



Influence of positive subliminal and supraliminal affective cues on goal pursuit in schizophrenia



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ABSTRACT

Goal pursuit is known to be impaired in schizophrenia, but nothing much is known in these patients about unconscious affective processes underlying goal pursuit. Evidence suggests that in healthy individuals positive subliminal cues are taken as a signal that goal pursuit is easy and therefore reduce the effort that is mobilized for goal attainment. Patients with schizophrenia and healthy controls were instructed that a long run of successive correct responses in a visual attention task would entitle them to a reward (the goal to attain). Affective pictures were displayed supraliminally or subliminally during each run and electrophysiological activity was recorded. Patients self-assessed the emotional content of the pictures correctly. However, differences between patients and controls emerged during the goal pursuit task. Healthy controls mobilized less effort for the positive than the neutral subliminal pictures, as suggested by increased error rates and the weaker contingent negative variation (CNV). For the patients, no influence of positive subliminal pictures was found on performance and on the CNV. Similarly the influence of positive pictures was absent or abnormal on components which are usually impaired in patients (fronto-central P2 and N2). In contrast, positive pictures influenced normally the parieto-occipital N2, related to a component of visual attention which has been proposed to be preserved in schizophrenia. The present study indicates the difficulties of patients to modulate effort mobilization during goal pursuit in the presence of positive subliminal cues. The results question the role of cognitive deficits on affective influences.

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1. Introduction

In schizophrenia motivation deficits are related to impeding symptoms such as avolition, a reduction in the ability to initiate and persist in goal-directed behaviour (Barch and Dowd, 2010). It is likely that this impairment affects a range of cognitive functions requiring a representation of goal information to guide behaviour (Lesh et al., 2010; Barch and Ceaser, 2012). Research into schizophrenia has mainly explored goal pursuit in relation to conscious mental faculties. However, research in healthy individuals has now established that subtle affective signals can modulate goal pursuit even though they do not reach awareness (Custers and Aarts, 2010). Given the clinical importance of goal-directed behaviour impairments in schizophrenia, we aimed at checking how patients are influenced by subliminal affective cues.

It has been shown that people's goal pursuit is influenced by subtle cues in the environment outside their awareness (Custers and Aarts, 2005, 2010; Capa et al., 2011a; 2011b). Positive subliminal cues are

thought to decrease the perceived difficulty of a task and consequently reduce effort mobilization (Niedenthal, 2008; Gendolla and Silvestrini, 2011; Silvestrini and Gendolla, 2011; Gendolla, 2012), which may result in decreased performance (Zemack-Rugar et al., 2007). Positive subliminal cues represent a sign that goal pursuit is easy and induce coasting. When people consciously perceive the pictures (supraliminal presentation), they attribute affect information to the picture displayed and not to their progress with goal pursuit in the task. One implication is that the effects of unconscious positive primes on goal pursuit are more pronounced than those of conscious affective primes (Clare and Huntsinger, 2007).

Recent research indicates that patients with schizophrenia self-report similar emotions to those of control participants (Burbridge and Barch, 2007; Gard et al., 2007; Heerey and Gold, 2007; Herbener et al., 2008; Kring and Moran, 2008; Cohen and Minor, 2010; Oorschot et al., 2013) and have intact initial event-related potential (ERP) components and partially preserved brain activity during an affective picture viewing task (Dichter et al., 2010; Dowd and Barch, 2010; Horan et al., 2010, 2012; Anticevic et al., 2011, 2012; Ursu et al., 2011; van Buuren et al., 2011; Taylor et al., 2012). Although it is clear from a clinical point of view that not all aspects of emotional experience are intact (Bleuler, 1950), it would nonetheless appear that patients have

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emotional perception which is roughly comparable to controls (Kring and Moran, 2008). However, consistent with clinical observations that patients with schizophrenia have problems translating emotional experience into behaviour (Bleuler, 1950) several studies have suggested that there is a disconnection between affective experiences and their influence on motivated behaviours (Heerey and Gold, 2007; Trémeau et al., 2010). Our point is that all these studies have mainly explored conscious emotional experience and little is known about the influence of subliminal affective cues in schizophrenia. As research suggests that subliminal processing of information is intact in patients (Dehaene et al., 2003; Del Cul et al., 2006; Huddy et al., 2009; Jahshan et al., 2012) any difference in the effects of positive subliminal cues compared to healthy individuals would indicate a deficiency in translating emotional information in motivated behaviour.

