An event-related potential study on exposure therapy for patients suffering from spider phobia

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ABSTRACT

The present event-related potential (ERP) study investigated electrocortical changes related to cognitive behavior therapy (CBT) in spider phobic females. Forty-five patients and twenty non-phobic women were presented with phobia-relevant, generally fear-inducing, disgust-inducing and affectively neutral pictures in a first EEG session. Phobic patients were randomly assigned to either a therapy (TG) or a waiting-list (WG) group. EEG measurement was repeated after CBT or a waiting period. ERPs were extracted in the time windows 340–500 ms (P300), 550–770 ms (late positive potential (LPP), early LPP) and 800–1500 ms (late LPP). Relative to controls, untreated phobics showed enhanced amplitudes of P300 and early LPP in response to spider pictures. This most likely reflects the emotional significance of the phobic stimulus, which automatically draws attention. The therapy effect consisted of a significant enhancement of late LPP amplitudes in response to spider pictures. Results are discussed in terms of reduced attentional avoidance.

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1. Introduction

Spider phobia is a common anxiety disorder, which in the majority of cases becomes chronic without treatment (Fredrikson et al., 1996). According to DSM-IV-TR (APA, 2000) the sufferers experience intense and immediate fear cued by the presence or the anticipation of spiders. As a result the phobic situation is avoided. The patients realize that their fear is excessive or unreasonable, but they are unable to control it. Consequently, symptoms lead to significant interference with the patients' normal functioning.

The somatic phobic response is sympathetically dominated and includes increases in heart rate, electrodermal activity, and blood pressure (Hamm, 1997). This response is accompanied by an automatic attentional bias towards spiders (Cisler et al., 2007) as well as an expectancy bias for fear and disgust stimuli (Olatunji et al., 2008). Eye tracking studies indicate a pattern of vigilance and avoidance in spider phobics consisting of a short fixation followed by the deployment of attention away from the phobic stimulus (Hermans et al., 1999; Rinck et al., 2005; Rinck and Becker, 2006). In several studies enlarged amplitudes of late event-related potentials (ERPs) were identified for phobia-relevant relative to affectively neutral stimuli (Kolassa et al., 2005; Miltner et al., 2005; Mühlberger et al.,

2006; Schienle et al., 2008). The presentation of spider pictures (relative to neutral pictures) was associated with greater parietal P300 amplitudes (ranging from 200 to 520 ms after stimulus onset) and LPP amplitudes (late positive potential, 550–770 ms after stimulus onset) in patients relative to non-phobic controls.

However, enhanced P300 and LPP components are not phobia-specific but can be regarded as general indicators of emotional significance and attention allocation (for a review see Olofsson et al., 2008). Pictures that differ in arousal (high/low) and valence (positive/negative) are able to modulate late ERP amplitudes. Consequently, they can be linked to the concept of motivated attention (Lang et al., 1997), which implies that emotionally significant stimuli automatically draw attention in order to allocate resources for a deeper processing. Especially highly arousing pictures (which are usually characterized by a very negative or positive valence) provoke an elevated and sustained late positivity (Cuthbert et al., 2000).

Moreover, there are studies suggesting that not only automatic but also directed attention is able to modulate the magnitude of the LPP (Dunning and Hajcak, 2009; Ferrari et al., 2008; Hajcak et al., 2009; Keil et al., 2005; Schupp et al., 2007). In a recent investigation, Dunning and Hajcak (2009) showed that directing attention towards non-arousing aspects of unpleasant images led to decreased LPP amplitudes (1000–3000 ms). There are, however, studies suggesting that LPP amplitudes in general become more frontally distributed over time. Whereas early enhancement effects of emotional relevance are prominent at posterior sites,

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this effect shifts to frontal sites in middle and later time windows (e.g., Foti et al., 2009; Foti and Hajcak, 2008).

