

RESEARCH ARTICLE

What happens in the brain in dental phobics after psychological interventions?

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Abstract:

Patients with a dental phobia (DP) are suffering from a disproportional fear of (invasive) dental procedures characterized by the severity of their psychological and physiological symptoms. The phobic stimulus is avoided. To find an effective method of treating the severe dental anxiety in these patients is thus highly relevant to prevent avoidance behavior and the resulting lack of dental care.

In this review, we discuss evidence on the effectiveness of psychological treatments of dental phobias. Special emphasis was given on dental hypnosis, virtual reality exposure therapy and meditation. We critically discussed the efficacy of these treatments and -provided studies when available- on the effects of the treatments on inhibiting the reaction of the fear circuitry structures in the human brain.

1.0. Dental phobia (DP)

1.1. Classification and definition:

Many people show some kind of apprehension or anxiety when they have to go for a dental treatment. According to Stouthard & Hoogstraten (1) 40% reported that they were anxious about dental treatment and 10% indicated to have severe anxiety when visiting a dentist. It is estimated that as many as 75% of US adults show some degree of dental anxiety (2). Although for many people a visit to the dentist seems to be accompanied by fear, it's around 11% of the patients who suffer from a dental phobia (DP) (3). Jöhren and Sartory (4) estimate that approximately 60% of the German adult population have a mild to moderate fear, 15% a strong above-average fear of tooth treatment and only 20-30% go to the dentist without any worries and anxieties. Numerous dentists also report their own fears when they themselves have to undergo dental treatment, as surveys have shown on some of our courses for the use of suggestive procedures in dentistry.

Patients with a dental phobia (DP) can be differentiated from subjects with a dental anxiety or dental fear. DP patients are suffering from a disproportional fear of (invasive) dental procedures characterized by the severity of their psychological and physiological symptoms.

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), the fear is so intense and out of proportion to the situation that the phobic stimulus is avoided. This avoidance behaviour interferes significantly with the person's normal functioning and most often results in the failure to appear for appointments. Often, physiological responses such as sweating or increased heart rate are reported (3, 5, 6).

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).

Many DP suffer from a traumatic experience caused by previous dental treatments, vicarious learning from anxious family members or peers, individual personality characteristics and lack of understanding (7).

According to DSM-V, dental phobia (DP) is classified as a specific phobia of the blood-injection-injury phobia (B-I-I). However, recent evidence (8) suggests that DP and B-I-I are independent subtypes. DP patients rated typical 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.

Oosterink et al. (9) analyzed which stimuli are the most fearful ones for DP patients. The authors reported that in DP invasive stimuli such as surgical procedures were rated as the most anxiety provoking stimuli. The most fearful stimuli (ranked in order of anxiety provoking) were as follows: 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.

To examine the mechanisms of dental phobia and their treatment methods is unique since no other body part has been so strongly associated with a specific phobia.

1.2. Neural mechanisms:

Several studies looked at the neural mechanisms of dental phobias (10-18). Schienle et al. (18) 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. (19) 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.

There are controversial results about the possible role of the amygdala in DP.

Lueken et al. (14-16) 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. Results suggest different neural response patterns in DP as compared to snake phobics (14).

In contrast, Halsband and Wolf (11) reported an activation in the amygdala, ACC, insula and hippocampus in these patients when extremely strong phobia-inducing video material was used. The authors used stimuli which are very highly frightening for patients suffering from a dental phobia specifically connected with dental treatments. Therefore, prior to the main experiment an extensive preliminary investigation was carried out 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 as used in the study by Lueken et al (14). Subjects 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

investigation by Halsband & Wolf (11).

The amygdala, insula and anterior cingulate cortex (ACC) form a crucial part of the so-called "anxiety circuit" put forth by Etkin & Wager (20). More recently, Bruehl et al. (21) confirmed the hyperactivation of the fear circuit. The insula is typically coactivated together with the amygdala (22, 23) especially during emotion processing (24) and has been shown to be involved in processing stimuli evoking disgust as an emotional response and in the representation of interoceptive information (25).