In the present study, patients with schizophrenia and controls were invited to perform long runs of successive correct responses in a visual attention task—a task in which difficulties of the patients are minimized (Luck et al., 2006; Gold et al., 2009). During each run, neutral, negative, or positive pictures were displayed either subliminally (24 ms, unconscious condition) or supraliminally (500 ms, conscious condition). Negative emotions related to anger and aggression share an important motivational property with positive emotion (Carver and Harmon-Jones, 2009). We thus explored whether negative pictures can also induce disengagement in goal pursuit (Freydefont et al., 2012). Influence of the subliminal and supraliminal affective pictures on goal pursuit and perseverance were examined by measuring how they modulated the number of successive correct responses and event related potentials (ERPs). Previous studies in healthy volunteers have shown the involvement of different ERPs during visual attention tasks: fronto-central positive and negative waves (P2/N2 complex) and parieto-occipital negative wave (N2). The fronto-central P2 and N2 components are related to the evaluation of the relevance of task stimuli and to conflict resolution and response selection, respectively (Di Russo et al., 2006; Gajewski et al., 2008). The parieto-occipital N2 reflects the allocation of visual attention (Luck and Hillyard, 2000). We also focus on the fronto-central contingent negative variation (CNV) which increases during trials in which healthy volunteers invest preparatory effort (Capa et al., 2013).

Our predictions are the following. For healthy controls, we expect to reproduce the disengagement from goal pursuit induced by positive affective pictures, with fewer successive correct responses and less efficient ERPs' amplitude (such as a decrease of the CNV amplitude), especially in the subliminal condition. Patients are expected to correctly self-assess affective pictures. We neither expect much effect in case of supraliminal pictures. However, if there is a decoupling of positive affect and effort mobilization even in case of unconscious primes, we expect a lack of disengagement from goal pursuit following nonconscious positive affective cues.

2. Methods

Details concerning participants, exclusion criteria, training task, selection and assessment of IAPS pictures, perceived difficulty scale, perceptual discrimination task and electrophysiological recording and analysis can be found in Supplementary data.

2.1. Participants

The participants' demographic and clinical data are presented in Table 1. All of the patients had been diagnosed by two senior psychiatrists based on the Mini International Neuropsychiatric Interview, according to the criteria laid down in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 1994) (paranoid, $n = 9$; residual, $n = 7$; undifferentiated, $n = 3$). Chlorpromazine equivalents were computed using the method of Woods (2003). Symptoms were assessed with the help of the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987) and the Scales for the Assessment of

Table 1
Demographic and clinical data.

	Patients	Controls
Gender (M/F)	13/6	13/6
Age (mean \pm SD)	35.9 \pm 8.3	34.5 \pm 9.2
Years of education (mean \pm SD)	12.9 \pm 2.1	13 \pm 2.2
Duration of illness (mean years \pm SD)	13.5 \pm 5.5	–
Onset of illness (mean years \pm SD)	24.0 \pm 5.6	–
Number of hospitalisation	5.8 \pm 5.1	–
Medication (typical/atypical/no medication)	3/14/2	–
Dose of chlorpromazine equivalents (mg/day)	242	–
PANSS positive symptoms (mean \pm SD)	14 \pm 4.1	–
PANSS negative symptoms (mean \pm SD)	16.9 \pm 8.3	–
PANSS general symptoms (mean \pm SD)	29.1 \pm 7.7	–
PANSS total (mean \pm SD)	59.9 \pm 16.5	–
SAPS (mean \pm SD)	19.6 \pm 10.7	–
SANS (mean \pm SD)	35 \pm 24.9	–

Positive Symptoms (SAPS; Andreasen, 1983) and Negative Symptoms (SANS; Andreasen, 1981).

The exclusion criteria for both patients and controls were: a history of alcohol or drug dependency, a neurological or medical pathology, a disabling sensory disorder, and general anaesthesia in the 3 months prior to testing. An additional exclusion criterion for controls was psychotropic medication in the 3 weeks prior to testing. Healthy controls were free of psychiatric diagnoses, were not taking psychiatric medications, and had no family history of psychosis. All participants had normal or corrected-to-normal visual acuity.

The project had the approval of the local ethics committee. All of the participants gave their informed written consent prior to testing. The experiment was conducted in accordance with the Declaration of Helsinki. Patients were stabilized, with relatively mild symptoms.

2.2. Procedure

Each participant first completed a training session, followed by the goal pursuit task. The training session minimized the possibility that learning interfered with the effects of affective primes on goal pursuit. Then, participants filled out a perceived difficulty scale (Eccles and Wigfield, 1995). Lastly participants were asked to perform a perceptual discrimination task and next to rate the valence and arousal of the IAPS pictures to ensure that supraliminal affective pictures were consciously perceived and subliminal affective pictures were not, and that participants self-assessed the emotional content correctly, respectively.

