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Positive affect increases cognitive control in the antisaccade task

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ABSTRACT

To delineate the modulatory effects of induced positive affect on cognitive control, the current study investigated whether positive affect increases the ability to suppress a reflexive saccade in the antisaccade task. Results of the antisaccade task showed that participants made fewer erroneous prosaccades in the condition in which a positive mood was induced compared to the neutral condition (i.e. in which no emotional mood was induced). This improvement of oculomotor inhibition was restricted to saccades with an express latency. These results are in line with the idea that enhanced performance in the positive affect condition could be caused by increased dopaminergic neurotransmission the brain.

1. Introduction

The question whether one's current emotional state influences one's cognitive abilities has been investigated in various domains. Positive mood has been shown to modulate cognitive functions, although the exact influence has been shown to vary between different functions: positive affect has been found to either impair or improve performance depending on the specific task. On the one hand, induced positive affect improves verbal fluency (Philips, Bull, Adams, & Fraser, 2002) and reduces interference between competing response alternatives in a Stroop-task (Kuhl & Kazén, 1999). On the other hand, positive affect has been shown to increase response interference due to increased distractibility (Rowe, Hirsh, & Andersen, 2007) and to impair performance on certain executive function tests (Oaksford, Morris, Grainger, & Williams, 1996). A series of studies by Dreisbach and colleagues revealed that positive affect results in flexibility benefits, but also in maintenance costs (distractibility) (Dreisbach, 2006; Dreisbach & Goschke, 2004; Dreisbach et al., 2005).

The exact effect of positive affect on cognitive control is therefore still unclear. To further delineate the modulatory effects of induced positive affect on cognitive control, we used a task that allowed us to study a specific aspect of cognitive control: the inhibition of reflexive eye movements ('oculomotor inhibition'). During the so-called antisaccade task, participants either make a saccadic eye movement towards the appearing stimulus after stimulus onset (i.e. prosaccade trials) or a saccade in the opposite direction as quickly as possible (i.e. antisaccade trials). Correct performance in the antisaccade task requires the inhibition of the automatic response to the stimulus onset. Results typically show that antisaccade trials have longer saccade latencies than prosaccade trials and that participants frequently make an erroneous saccade to the stimulus onset in antisaccade trials (Everling & Fischer, 1998; Hutton & Ettinger, 2006).

Neuropsychological research has revealed that correct performance in the antisaccade task is subserved by brain areas that are also known to be involved in cognitive control. For instance, imaging studies have identified various frontal areas that are active during the antisaccade task such as the frontal eye fields and dorsolateral prefrontal cortex (Everling & Munoz, 2000; Funahashi, Bruce, & Goldman-Rakic, 1993). Lesion studies have revealed that successful inhibition in the antisaccade task relies heavily on frontal circuits (Guitton, Buchtel, & Douglas, 1985; Pierrot-Deseilligny, Rivaud, Gaymard, & Agid, 1991; Pierrot-Deseilligny et al., 2003). Furthermore, the amount of erroneous eye movements is known to be increased when a working memory task is performed simultaneously (Mitchell, Macrea, & Gilchrist, 2002) and successful performance in the antisaccade task is linked to working memory capacity (Eenshuistra, Ridderinkhof, & van der Molen, 2004; Roberts, Hager, & Heron, 1994). Therefore, oculomotor inhibition in the antisaccade task is generally linked to prefrontal cognitive control.

In the current study, it was investigated whether induced positive affect increases the ability to suppress a reflexive saccade in the antisaccade task. Participants performed the antisaccade task twice: once after seeing a neutral movie and once after seeing a movie which is expected to induce positive affect. The amount of erroneous eye movements was compared between the two sessions. In this analysis, a distinction was made between erroneous eye movements with express (80–130 ms) and regular (>130 ms) latencies, because

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these errors have been argued to reflect different and distinct phenomena (Klein & Fischer, 2005). Whereas express errors seem to reflect reflex-like prosaccades to the stimulus onset, erroneous eye movements with a regular latency reflect errors in the intentional processes associated with the execution of a correct antisaccade (Klein, Rauh, & Biscaldi, 2010). For instance, although erroneous eye movements with a regular latency are correlated with ('higher') cognitive measures, like executive function and working memory, similar correlations are absent for express errors (Klein et al., 2010).

If induced positive affect increases cognitive control, as observed in the Stroop-task (Kuhl & Kazén, 1999), this should result in stronger oculomotor inhibition, reflected by a decreased number of erroneous eye movements on antisaccade trials. The analysis of express and regular latencies will provide insight in whether this possible improvement is related to an increased inhibition of reflex-like prosaccades or related to reduced errors in intentional processes, as measured by erroneous eye movement with a regular latency.