Meier et al. (26) reported about an enhanced susceptibility of tooth pain to fear conditioning. Results showed a pronounced 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 (27, 28).

1.3. Origin and prevention of dental phobia:

In most cases, dental anxiety (DA) and dental phobia (DP) have their origin in childhood and adolescence (29).

There are at least three important factors that have an impact on the origin of dental anxiety and dental phobia:

Personal-, external/social- and dental factors.

Personal factors and external/social factors represent a person's individual ability to cope with a dental treatment. This is influenced by family, culture and social background.

The two main dental factors are fear of painful dental procedures and lack of control.

Perceived lack of control may come from insufficient information, the feeling of not being able to stop the treatment if necessary

and not having the chance to ask questions after the treatment. These situations typically occur when dentists are more occupied with accomplishing the dental treatment rather than taking care of the patient as a whole.

Children who reported painful treatment and perceived lack of control at the dentist were 13.7 times more likely to report high fear and 15.9 times less likely to be willing to return to the dentist or dental nurse (30).

We are usually not able to change the personal and external/social factors but need to have them in mind and adapt the dental factors (pain stimuli and the dentist behaviour) accordingly.

A trusting relationship (see section 2.1.1. "rapport") between the patient and the dental personnel is important not only for the treatment of dental anxiety and dental phobia, but also for its prevention, since it can help in reducing the feeling of loss of control.

Especially with children, trust is very important and needs to be build prior to the actual treatment.

The other factor; painful dental experiences, could also be prevented through the additional use of psychological interventions, therefore, psychological interventions for the treatment of DP could also be helpful techniques for its prevention.

In conclusion it can be said, that not only dentists who plan on specializing in treating dental phobics should acquire extra psychological skills, but it is also useful for everyday practice.

2.0. Psychological interventions

2.1. Dental hypnosis

The term 'hypnosis' was derived from the Greek word 'hypnos' meaning sleep and is characterized by focused attention, a heightened compliance with suggestion, an awareness of internal images and a reduced

ability to think critically. Hypnosis extends to different aspects of the subject's personal awareness and may turn their experience into a different form of reality (31, 32). Neuroscientific evidence interprets hypnotic trance as a modified state of consciousness that emphasizes attention, concentration and the letting go of thoughts (33). Hypnosis can just be interpreted as a psychological intervention by which attentional control can modulate the neural circuitry of fear and anxiety and interact with structures related to unpleasant memories.

2.1.1. Why to use a hypnotic intervention?

Attentive used suggestion procedures in dentistry can be historically traced back to the beginnings of the last century (34). Documented case reports originally refer to the use of hypnotic suggestion for pain control. In the course of time, however, an ever increasing range of dental treatment problems is considered. In most of the publications on this subject, reference is made to the importance of hetero- or autosuggestive relaxation (35).

In the meantime, there are numerous areas where dental hypnosis and relaxation procedures are used in daily practice (36).

In hypnosis, a special rapport with the hypnotist is of crucial importance. The special rapport between hypnotist and the hypnotized person as well as the absorption of the voice of the hypnotist take a key role. In hypnosis, sensory processing is limited and determined by suggestions. The aim is to establish a psychological interaction with the patient by focusing his attention on evoked ideas and images (37, 38).

Although hypnosis is a traditional healing method, it has recently generated a multitude of techniques.

Revenstorff (39) reviewed 80 group studies concerning their empirical evidence for the effectiveness of hypnosis in a variety of psychological and medical problems. It was

concluded that hypnosis is an effective treatment method which proves its clinical impact in various areas of application.

Häuser et al. (40) reviewed meta-analyses of randomized controlled trials of medical hypnosis. Although the authors were able to retrieve 391 relevant publications, only five were studies on meta-analyses. Out of these, only one study was ranked to be of high quality, three of moderate and one of poor quality. Based on this limited material available, the effect size of hypnosis on emotional stress during medical interventions was high in one, moderate in one and low in one, two meta-analyses revealed no difference between hypnosis and controls.