2.3. Goal pursuit task

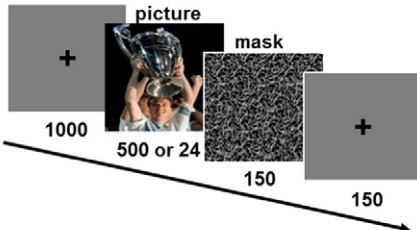
The task was programmed with E-Prime and presented on an 85-Hz CRT screen. There were 54 runs (9 runs each for each of the 6 conditions). Each condition (2 picture presentation durations multiplied by the 3 affect pictures) was administered in random order across runs. However, the condition was identical within each run. At the start of each run, participants were told that if they gave a long series of successive correct responses they would receive a monetary reward (Fig. 1A). No information and feedback was given about the number of successive correct responses required to earn the reward. This method was adopted because feedback could have confused the results, since patients have abnormal brain responses to feedback (Waltz et al., 2010). This could have altered the effects of affective pictures on goal pursuit.

Next (Fig. 1B), a fixation cross appeared and was followed immediately by a neutral, negative, or positive picture taken from the International Affective Picture System (IAPS; Lang et al., 2005), a mask, and a fixation cross. The picture ($10^\circ \times 8^\circ$) was displayed either supraliminally (500 ms) or subliminally (24 ms). The masks were textures of oriented lines covering the whole of the pictures, and were presented 150 ms after the pictures, for 150 ms. Patients are known to display impairments

A—Goal induction



B—(Un-)conscious affective primes



C—Goal pursuit task

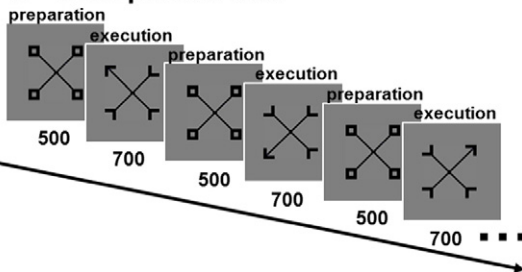


Fig. 1. Design of the experimental task. Successive screens are displayed during one run, with durations in milliseconds. Firstly (A), participants were informed that if they gave a long series of successive correct responses, they would receive a reward (2 euro). Next (B), a neutral, negative or positive picture from the IAPS was displayed regularly either supraliminally or subliminally. The picture shown here is merely an example. It was not used in the experiment and is not taken from the IAPS library. Finally (C), participants performed the goal pursuit task. They had to respond in the direction and side indicated by the arrow (task execution). After every 8 successive correct responses, a new picture was displayed with identical presentation duration and affect as the picture at the beginning of the run (B). If participants gave an incorrect response or responded out-of-time a new run started.

in masking tasks (Sacuzzo and Braff, 1981; Green and Walker, 1986). However, a recent study showed that patients' performance in backward masking is identical to that of controls when targets are presented in both hemifields (Lalanne et al., 2012).

Lastly (Fig. 1C), participants had to perform the goal pursuit task composed of preparation and execution steps. The preparation task stimulus was composed of four squares located on both sides of two perpendicular lines. During the task execution phase, one square became an arrow. Participants had to respond in the direction indicated by the arrow by pressing a left up, left down, right up, or right down key. The task execution stimulus remained on the screen until the participant responded. If participants attained the upper limit of 70 successive correct responses, gave an incorrect response, or responded slowly, a new run started. Every 8 successive correct responses, a new affective picture was displayed (Fig. 1B).

3. Results

Neither patients nor controls were able to perceive subliminal IAPS pictures. A one-way ANOVA revealed no difference between patients and controls on the perceived difficulty scale ($p = .61$). Details concerning prime visibility test and training can be found in Supplementary data. All the data presented below were examined by means of three-way ANOVAs (2 picture presentation durations: supraliminal vs. subliminal \times 3 affective pictures: neutral vs. negative vs. positive, as within-participants factors, \times 2 groups, as between-participants

factor). In case of significant results in the overall (three-way) ANOVA, one-way ANOVAs were conducted.

3.1. Subjective evaluation of IAPS pictures

A main effect of affective picture was found on arousal ($F(2,72) = 38.8, p < .001, \eta^2 = .52$) and valence assessment scores ($F(2,72) = 196.9, p < .001, \eta^2 = .84$), reflecting a successful selection of pictures. As expected, the negative and positive pictures were perceived as being more arousing than the neutral pictures. Moreover, the positive pictures were viewed as being more pleasant than the neutral and in particular the negative ones (Fig. 2). Each one-way ANOVA between affective picture conditions was significant for patients (all $ps < .001$) and controls (all $ps < .001$). Moreover, no difference was found between patients and controls in any affective picture condition, suggesting that patients self-assessed the emotional content correctly.