Altogether, existing empirical data support the view that late ERP positivity to affective pictures can be modulated by intrinsic motivation and attention allocation. Therefore, it seems promising to investigate these components not only with regard to symptom provocation in spider phobics but also with regard to symptom reduction. The most frequently used symptom reduction method for spider phobia is cognitive behavior therapy (CBT; Choy et al., 2007; Öst, 1989, 1996; Öst et al., 1997). Untreated spider phobics perceive spiders as unpredictable and dangerous (dysfunctional cognitions) and they show deficits in controlling their anxiety (Armfield, 2007, 2008). Therefore, the main goal of CBT is to help patients gaining control over their dysfunctional cognitions (e.g., the spider will bite me), emotions, and behaviors via gradual exposure to the phobic object. In the course of CBT patients are guided to focus attention on the feared object (e.g., count legs, eyes of the spider). Through exposure, patients realize that the feared consequences do not occur and that avoidance is not necessary for anxiety to reduce.

Neural correlates of CBT in spider phobia have only been investigated with functional magnetic resonance imaging (fMRI). In a first controlled study (Straube et al., 2006) the therapy effect consisted of a significant activation attenuation in the insula and the anterior cingulate cortex. The authors interpreted this outcome in terms of a therapy-induced normalization of (autonomic) hyperactivation. In a second fMRI study (Schienle et al., 2007) successful CBT provoked increased activation of the medial orbitofrontal cortex (OFC). This region of the brain is crucial for emotion regulation and relearning of stimulus-reinforcement associations (Rolls, 1999). In a 6-month follow-up study the medial OFC effect showed temporal stability in those patients who were able to maintain symptom reduction (Schienle et al., 2009). This finding shows that successful CBT can result in increased neural activation in specific brain regions as opposed to a simple attenuation of hyperactivation. Since fMRI is characterized by a high spatial but low temporal resolution, ERPs seem to be a helpful tool to complement existing fMRI findings on CBT effects in spider phobia.

The goal of the present study was to extend previous work on enhanced late ERPs to phobia-relevant material in spider phobics and to determine if these ERPs are sensitive to CBT. We expected enlarged parietal P300 and LPP amplitudes in untreated spider phobics when exposed to spider pictures and a reduction in those ERP components after successful exposure therapy.

2. Methods

2.1. Participants

Forty-five right-handed, medication-naïve, female patients suffering from spider phobia (DSM-IV-TR: 300.29) and twenty non-phobic women (control group, CG) participated in this study. They were recruited via an article in a local newspaper and announcements at the campus. Diagnoses were made by a board-certified clinical psychologist. Patients were randomly assigned to either a therapy group (TG; $N = 22$) or a waiting-list group (WG; $N = 23$). Both patient groups were comparable with respect to age (M (SD): TG = 26.0 (6.6) years; WG = 28.8 (10.7) years) and years of education (M (SD): WG = 12.4 (2.8) years; TG = 12.1 (3.8) years). The non-phobic females did not differ from the patient group with respect to age (M (SD) = 24.2 (3.8) years) and years of education (M (SD) = 12.1 (1.3) years). All participants gave written informed consent after the nature of the study had been explained to them. The study was approved by a local ethic committee.

2.2. Procedure

First, participants underwent a diagnostic session consisting of a clinical interview (Mini-DIPS, Margraf, 1994). Additionally, they filled out the Spider Phobia Questionnaire (SPQ, Klorman et al., 1974), the Questionnaire for the Assessment of Disgust Sensitivity (QADS, Schienle et al., 2002), the trait scale of the State-Trait Anxiety Inventory (STAI, Laux et al., 1981) and the Beck Depression Inventory (BDI, Hautzinger et al., 1993). Patients who suffered from any other mental disorder than

spider phobia were excluded. Control group participants who suffered from any mental disorder were excluded. Finally, participants underwent a behavior avoidance test (BAT). A spider (Tegenaria atrica, approximately 3 cm) was put in a transparent case and placed on a table 5 m from the participant who was then instructed to approach the box. Participants received scores (range 0–12) according to their approach behavior (0 points = no movement, 12 points = removing the spider from the box and holding it in their hands for 20 s).