The authors concluded that overall hypnosis was found to be superior to controls with respect to the reduction of pain and emotional stress during medical interventions. This encourages the use of hypnosis as a complementary technique for use in medical procedures. Hypnosis can be successfully combined with other psychological treatment methods. For instance, in a case study of two dental patients suffering from a needle phobia a combination of hypnosis-meditation and systematic desensitization was successfully used to reduce anxiety symptoms in these patients (41). However, this is anecdotal evidence and systematic and well-controlled studies with a larger group of patients are lacking.

Kleinhauz and Eli (42) report in this context the successful use of induction methods specially adapted to the wishes of the patient, in order to give the patient a stronger feeling of self-control in the dental treatment situation which is already strongly determined by the patient.

Bruxism is the involuntary, often unconscious, or nocturnal grinding or crunching of the teeth. As a result of the chewing forces occurring, the tooth hard

substance is increasingly damaged. The result is a series of abrasion and attrition, in which the dentist can detect a bruxism-suffering by inspection of the teeth during the semi-annual routine examination. Symptomatic therapy option is conventional splint therapy (43). The individually designed bite splint serves the patient to protect the teeth and as a prophylaxis against further abrasion of the teeth by clenching and crunching. If the patient wishes to supplement a cause analysis or further therapy, a hypno-therapeutic treatment is an option. Many dental practitioners delegate these indications to psychotherapists with whom they work together, since the required length of treatment cannot be guaranteed in their practice due to a high volume of patients. Splint therapy and other treatment options are discussed holistically also in other medical disciplines (44). One treatment option is the combination of a conventional splint therapy with hypnotherapy. Sometimes hypnosis helps to uncover and resolve earlier conflict in the patient's life; bruxism is also discussed as a multiple etiological factors-associated disease with a psychosomatic nature (45, 36).

Patients with chronic pain in the maxillofacial area are not uncommon. The quality of life of those affected is severely impaired. In the meantime, relaxation methods have been used for more than a few decades. While hypnosis was usually chosen as the last resort or after many failed standard therapies, awareness of those pain-alleviating therapy options among the people has increased vehemently. A complete replacement as an alternative is however not at all intended. Rather, an adjuvant/complementary hypnotherapeutic support is desired for the everyday use in practice, with the resultant, quantitatively lower use of anesthetics (36, 46, 47).

In addition to targeted behavioural management and communication, the

treatment of children requires special attention for the dental team. Since first contact, short waiting times, communicating with the parents and the actual treatment have to be considered. Due to their age, children are in different stages of developmental psychology. The cognitive abilities of an adult must never be assumed in children. The phases of concentration in children are extremely short. Therefore, the dental treatment must also be quick. In order to avoid an immediate anesthesia if there is a lack of compliance, the dental hypnosis with all its components has gained worldwide interest from the dental profession. The use of hypnosis with playful elements is an important treatment option, combined with behavioural guidance, a clear treatment structure with a defined goal and well-established communication. The children can be treated very well with dolls, "thumb-TV" and "magic bags" (bags with small toys, into which the child can reach without having a look to search for a present, it can be used as a reward after the treatment). In summary, using hypnosis in pediatric dentistry is evident (48) and is an important tool that can help pediatric dentists to increase patient cooperation, reduce fear, decrease resistance during painful procedures and also lead to a lower heart rate (49, 36).

The urge to gag is physiologically given by the innervation of the pharynx in every human being. However, a psychological, anxiety-induced gag reflex may occur, especially in dental procedures. In addition to anamnestic possible oral abuses, there might be other causes. Whether in x-ray images, where the sensor must be placed in the mouth or impressions or bites, the gag reflex can happen. Behavioural training, distraction, or symptom prescription are methods that are used in combination with hypnotic gag reflex control (50). The problem of a severe gag reflex is a challenging problem both for the treatment team and the patients who may have to

vomit (51). A pure symptom treatment is possible as well as the more frequent variant of the symptom treatment in combination with hypnotherapy or a combination of hypnosis with acupuncture. In that case, psychological and physiological aspects are influenced at the same time and can successfully treat the gag reflex; this is an effective therapeutic option (36, 50).

2.2. What is specific about dental hypnosis?

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 time-consuming hypnotherapy with a local specialist which may last several weeks. Thus, short hypnotic interventions performed by the dentist himself or audio-taped by a professional hypnotherapist have become an important and effective method to help these patients to enter therapy.