3.2. Goal pursuit task

The analysis of the total number of successive correct responses revealed a significant three-way interaction ($F(2,72) = 4.7, p < .01, \eta^2 = .11$, Fig. 3). We broke this interaction down by performing two separate ANOVAs (3 affective pictures \times 2 groups) as a function of picture presentation durations. There was a significant interaction in the subliminal condition ($F(2,72) = 5.1, p < .009, \eta^2 = .12$), but no difference in the supraliminal condition. One-way ANOVAs revealed that controls performed less successive correct responses when positive rather than neutral ($F(1,18) = 11.9, p < .003, \eta^2 = .40$) or than negative subliminal pictures were displayed ($F(1,18) = 6.8, p < .02, \eta^2 = .27$). For the patients, no significant effect of subliminal affective pictures was found. No other effect was significant.

3.3. Task preparation ERP results

There was a main effect of group with weaker CNV for the patients ($M = -1.66 \mu V, SD = 2.18$) compared to the controls ($M = -3.08 \mu V, SD = 2.46$), ($F(1,36) = 4.3, p < .05, \eta^2 = .11$). Additionally, a significant three-way interaction was found ($F(2,72) = 3.6, p < .03, \eta^2 = .09$, Fig. 4). A breakdown of the interaction in the form of two separate two-way ANOVAs (3 affective pictures \times 2 groups) as a function of picture presentation durations showed a significant interaction in the subliminal condition ($F(2,72) = 5.1, p < .008, \eta^2 = .12$), but not in the supraliminal condition. One-way ANOVAs showed that for the controls, the CNV was weaker for the positive than the neutral ($F(1,18) = 11.4, p < .003, \eta^2 = .39$) or than the negative subliminal pictures ($F(1,18) = 8.3, p < .01, \eta^2 = .32$). For patients, no significant effect of subliminal affective pictures was found on the CNV. No other effect was significant.

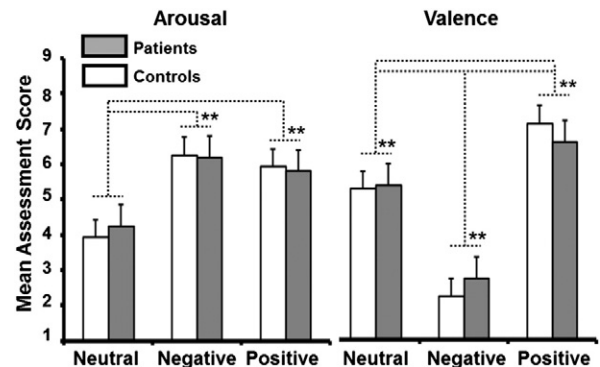


Fig. 2. Arousal and valence mean assessment score of the IAPS pictures as a function of groups and affective pictures. Patients perceived correctly the emotional content and no difference between groups were found (** for $p < .001$).

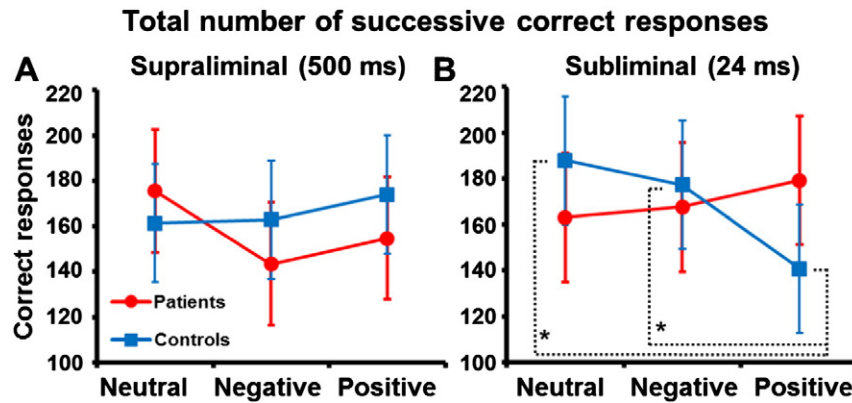


Fig. 3. Total number of successive correct responses as a function of groups when neutral, negative or positive pictures from the IAPS were displayed either supraliminally (A) or subliminally (B). For the controls, no difference was found in the supraliminal condition, however, they performed shorter runs of successive correct responses when positive subliminal pictures were displayed regularly as compared to neutral subliminal or negative subliminal pictures. For the patients, no difference was found in the supraliminal and subliminal conditions (* for $p < .05$).