In a subsequent experimental session participants were exposed to a total of 160 pictures representing four different emotional categories: 'Spider', 'Fear', 'Disgust' and 'Neutral' during EEG recording. Pictures were selected from the International Affective Picture System (IAPS, Lang et al., 1999) and a second picture set (Schienle et al., 2005). The phobia-related stimuli depicted spiders in different environments. Disgust-relevant pictures represented different domains like 'repulsive animals' or 'poor hygiene'. Fear-related pictures showed predators (e.g., shark, lion) or attacks by humans (e.g., with knives, pistols), whereas neutral pictures consisted of household articles, or geometric figures. The pictures were shown in random order for 1500 ms each. Inter-stimulus intervals varied between 1500 and 5500 ms. After the experiment, participants rated their impression of the pictures by means of the Self-Assessment Manikin (SAM; Bradley and Lang, 1994) for valence and arousal, and on two nine-point Likert scales on the dimensions 'Disgust' and 'Fear' (range 1–9, with '9' indicating that the subject felt very positive, aroused, disgusted or anxious).

One week later, the therapy group received a single-session cognitive behavior therapy (CBT) of up to 4 h according to Öst (1989, 1996), Öst et al. (1991). The therapy was conducted by a board-certified psychotherapist. The patients, who participated in groups of up to four patients, were taught to gradually approach a spider (e.g., looking at a spider, catching a spider with a glass and a piece of paper, holding a spider in the hands). Each task was first demonstrated by the therapist and then repeated by the patients. A task was considered as successfully managed when the anxiety level had been reduced by at least 30% of its highest value.

A second EEG recording was conducted 1 week after the therapy with the same experimental design as in the first EEG session. Subsequent to the picture presentation the subjects were again asked to rate the experienced arousal, valence, disgust and fear. They also completed the SPQ, QADS, STAI and BDI and underwent the BAT. The patients of the waiting-list group received CBT after the second EEG session. Control group participants underwent the diagnostic session and a single EEG session.

2.3. Data recording and analysis

The EEG was recorded with a Brain Amp 32 system (Brain Vision, Munich) and an Easy-Cap electrode system (Falk Minow Services, Munich) from 29 sites (Fp1, Fp2, F3, F4, F7, F8, Fc1, Fc2, Fc5, Fc6, C3, C4, T7, T8, Cp1, Cp2, Cp5, Cp6, P3, P4, P7, P8, O1, O2, Fz, Cz, Pz) including the mastoids (Tp9, Tp10). All sites were referenced to FCz. A bipolar horizontal electrooculogram (EOG) was recorded from the epicanthus of each eye, and a vertical EOG was recorded from the infra-orbital position of the right eye. The EEG and the EOG were recorded with Ag/AgCl electrodes. Prior to the placement of the electrodes, the sites on the participants' scalp and face were cleaned with alcohol and gently abraded. All impedances of the EEG electrodes were below 5 kΩ. EEG data were sampled with 200 Hz and passband was set to 0.016–70 Hz. Independent component analysis (ICA) was computed in order to correct for EOG artifacts. EOG relevant ICs were identified by visual inspection and comparison to EOG channels. Afterwards, the EEG was re-referenced to linked mastoids (Tp9, Tp10). EEG data were segmented into epochs of 1700 ms starting 200 ms before the onset of the stimulus. Subsequently, segments were visually inspected to discard remaining artifacts. After artifact correction data were low-pass filtered (20 Hz, 24 dB/octave) and a baseline correction was performed using the first 200 ms as reference. Epochs were averaged separately for each condition. Magnitudes of the ERP components were extracted via average amplitudes for the time windows 340–500 ms (P300), 550–770 ms (early LPP) and 800–1500 ms (late LPP) based on previous work of our group (Schienle et al., 2008) and other studies (e.g., Hajcak and Olvet, 2008; Miltner et al., 2005; Olofsson et al., 2008). We calculated topographical maps for activation differences: for symptom provocation we calculated activation differences between phobics (both TG and WG) and controls for the contrast Spider–Neutral. For the therapy effect we calculated activation differences between the second and first EEG session between TG and WG [($TG_2 - TG_1$) – ($WG_2 - WG_1$)] for the difference Spider–Neutral. These topographical maps were inspected to assure the typical scalp distribution of ERP components. We also selected electrode sites for statistical analyses based on these maps.

3. Results

3.1. Symptom provocation

3.1.1. Self-report and behavior avoidance test data

All CG participants were able to hold the spider in their hands for 20 s during the behavior avoidance test (BAT), whereas the TG and WG participants kept a distance of approximately 1 m from the spider box (see Table 1). A Kruskal–Wallis H-test revealed a