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Original Research Paper

Functional changes in brain activity after hypnosis in patients with dental phobia

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ABSTRACT

Visiting the dentist is often accompanied by apprehension or anxiety. People, who suffer from specific dental phobia (a disproportional fear of dental) procedures show psychological and physiological symptoms which make dental treatments difficult or impossible. For such purposes, hypnosis is often used in dental practice as an alternative for a number of treatments adjuvant or instead of sedation or general anaesthetics, as medication is often associated with risks and side effects. This is the first study to address the effects of a brief dental hypnosis on the fear processing structures of the brain in dental phobics using functional magnetic resonance imaging (fMRI). 12 dental phobics (DP; mean 34.9 years) and 12 healthy controls (CO; mean 33.2 years) were scanned with a 3 T MRI whole body-scanner observing brain activity changes after a brief hypnotic invervention. An fMRI event-related design symptom provocation task applying animated audio-visual pseudorandomized strong phobic stimuli was presented in order to maximize the fearful reactions during scanning. Control videos showed the use of familiar electronic household equipment.

In DP group, main effects of fear condition were found in the left amygdala and bilaterally in the anterior cingulate cortex (ACC), insula and hippocampu (R < L). During hypnosis DP showed a significantly reduced activation in all of these areas. Reduced neural activity patterns were also found in the control group. No amygdala activation was detected in healthy subjects in the two experimental conditions. Compared to DP, CO showed less bilateral activation in the insula and ACC in the awake condition. Findings show that anxiety-provoking stimuli such as undergoing dental surgery, endodontic treatments or insufficient anaesthetics, can be effectively reduced under hypnosis. The present study gives scientific evidence that hypnosis is a powerful and successful method for inhibiting the reaction of the fear circuitry structures.

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1. Introduction

Most people show some kind of apprehension or anxiety when they have to go for a dental treatment. According to Stouthard and Hoogstraten (1990) 40% reported that they were anxious about dental treatment and 10% indicated to have severe anxiety when visiting a dentist.

However, subjects with dental anxiety or dental fear are differentiated from patients with a dental phobia (DP), suffering from a disproportional fear of (invasive) dental procedures by the severity of their psychological and physiological symptoms. The phobic stimulus is avoided. Triggers of fear are the perception of multimodal sensory stimuli, including visual (the sight of the dentist, the dentist's chair and the surgery kit), auditory (e.g. the sound of a drill) and olfactory (the smell of the dentist's surgery room). Phobic patients may suffer from a traumatic experience caused by previous treatments. Oosterink et al. (2008) carefully analysed the anxiety-provoking capacity of a large set of dental stimuli. Results indicate that invasive stimuli such as surgical procedures were rated as the most anxiety provoking stimuli. The most fearful stimuli were as follows (ranked in order of anxiety provoking): (1) having dental surgery, (2) having some gum burned away, (3) having a root canal treatment, (4) insufficient anaesthetics and (5) extractions of a tooth.

According to DSM-IV-TR dental phobia (DP) is classified as a specific phobia of the blood-injection-injury phobia (B-I-I). However, recent evidence (van Houtem et al., 2014) suggests that DP and B-I-I are independent subtypes. DP patients rated typical

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B-I-I phobic stimuli, like the sight of blood, significantly lower as compared to individuals with B-I-I. Patients with DP showed a high level of fear to multiple stimuli, particularly involving invasive procedures, but they are not afraid of blood or injections per se. Also, 95% of the patients with DP showed avoidance behavior for dental care, but only 13% of the dental phobics reported a history of fainting during dental treatment. The authors concluded that DP should be considered as a specific subtype in the DSM classification system independent of B-I-I.

Several authors reported about the good acceptance of hypnosis in DP patients and their effectiveness in reducing pain and anxiety (Abdeshahi et al., 2013; Fabian et al., 2009; Glaesmer et al., 2015; Halsband, 2011; Schmierer and Schuetz, 2008). Positive effects of hypnosis in patients with dental phobias include prevention of avoidance behavior and the resulting lack of dental treatment, reduction of extreme fear and anxiety, reduced felt pain, less bleeding during tooth extractions and better and faster wound healing. Taken together, a successful implementation of hypnotherapeutic interventions in dental treatments has positive effects on both the extreme fear and the felt pain of the patients while side effects are reduced to a minimum. An improvement of the subjective experience of a dental treatment is highly relevant to prevent avoidance behavior and the resulting lack of dental care.

In daily dental practice many dentists have to cope with a large number of patients. This means that often there is little additional time available to help the patient to overcome his fears and anxieties. Also, a dental surgery may be urgent, e.g. in case of a root canal treatment, so there is not enough time to allow the patient to enter a hypnotherapy with a local specialist which may last several weeks. Thus, short hypnotic interventions performed by the dentist himself have become an important and effective method to help these patients to enter therapy. Therefore, in the present study we examined the effects of such a short dental hypnosis on the neural mechanisms of DP patients.