3.4. Task execution ERP results

ANOVAs were carried out on the latency peak of each component. The fronto-central P2 latency was longer for the patients ($M = 233.62$ ms, $SD = 6.09$) than the controls ($M = 205.02$ ms, $SD = 6.07$) ($F(1,36) = 11.1$, $p < .002$, $\eta^2 = .24$). No other effect was found. The following analyses were conducted on the ERPs' amplitude.

For the P2 (Fig. 5), we found a significant interaction between affective pictures and groups ($F(2,72) = 12.81$, $p < .001$, $\eta^2 = .26$).

One-way ANOVAs revealed that for the controls, the P2 was smaller for the positive than the neutral pictures in the supraliminal ($F(1,18) = 4.6$, $p < .05$, $\eta^2 = .20$) and subliminal ($F(1,18) = 6.3$, $p < .02$, $\eta^2 = .26$) conditions. For patients, there was an opposite response pattern, with larger P2 for the positive than the neutral pictures, in the supraliminal ($F(1,18) = 9.6$, $p < .006$, $\eta^2 = .35$) and subliminal ($F(1,18) = 5.9$, $p < .03$, $\eta^2 = .25$) conditions. The P2 was also larger for the positive than the negative pictures displayed subliminally ($F(1,18) = 9.6$, $p < .006$, $\eta^2 = .35$). No other effect was significant.

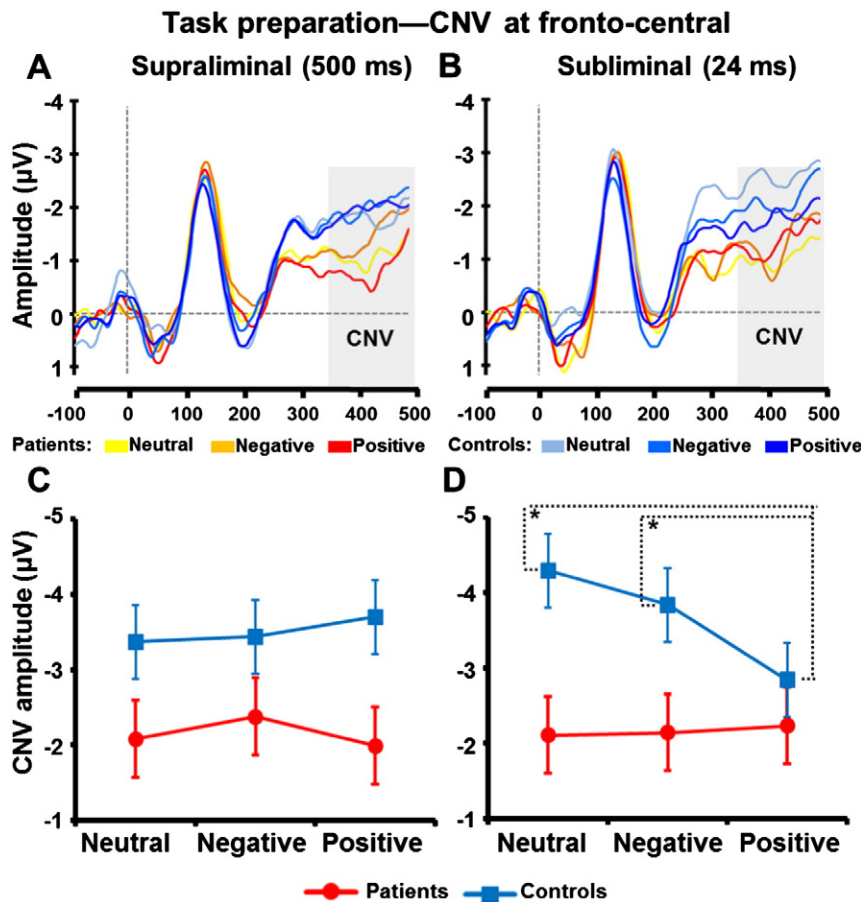


Fig. 4. Grand mean ERP waveforms of the fronto-central (FCz) CNV (grey bar) during task preparation in the supraliminal (A) and subliminal (B) conditions as a function of groups and affective pictures. For the controls, no effect was found in the supraliminal condition (C). However, when pictures were displayed subliminally (D), controls had a weaker CNV for positive than neutral or than negative pictures. For the patients, no effect was found in the supraliminal and subliminal conditions (* for $p < .05$).