2. Method

2.1. Participants

Twelve students of the Utrecht University, aged between 18 and 25 years, served as paid volunteers. Six participants were male. All reported having normal or correct-to-normal vision. They were naive as to the purpose of the experiment. All participants gave their informed consent prior to their inclusion in the study.

2.2. Apparatus

An Intel Core2 computer controlled the timing of the events. The displays were presented on a LaCie 22″ monitor with a resolution of 1024 × 768 pixels. Eye movements were registered with the Desktop Mount EyeLink1000. The EyeLink1000 has a temporal resolution of 1000 Hz and a spatial resolution that is smaller than 0.5°. Although the system can compensate minimal head movements, the participant's head was stabilized using a chin rest. The distance between the monitor and the chin rest was 65 cm. Participants performed the experiment in a sound-attenuated and dimly lit room.

2.3. Stimuli, procedure and design

Participants performed two sessions: the positive affect condition and the neutral condition. The time between these two sessions was at least 24 h. The order of the sessions was counterbalanced between participants. The order of each session was the following: first questionnaire, calibration procedure, practice trials of eye movement task, movie fragment, second questionnaire, experimental trials eye of movement task. These elements will now discussed in detail.

2.3.1. First questionnaire

In the questionnaire participants indicated on a five-point scale whether they were refreshed vs. tired, calm vs. anxious, alert vs. unaware, amused vs. sober and positive vs. negative (Isen, Daubman, & Nowicki, 1987). Zero on this scale indicates the first extreme (i.e. 0 is positive, 5 is negative).

2.3.2. Calibration procedure

Each session started with a nine-point grid calibration procedure. Participants were required to saccade towards nine fixation points sequentially appearing at random in a 3 × 3 grid. In addition, simultaneously fixating the central fixation point and pressing the space bar recalibrated the system by zeroing the offset of the measuring device at the start of each trial.

2.3.3. Practice trials of eye movement task

See Fig. 1 for an example of the display sequence. Participants viewed a display containing a plus sign (0.70°) on a black background in the centre of the display, which was used as fixation point. The color of the plus sign indicated the type of trial: red indicated an antisaccade trials and green indicated a prosaccade trial. Half the trials were prosaccade trials and the other half were antisaccade trials. After 1000 ms the fixation point disappeared and 250 ms after the fixation point offset one circle (1.30° in diameter) appeared at a distance of 10° either to the right or left side. The circle appeared at the same *Y* coordinate as the fixation point. The target was presented for 1500 ms. Afterwards all objects were removed from the display. The practice of the eye movement task consisted of 40 trials.

Participants were instructed to fixate the central fixation point until target onset and to then move their eyes towards or away from the target location (depending on the task). It was stressed that one had to make a single accurate saccade toward the correct location. Participants heard a short tone when the saccade latency was higher than 600 ms or shorter than 80 ms. The sequence of trials was counterbalanced and randomized for each participant.

2.3.4. Movie fragment

The movie fragment in the neutral condition contained two crossroads in Amsterdam showing normal traffic. In the positive affect condition, participants could choose between different movie fragments: a fragment from a Disney movie ("The Little Mermaid" or "Lion King") or a sketch from a Dutch comedy program ("De Lama's"). In contrast to the movie fragment in the neutral condition, the fragment in the positive affect condition was hypothesized to induce positive affect.

2.3.5. Second questionnaire

Participants filled out the same questionnaire as discussed above.

2.3.6. Experimental trials of eye movement task

The eye movement task as outlined above consisted of 200 trials.

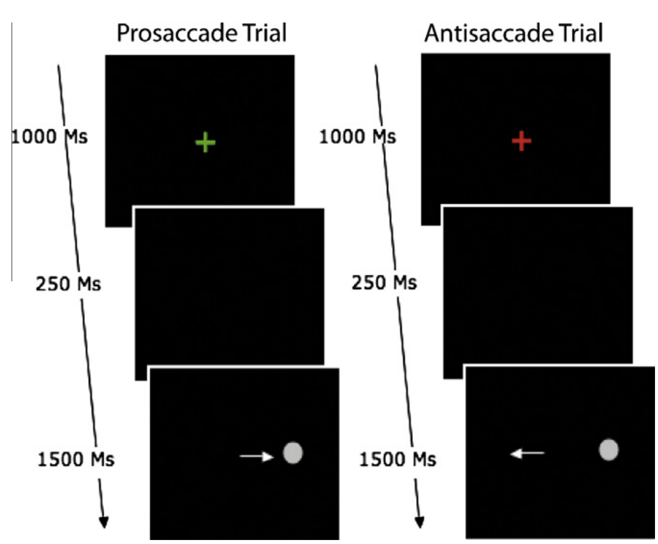

Fig. 1. Example of the display sequence for the antisaccade task. The arrow in the third panel of the antisaccade task depicts the direction of the required eye movement and was not present in the experiment.