Several studies looked at the neural mechanisms of dental phobias (e.g. Caseras et al., 2010a; Hilbert et al., 2014, 2015; Lueken et al., 2011a, 2011b, 2014; Scharmueller et al., 2015; Schienle et al., 2013). Results suggest different neural response patterns in DP as compared to snake phobics (Lueken et al., 2011a). Schienle et al. (2013) reported about gender specific brain activation patterns: males presented with a greater activation of the caudate nucleus, females showed an enhanced dorsolateral prefrontal cortex involvement. Muensterkoetter et al. (2015) reported about different neural correlates of sustained vs. phasic fear in phobics. Phasic fear was accompanied by a strong amygdala activation, whereas sustained fear was characterized by an activation in the insula, anterior cingulate cortex (ACC) and the bed nucleus of the stria terminalis.

Why to study the mechanisms of dental phobia and the effect of a hypnotic intervention? To examine dental phobia is unique since no other body part has been strongly associated with a specific phobia. Meyer et al. (2014) reported about an enhanced susceptibility of tooth pain to fear conditioning. Results showed an enhanced amygdala and orbitofrontal cortex activity in the first half of the conditioning procedure. Their findings are in agreement with previous fear conditioning studies which indicate that the amygdala is involved during the initial phase only (Büchel et al., 1998; LaBar et al., 1998).

The **amygdala, insula and anterior cingulate cortex (ACC)** form a crucial part of the so-called "anxiety circuit" put forth by Etkin and Wager (2007). More recently, Bruehl et al. (2014) confirmed the hyperactivation of the fear circuit. The insula is typically coactivated together with the amygdala (Kohn et al., 2014; Robinson et al., 2010) especially during emotion processing (Stein et al., 2007) and has been shown to be involved in processing stimuli evoking disgust as an emotional response and in the representation of interoceptive information (Chen et al., 2009).

We aimed to investigate whether these structures can be activated in dental phobics and whether a brief dental hypnosis has direct enhancing effects on the neural activity patterns in these fear circuitry structures. We also hypothesized that in many patients with dental phobias strong fearful reactions can be traced to a triggering of traumatic recollections associated with previous dental treatments. Therefore we expected a significant increase in **hippocampal** activity in the awake state and a reduction in hippocampal activity during hypnosis.

Not using any kind of hypnotic intervention Lueken et al. (2011a, 2011b, 2014) investigated in very well-controlled and systematic studies neural activity in patients with specific phobias (dental phobia as compared to snake phobia). Interestingly, in dental phobics no defensive mechanisms in the amygdala and the hippocampus were observed after the presentation of phobic stimulus material. However, one may question whether the phobic stimuli used in their study were strong enough to elicit the maximum of fear responses. For instance, Lueken et al. (2011a, 2011b) showed a video when a dentist puts on his latex gloves to prepare for the treatment. We hypothesized that an activation in the **amygdala, ACC, insula and hippocampus** may occur in these patients if we use extremely strong phobia-inducing video material. We wanted to find stimuli which are very highly frightening for patients suffering from a dental phobia- they also had to be specifically connected with dental treatments. We therefore performed an extensive preliminary investigation in order to ensure that only those video-clips were used which had a very high potential of fear inducing capacity. No videos were shown which illustrated more general preparations for a hygienic medical treatment like putting on sterile gloves. Our preliminary study was based on a different group of subjects. They were asked to rank the video material on a rating scale according to their feelings of dislike. Only those stimuli which were judged to be most frightening/disgusting were included in the present investigation. Full details are presented in the section "preliminary investigation". In addition we hypothesized that normal control subjects (CO) would show a measurable brain reaction to the negative video material. We postulated that these brain regions are less activated in CO as compared to our phobic patients because the video material did not appear to be extremely frightening to them.

However, in our extensive preliminary investigation (Halsband, 2011; Strickner and Halsband, 2010) our control subjects ranked the dental stimuli as very disgusting and unpleasant to look at. We therefore postulated that hypnosis would also result in a decrease in brain activation in our normal subjects. This hypothesis is supported by recent fMRI findings by Jiang et al. (2016). The authors showed in highly hypnotizable healthy subjects under hypnosis plasticity changes in the ACC and insula. It was concluded that there is a altered state of attention under hypnosis and a modified body awareness. Furthermore, in a fMRI study by Robinson et al. (2016) it was shown that attentional control can modulate activity within anxiety potentiated amygdala-frontal coupling in healthy subjects. When subjects were instructed to shift their attention away from threatening emotional stimuli a corresponding down regulation of circuit coupling was observed despite the fact that the threatening context of the stimuli remained. Hypnosis is an example of a psychological intervention by which attentional control can modulate the neural circuitry of fear and anxiety. In hypnosis, sensory processing is limited and determined by suggestions. In accordance with the findings by Robinson et al. (2016) we hypothesized that a shift of attention away from the threatening and disgusting character of the dental stimuli may result in a reduction of activity after hypnotic induction in our healthy subjects as well as in our phobic patients.

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