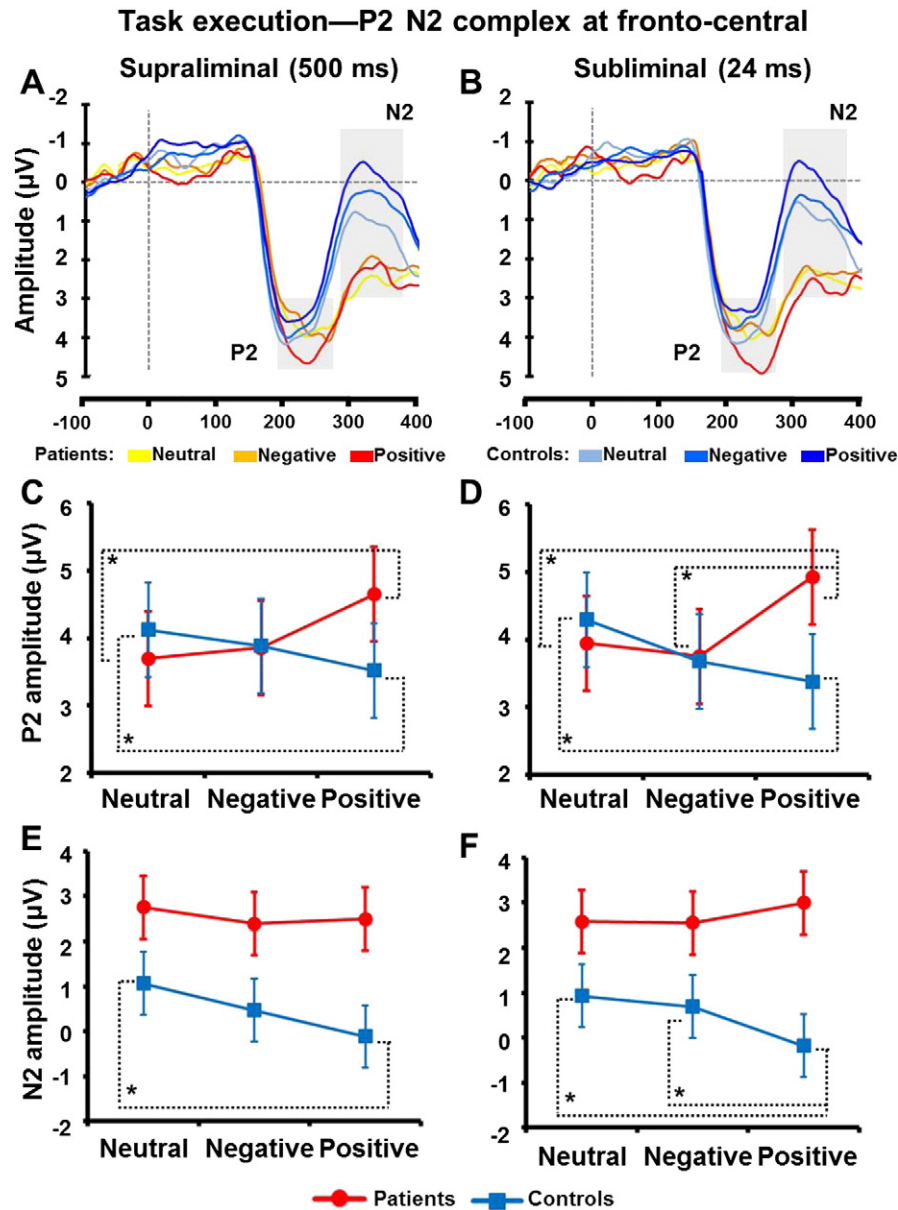


Fig. 5. Grand mean ERP waveforms of the fronto-central (FCz) P2 and N2 (grey bar) during task execution in the supraliminal (A) and subliminal (B) conditions as a function of groups and affective pictures. For the P2, patients and controls had an opposite pattern of response with larger for the patients and weaker for the controls P2 amplitude with the positive than the neutral pictures in the supraliminal (C) and subliminal (D) conditions. For the N2, controls had a greater N2 for positive than neutral pictures displayed supraliminally (E) and subliminally (F). For the patients, no effect of supraliminal and subliminal affective pictures was found on the N2 (* for $p < .05$).