In this context, we consider the work by Fiedler (52) for the treatment of dental phobias to be of crucial importance. The main concept is that three key words particularly associated with a feeling of deep relaxation were given before the presentation of the stimuli. Important to know is that these words were individually chosen in advance by our subjects. Typical examples of words chosen are "sun-beach-sea" or "caribics-holidays-palm trees". Every subject had chosen those words which would trigger the best possible association with happiness and relaxation. This was the method we used in our own investigation: Subjects informed us about five days before scanning which words they had selected. These words were slowly spoken, audio-taped and integrated into our stimulus presentation. In the awake condition, non-

sense words were used as a control. We believe that this individual approach under hypnosis helped the subjects to reach a maximum of relaxation. For instance, if a person is particularly fond of mountain climbing it is unlikely that he would choose an association connected with the sea side. We ascertained that individual hypnosis is helpful for hypnotic intervention instead of a standardized hypnotic induction from a tape. In individual hypnosis, the selected key words are strongly associated with a relaxing state and can be used for an effective hypnosis in multisensory modalities (46, 47).

From childhood the visit to the dentist is one of the recurring events in life. For the majority of patients the treatment is associated with unpleasant experiences and feelings. This discomfort manifests itself in fear of pain, of injections, or of imminent loss of control, as some patients feel abandoned by their dentist, but also in a fear of criticism of their lack of oral hygiene through the dental team. The oral cavity has a very high density of sensory receptors (53). Dental interventions can therefore often be associated with a painful experience. The maxillofacial area is distinguished by a disproportionate representation at the sensory cortex in comparison to other areas of the body's surface. In addition, the mouth area also has an important psychological significance, so that the actual treatment is experienced by some patients as a "penetration into the intimate sphere" (54). A general tooth treatment anxiety can result from the mentioned stress factors, which can increase until a dental phobia occurs, depending on the case (36).

In clinical-experimental studies on hypnosis and self-hypnosis on vital teeth, both an increase in the subjectively perceived and individually determined pain threshold as well as a reduced individually determined subjectively perceived maximal pain intensity by electrical stimulation of the

dental pulp has been reported (46, 47, 55). This means that the patient is able to withstand "more pain" and only afterwards assesses this as a "pain experience". The use of hypnosis with audio-tapes (e.g. via CD) may not only have positive effects on the average diastolic blood pressure and the heart rate; the subjectively perceived anxiolytic effect has also been observed in patients during dental implantations (56). Also, by means of live hypnosis in wisdom teeth extractions, an effective reduction in the patient's anxiety was noted in addition to pain and bleeding reduction (57). The anxiolytic effect of hypnosis, often accompanied by observations of simultaneous reduction of anxiety and pain, is demonstrated by Huet et al. (58). In patients with persistent orofacial chronic pain ulcers treated with hypnosis, clinically relevant pain relief was demonstrated (59). The effectiveness of the treatment of craniomandibular dysfunction (CMD) was also confirmed by the study of functional impairment of the masticatory system (fMRI) (36, 60, 61).

Pain, anxiety and haemorrhage can be effectively reduced through hypnotic intervention (57, 58, 62). Furthermore, hypnosis can be presented as a gentle, non-invasive procedure without any known side effects. Nowadays, hypnosis is a routinely used technique in dentistry. Especially in situations when medication or anesthesia are contraindicated or declined by the patient, hypnosis is able to help (48). Montenegro et al. (63) published a case report which confirms that hypnosis is a useful technique in the management of patients who have to undergo surgery in the oral areas. Hypnosis helped to reduce pain and fear in these patients.

