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Electrocortical effects of directing attention during visual exposure in dentophobia

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ABSTRACT

Fear of pain is a main motivator for avoidance or delay of dental treatment in patients afflicted with dentophobia. Studies employing passive viewing paradigms found motivated attention to the phobic object to be associated with enhanced amplitudes of the late positive potential (LPP). The aim of the current study was to investigate, if explicit attention-guiding instructions are able to modify the LPP. Twenty-three patients suffering from dentophobia and 23 controls were presented with pictures showing disorder-relevant or neutral contents, which were combined with different instructions: to distract the attention away from the picture, to classify the content, or to decide whether the scene elicited fear of pain. Relative to controls, dentophobics displayed enhanced late positivity (300–1000 ms after picture onset) in the fear of pain condition at frontal and central recording sites, whereas there was no group difference during classification and distraction. Within patients, fear of pain elicited greater positivity than classification and distraction. The findings are discussed within the framework of attentional direction. Future studies could investigate whether psychotherapy differentially affects neural correlates of attention regulation.

1. Introduction

Patients suffering from dentophobia frequently report to have experienced excessive pain during dental treatment. Moreover, they expect future treatments to be very painful (Jöhren and Sartory, 2002). This expectation of pain is the main motivator for avoidance or delay of dental treatment. The fact that the threshold for the perception of pain is generally lowered when participants are in an anxious mood might be one cause for the vicious cycle of fear and avoidance in dentophobia (Lautch, 1971). Cognitive behavioral therapy (CBT) has consistently proven to be effective in managing fear of dental treatment (Gordon et al., 2013). Empirical evidence emphasizes the importance of exposure techniques, which include directing the patients' attention to the feared stimulus. However, distraction strategies have also been found to be useful (e.g., relaxation techniques), leaving the role of attentional direction in dentophobia unresolved. The goal of the current investigation was to study electrocortical correlates of different attentional strategies during symptom provocation.

The electroencephalogram (EEG) was chosen for the experiment because of its excellent temporal resolution. It provides researchers with the opportunity to study attentional processes that are characterized by a rather short duration as in specific phobia. According to the theory of motivated attention (Lang et al., 1997; for a discussion see Bradley, 2009) late positive event-related potentials (ERPs) can be interpreted as indicators of emotional significance and attention allocation. There is a long tradition of studies, showing that emotionally significant stimuli automatically draw attention in order to recruit resources for a deeper processing (for a review, see Olofsson et al., 2008). The electrocortical substrate is reported to be a sustained positive slow wave at posterior recording sites. One typical component, the late positive potential (LPP), is a central-parietal positivity which can be seen about 300 ms after picture onset (e.g., Cuthbert et al., 2000). Research with dentophobics (Leutgeb et al., 2011; Schienle et al., 2011) showed enhanced LPPs (300 to 1500 ms after picture onset) in response to slides showing dental treatment relative to controls. However, the LPP is not only an indicator of orienting to salient stimuli, but also seems to be modulated by top-down attentional processing (Li et al., 2010). Several investigations report that directing the attentional spotlight toward or away from emotionally relevant scenes influences the magnitude of the LPP amplitude. For example, an explicit distractor task seems to tax perceptual resources and to reduce affective ERP modulation (De Cesarei et al., 2009; Pessoa, 2005; Schupp et al., 2007). Moreover, a reliable reduction of the LPP magnitude has been reported, when attention is directed to neutral features of unpleasant pictures (for a review, see Hajcak et al., 2010).

As all published investigations on ERPs in dentophobia (Leutgeb et al., 2011; Schienle et al., 2011) employed a passive viewing paradigm, the interpretation of attentional direction remains somewhat speculative. Therefore, in the current study the attentional focus of participants onto the emotional quality of the pictures and their own emotional

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involvement was systematically increased across three tasks. A similar paradigm has already been employed in a functional magnetic resonance imaging study by Straube and Miltner (2011). The authors presented subjects with threatening and neutral pictures and increased the emotional involvement by means of four different tasks (distraction task, classification of living vs. non-living stimuli, classification of threatening vs. non-threatening stimuli, rating of one's own emotional response). The main result was an increase of activation with increasing attention focus on one's own emotional experience in the right posterior insula and in the right somatosensory cortex. These regions are crucial for the awareness of bodily states.

The goal of the current investigation was to identify whether attention-guiding instructions are able to modify late positivity in patients suffering from dental phobia. Participants were presented with images of dental treatment and neutral scenes, and were asked to either decide, whether a line displayed in the foreground of the picture was horizontal, whether the scene showed a dental treatment situation or not, or whether the picture elicited fear of pain within them. As the emotional involvement was systematically increased across the three different tasks, we expected enhanced late positivity with increasing self-directed attention in dentophobics relative to controls.

2. Materials and methods

2.1. Participants

Twenty-three right-handed and non-medicated patients (18 females and 5 males) suffering from dental phobia (DSM-5: 300.29; APA, 2013) and 23 non-phobic controls (15 females and 8 males) participated in this study. They were recruited via announcements at the campus and the Internet. Diagnoses were made by a board-certified clinical psychologist. The two groups did not differ with respect to age (phobics: M (SD) = 29.4 (10.2) years; controls: M (SD) = 27.2 (8.0) years; $T(44) = 0.8$, $p = .424$). All participants gave written informed consent after the nature of the study had been explained to them. The study was approved by the local ethics committee.