There was a main effect of group with weaker fronto-central N2 for the patients ($M = 2.63 \mu\text{V}$, $SD = 3.42$) compared to the controls ($M = .48 \mu\text{V}$, $SD = 3.46$), ($F(1,36) = 4.0$, $p < .05$, $\eta^2 = .10$). The N2 amplitude varied also as a function of affective pictures for the controls but not for the patients, as suggested by a significant interaction between affective pictures and groups ($F(2,72) = 5.05$, $p < .009$, $\eta^2 = .12$, Fig. 5). For the controls, one-way ANOVAs showed that the N2 was larger for the positive than the neutral pictures, in the supraliminal ($F(1,18) = 6.3$, $p < .02$, $\eta^2 = .26$) and subliminal ($F(1,18) = 4.4$, $p < .05$, $\eta^2 = .20$) conditions. The N2 was also larger for the positive than the negative pictures displayed subliminally ($F(1,18) = 8.9$, $p < .008$, $\eta^2 = .33$). For patients, however, no significant effect of supraliminal or subliminal affective pictures was found on the N2 amplitude. No other effect was significant.

The parieto-occipital N2 varied as a function of affective pictures ($F(2,72) = 4.48$, $p < .01$, $\eta^2 = .11$; Fig. 6). A similar response pattern was found at P4, P3 and PO3, and it is the results at P4 that are presented here. For the controls and also the patients, one-way ANOVAs showed

that the N2 was larger for the positive than the neutral pictures, in both supraliminal ($F(1,18) = 4.7$, $p < .04$, $\eta^2 = .21$, and $F(1,18) = 6.0$, $p < .02$, $\eta^2 = .25$, respectively) and subliminal conditions ($F(1,18) = 4.8$, $p < .04$, $\eta^2 = .21$, and $F(1,18) = 4.8$, $p < .04$, $\eta^2 = .21$, respectively). Additionally, for patients the N2 was larger for the positive than the negative pictures in the subliminal condition ($F(1,18) = 6.5$, $p < .02$, $\eta^2 = .27$). No other effect was significant.

No Pearson correlation coefficient with clinical symptoms or neuroleptic dosage (see details in Supplementary material) was significant (all $ps > .14$ and $ds < .13$).

4. Discussion

Patients and controls self-assessed the emotional content of the pictures correctly. Moreover, mean performance and perceived difficulty during the task was similar in patients and controls, suggesting that difficulties of the patients to perform the visual attention task were

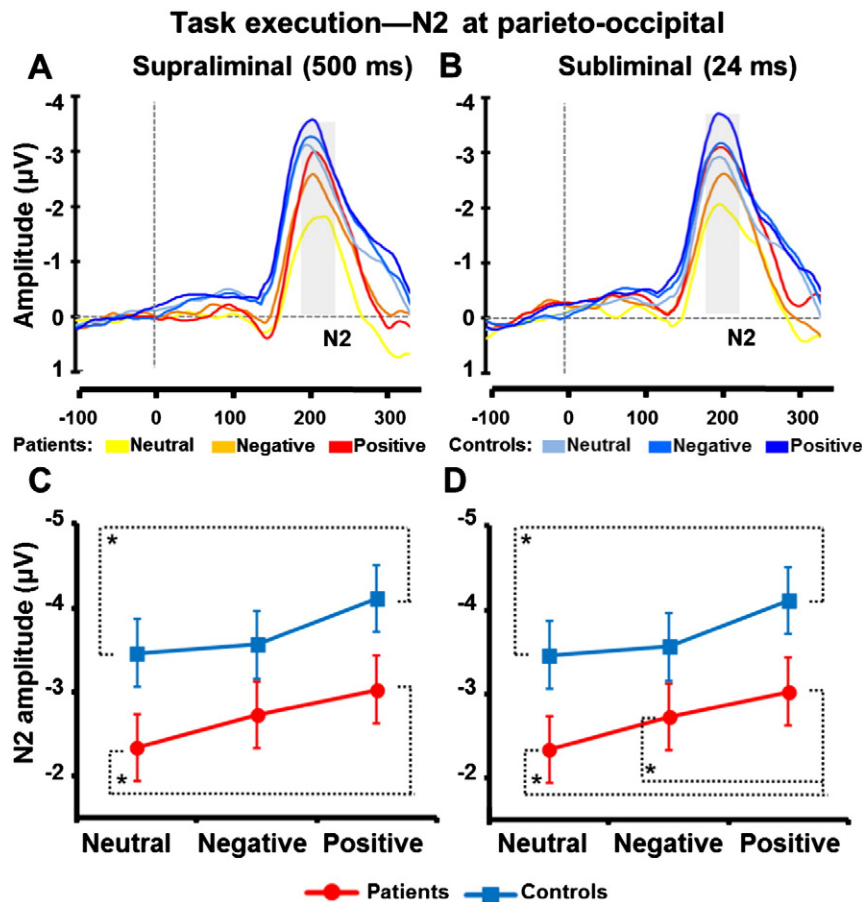


Fig. 6. Grand mean ERP waveforms of the parieto-occipital (P4) N2 (grey bar) during task execution in the supraliminal (A) and subliminal (B) conditions as a function of groups and affective pictures. Both patients and controls had a larger N2 when positive pictures compared to neutral pictures were displayed supraliminally (C) or subliminally (D) (* for $p < .05$).

weak. However, all results being otherwise comparable, subliminal positive pictures did not influence performance and ERPs in the same way in patients and in controls.

