was calculated[6]. Distances were calculated from participants' point of regard to the centre of the change. A time delay of 350 ms. was chosen because onset between initiation of a motor action and the movement itself is believed to take about 350 ms (Libet, Gleason, Wright, & Pearl, 1983). No difference was found in distance from point of regard to the change between the two mood conditions, $F(1,41) = .339$, *ns*.

To test the hypothesis that people in a positive mood make more saccades compared to people in a negative mood, as a result of higher attentional flexibility, the number of saccades was calculated using the software program BeGaze (Sensomotoric Instruments, Berlin, Germany). After correction for reaction times and performance on the change blindness task, no significant difference between the two mood conditions was found, $F(1,34) = .540$, *ns*.

DISCUSSION

The aim of the present research was to investigate the influence of mood on change blindness. In particular, people in a positive mood were expected to perform better on peripheral change trials as a consequence of attentional flexibility or a broadened visual attention focus.

As expected, participants in the positive mood condition performed better on the peripheral change trials compared to participants in the negative mood condition. This effect was less robust, but still marginally significant, when false alarms were taken into account. It is noteworthy that people in a positive mood did not have a higher bias to respond compared to people in a negative mood.

The obtained results support the presence of visual sensing in the conducted experiments. Participants in the positive mood condition were less certain that they did not see a change when indeed there was a peripheral change. Participants in the negative mood condition were also less certain that a change was absent in the peripheral change trials compared to the no change trials, indicating that visual sensing might also be present in people in a negative mood. Important to note is that participants were more certain that a change was indeed absent in the no change trials than in the peripheral change trials, indicating that the differences in confidence levels do not merely reflect a response strategy, but are evidence for the process of visual sensing. One explanation for the fact that people in a positive mood perform better on

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[5] A complete description of these analyses and statistics can be found in Rondeel (2007).

[6] Eye track data for the 37 participants who were included in the previous analyses plus the eye track data for participants who did not direct their attention to the prime on more than 60% of the total amount of trials (because the type of change is not of relevance here) was analyzed. In total, the eye track data from 42 participants was analyzed.

the change blindness task, despite the presence of visual sensing in both mood conditions, might be that people in a positive mood rely more on this visual sensing than people in a negative mood. The fact that no difference was found for distances to the change between the two mood conditions and the fact that participants in the positive and the negative mood condition made approximately the same amount of saccades also support the idea of visual sensing. That is, people in a positive mood do not perform better because they make more eye movements (representing a high visual attentional flexibility) or because they have a broader visual focus. More plausible is that people in a positive mood rely more on their intuition and on heuristics (see also De Vries, Holland, & Witteman, 2008), i.e., they rely more on the process of visual sensing, leading to the detection of a change. The finding that people in a positive mood rely more on implicit processes is also consistent with research from Hermsen, Holland and Van Knippenberg (2006), who found that the relation between behaviour and implicit attitudes is strong in a positive mood, whereas this relation is weak in a negative mood.

Although the findings from the present study do not seem to be in line with an increased visual attentional breadth or an increased visual attentional flexibility for people in a positive mood, they do correspond with related research on visual attention. The findings from the present study are in line with the idea that people in a positive mood have a more relaxed processing style or are in a so-called distracted state, thereby letting the stimuli ‘pop into their minds’, leading to a better ability to detect a change (Smilek et al., 2006). A more passive processing style for people in a positive mood is also in line with research from Olivers and Nieuwenhuis (2005) and from Rowe et al. (2006), who all found that when participants are distracted from their task (e.g., by music), their performance increased on certain attentional tasks.

Furthermore, the obtained results are in line with a more neuropsychological view on mood and cognition, namely with the dopamine hypothesis. Ashby, Isen and Turken (1999) suggest that the influence of positive affect on cognitive processes may be mediated by the neurotransmitter dopamine. Furthermore, and of specific relevance for the results from the present study, the dopamine hypothesis does not predict an influence of mood on change blindness, because the visual areas of the brain are not rich in dopamine receptors (Ashby et al., 1999).

Limitations, future directions and implications

Although support for visual sensing was found in the present study, it still needs to be investigated whether the process of detecting a change is indeed implicit. Of interest is to study performance on a detection task in which explicit perception is impossible. Another point of interest is whether the results found in the present study can be generalized to moving images or natural situations in the real world. It is of additional value to repeat the experiment with other groups of participants than used in the present study (i.e., students), for example people that work with radar screens.

If performance under normal circumstances is already impaired, consequences of decreased performance in crisis situations must be questioned seriously. In this context stress is worth investigating, as stress is often accompanied by a higher level of arousal. If the level of arousal increases, attention is further restricted and cues that might be relevant to a certain task could be neglected. An important question is whether this narrowing of attention, as a consequence of an increased arousal level also applies to visual processing.

The results from the present study give reason to assume that human operators working with information presentation on computer screens are less likely to detect a change if their view is disrupted for a split second when they are in a negative mood, especially in the case when the change occurs at another location than the original point of regard. To counteract change blindness, manipulating a person’s mood could be effective. In addition, human operators can be instructed to adopt counter strategies, for example passively looking for information on a screen. A software agent can be envisioned supporting time-constrained decision making processes, where the agent is capable of monitoring an operator's mood state and is able to give feedback, or even manipulate the operator's mood. This implies that future research should aim at not only attentional-based but also affective-based heuristics for computational models that can be created to assist human operators to (better) detect changes on a computer screen.

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