2.2. Procedure

At first, the participants were contacted by phone and a short interview on the diagnostic criteria of dentophobia and the most common mental disorders was conducted. Afterward, participants underwent a diagnostic session consisting of a clinical interview (Mini-DIPS; Margraf, 1994). Additionally, a self-constructed interview on diagnostic criteria of dental phobia according to DSM-5 (APA, 2013) was conducted. Patients who suffered from any other mental disorder than dentophobia were excluded. Control group participants who suffered from any mental disorder were also excluded. Participants filled out the Dental Anxiety Scale (DAS; Corah, 1969), which consists of four questions targeting subjective anxiety during anticipation and dental treatment (e.g., "If you had to go to the dentist tomorrow, how would you feel about it?"). The first question is answered on a five-point scale from "I would look forward to it as a reasonably enjoyable experience." to "I would be very frightened of what the dentist might do." The three remaining questions concern feelings in anticipation of or during actual treatment (e.g., "When you are waiting in the dentist's office for your turn in the chair, how do you feel?"). They are answered on a five-point scale from 1 = "Relaxed" to 5 = "So anxious that I sometimes break out in a sweat or almost feel physically sick." Resulting sum scores range from 4 to 20. Mean values are reported to be 9.33 (SD = 3.17) for controls and 17.18 (SD = 1.8) for phobics. According to the authors (Corah, 1969) the DAS shows sufficient reliability (Kuder–Richardson formula coefficient = 0.86) and test–retest stability (correlation coefficient $r = 0.82$). Moreover, participants filled out the Fear of Dental Pain Questionnaire (FDP; Van Wijk and Hoogstraten, 2003), which measures pain-related fear of a variety of painful stimuli. The questionnaire consists of 18 items (e.g., "An old filling that's being removed.") for which subjects are asked to think about the pain and to indicate the amount of anxiety experienced on a scale from 1 (not at all) to 5 (extreme). Resulting sum scores range from 18 to 90. Mean sum scores in the general populations are reported to be 43.3 (SD = 13.0). The authors report high internal consistency (Cronbach's alpha = 0.93) and satisfactory test–retest reliability (correlation coefficient $r = 0.75$; Van Wijk and Hoogstraten, 2003). In addition, participants completed the trait scale of the State-Trait Anxiety Inventory (STAI; Laux et al., 1981). This questionnaire is widely used to measure trait anxiety in adults (e.g., "I worry too much over something that really doesn't matter."). The scale consists of 20 items, which have to be judged on 4-point scales (1 = "hardly ever"; 4 = "nearly ever"). Sum scores range from 20 to 80. In samples afflicted with specific phobia or other anxiety disorders mean scores are reported to be 53.3 (SD = 11.4). According to the authors the Chronbach's alpha is sufficient with a value of $\alpha = 0$ .90.

After diagnostics, participants underwent an electroencephalographic (EEG) session. They were exposed to 28 phobia-relevant and 28 neutral scenes. The phobia-relevant pictures have been previously used (Leutgeb et al., 2011; Schienle et al., 2011, 2013) and have been reported to successfully induce phobic symptoms in patients suffering from dental phobia. Neutral pictures were taken from the International Affective Picture System (IAPS; Lang et al., 1999) and showed household articles. The pictures were shown in three different conditions varying in attentional engagement: In the "Distraction" condition a small line was displayed either in a vertical or a horizontal orientation in the foreground of the pictures. For half of the pictures the line was horizontal and for the other half the line was vertical. The participant was asked to decide whether the line in the foreground was horizontal ("Is the line horizontal?"). This task distracted the attention of the participant from the background picture. In the "Classification" task, the participants had to decide whether the pictures show dental treatment situations or objects related to dental treatment ("Dental treatment?"). This task requested a conceptual decision, but the participant was not forced to attend to his own emotional response. In the "Fear of Pain" task subjects had to indicate if the picture elicited fear of pain within them ("Fear of pain?"). This task explicitly required the participants to refer to their own emotional involvement.

Each picture was shown for 1.5 s in blocks consisting of 28 pictures. A block included 14 neutral and 14 dental treatment scenes in random order. The whole experiment consisted of six blocks. Prior to a block a fixation cross (11 s) and the instruction (key question) were presented for 3 s. After each picture presentation, the response options "yes" and "no" were shown on a black screen in white letters for a maximum of 4 s. For a judgment of each picture, subjects use a two-button device (computer mouse) with either the first or the middle finger of the right hand. Afterward a fixation cross was shown with the average duration of 700 ms. When a participant answered before the deadline, a fixation cross was shown for the rest of the 4-s interval. Subsequently, the next picture was shown. Each key question was presented twice during the experiment (once for each block). The order of tasks and assignment of response buttons to the answer alternatives were counterbalanced across subjects.

After the EEG session, participants rated the pictures of each category by means of the Self-Assessment Manikin (Bradley and Lang, 1994) for valence (1 = very unpleasant to 9 = very pleasant) and arousal (1 = not arousing to 9 = very arousing).

2.3. Data recording and analysis

The EEG was recorded with a Brain Amp 32 system (Brain Products GmbH, Gilching). Data were sampled with 500 Hz and passband was set to 0.016–70 Hz. We employed an Easy-Cap electrode system (Falk Minow Services, Munich) and recorded the EEG from 30 sites (Fp1, Fp2, F3, F4, F7, F8, Fc1, Fc2, Fc5, Fc 6, C3, C4, T7, T8, Cp1, Cp2, Cp5, Cp6, P3, P4, P7, P8, O1, O2, Fz, Cz, Pz, POz) including the mastoids (Tp9,