During task preparation, healthy controls had a weaker fronto-central CNV amplitude when positive subliminal pictures were displayed as compared to neutral subliminal pictures. The CNV amplitude is proportional to the amount of preparatory effort (Capa et al., 2013). This means that healthy controls mobilized less effort for the positive subliminal pictures. This is further supported by the impairment of performance in case of subliminal positive pictures. Taken together, these results reflect successful experimental manipulation of positive subliminal pictures on goal pursuit, as previously observed (Gendolla, 2012). For the patients, no influence of positive subliminal pictures was found on performance or CNV. This fits well with the fact that patients with schizophrenia have problems translating positive emotional information into motivated behaviours (Heerey and Gold, 2007). The new result here is that patients' performance is qualitatively different from controls even when the positive emotional information is subliminal. This effect is not straightforward given the fact that subliminal processing is usually preserved in schizophrenia (Jahshan et al., 2012). On the contrary, the results suggest that the integration of affective processes in the motivational system appears to be impaired even at an unconscious and automatic level. As positive affective cues have been shown to promote more automatic forms of goal pursuit (Custers and Aarts, 2010), the inability to use such cues in schizophrenia could help to explain difficulties of the patients to initiate and persist in goal-directed behaviour in their daily-life.

The preserved influence of positive pictures on the posterior-occipital N2 shows that the pictures have been processed efficiently by patients and contrasts with the alterations of the CNV, and the

fronto-central P2 and N2. Decreased amplitude and longer latency of these ERPs were observed in patients whatever the affective pictures. In addition, these ERPs were not modulated by positive (subliminal or supraliminal) pictures like for controls. It might thus be asked whether the lack of modulation is related to a more general impairment of the cognitive processes involved in the task. As a matter of fact, the fronto-central CNV and N2 are components mainly attributed to the anterior cingulate cortex (ACC) (van Veen and Carter, 2002; Gómez et al., 2003). Patients with schizophrenia have an altered ACC activation (Carter et al., 2001) and attenuations of the CNV (Klein et al., 2000) and N2 (van Veen and Carter, 2002) amplitude in cognitive tasks. This might suggest that the influence of affective pictures is all the more altered that the targeted cognitive processes are themselves altered.

Patients with schizophrenia were taking antipsychotic medications, which could impact the processing of positive affective cues and reward information via blockade of subcortical dopamine receptors (Braver et al., 1999). An explanation in terms of psychotropic dosage, although difficult to strictly exclude, seems unlikely. There is no correlation with equivalents chlorpromazine and data. The preserved influence of positive pictures on the posterior-occipital N2 shows that the pictures have been processed efficiently by patients, eliminating a decrease in affective processes. Furthermore, a difficulty in taking reward into account should have led to impairments in case of supraliminal cues, which was not the case. Several studies have shown that abnormalities in reward processing were mainly observed when involving impaired cognitive mechanisms (Gold et al., 2008). Abnormalities in reward processing are also mediated by negative symptoms. In the present study, patients had relatively mild symptoms. This might also explain why we did not find any relationships between the results and clinical

symptoms. It will be important to examine these relationships in future studies with patients having more symptoms.

Our results show that the patients' difficulties at modulating effort mobilization can occur even in the presence of subliminal cues, at least when these cues convey positive information. Future studies are necessary to lend support to the notion that deficits in cognition amplify deficits in affective processes underlying goal pursuit (Barch, 2005; Heerey and Gold, 2007).

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Contributors

Anne-Clémence Chaillou collected the data and contributed to the statistical analyses, the literature searches and writing of the manuscript.

Anne Giersch designed the study and contributed to the writing of the manuscript.

Anne Bonnefond contributed to the EEG analyses.

Ruud Custers contributed to the literature searches and writing of the manuscript.

Rémi L Capa designed the study and contributed to the statistical analyses, the literature searches and writing of the manuscript.

Conflict of interest

The authors have no conflict of interest in relation to the subject of this study.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.schres.2014.10.052>.

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