Interestingly, there are several most recent studies available on the effect of psychological interventions in pediatric patients with dental anxieties (64-66), but as yet little is known about the effects of

psychological therapies in adult dental patients. Goettems et al. (65) reviewed 22 articles on the effect of psychological interventions in behaviour, anxiety and pain perception in children undergoing dental treatment. The majority of the studies used distraction methods rather than hypnosis. Distraction is a psychological procedure of diverting the patient's attention away from the threatening stimuli (e.g. dental treatment). It has been shown earlier that distraction can help patients showing mild or moderate anxiety with a dental treatment (67, 68), but it is not known yet whether this also helps phobic patients. In the review of Goettems et al. (65) eight studies presented bias and results were not included in the analysis. Out of the remaining studies, 13 had control groups with inactive controls. The authors concluded that although the majority of psychological techniques used showed some improvement on the child's anxiety feelings and pain perception, there is as yet too little evidence to say which techniques are the most effective ones for improving behaviour and reducing children's pain and distress during dental treatment. Anthonappa et al. (64) are planning a detailed review on the efficacy of psychological treatment for managing dental anxiety in children. The protocol sounds very promising, but unfortunately no results have been published yet.

3.0. Virtual reality exposure therapy

Virtual Reality (VR) integrates high-end computer graphics, 3D visual displays and multi-sensory inputs to create sensory illusions that simulate reality. Use of such computer-generated VR environments in the form of Virtual Reality Exposure Therapy (VRET) has emerged as a promising modality in the treatment of specific phobias (69) including dental phobia (70, 71). A recent systematic review has indicated that VRET is slightly better compared to the gold standard in-vivo exposure therapy (IVET) in

the treatment of specific phobias (72). VRET, similar to IVET works by processing emotions, by activating a phobic person's underlying fear structure through controlled confrontation with the fearful stimuli, without aversive outcomes (73). This causes learning that the fear is unfounded, thereby adjusting negative, irrational predictions (74) resulting in wearing-off the association between the fearful stimuli and maladaptive emotion.

For VRET to be effective in triggering anxiety, subjects should perceive themselves to be physically present in the virtual world (immersion and presence). Thus, presence and immersion are important mediating variables (75) between the VR environment and the anxiety induced (69). The most common measures utilized to evaluate the immersion, presence and distress involve the use of subjective measures such as self-reported questionnaires and objective physiological measures such as heart rate, skin conductance response, temperature and respiratory rate. These subjective and objective measures have potential set-backs. Firstly, though self-reported responses are easily obtained, they are prone to bias (76). Secondly, there is as yet little information about the relationship between neural correlates and observed peripheral physiological measures available. However, most recent evidence suggests that there is a link between heart rate variability and neuroimaging studies: Thayer et al. (77) performed a meta-analysis of studies relating cerebral blood flow to heart rate variability. The authors found several areas including the amygdala and the medial PFC that are involved in the perceptions of threat and associated with heart rate variability.

Lastly, there is no evidence if neural recovery occurs and whether the improvement is partial or total following VRET. This necessitates us to understand the accurate brain changes caused during

VRET which can determine a more reliable outcome.

The common tools used for brain imaging involve the use of functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) and functional near-infrared spectroscopy (fNIRS). An fMRI study has demonstrated that VRET is known to restore normal brain activity in PTSD patients (post-traumatic stress disorder) (78). However, only limited studies have utilized brain imaging to determine the effectiveness of VRET in the treatment of specific phobias.

There are several potential advantages of using a combination of VRET with brain imaging devices such as better evaluation of the disorder prior to VRET, real-time monitoring of the neuronal activity and controlling the exposure based on response of the brain to stimuli, studying the complexities of brain function when confronted with fearful stimuli and recording of cerebral activity which is far less biased compared to subjective evaluation with self-reported questionnaires. Additionally, brain imaging pre-post intervention and follow-ups will enhance our understanding of non-responders and developing an effective future treatment. This could help in developing a direct link between the nervous system and virtual reality by establishing a brain and computer interface that can control the VRET without the need of a therapist. Hence, it seems worthwhile to explore the combination of brain imaging with VRET in the treatment of dental phobia.

Recently, the use of portable fNIRS has gained considerable attention in VR research. It is portable, quieter and less prone to motion artifacts compared to fMRI and PET scanning. The improvements in hardware and software of virtual reality technology could facilitate integration of VRET with fNIRS or fMRI which may optimize the treatment of dental phobias, improve the current VRET systems and

foster better understanding of brain function. However, fNIRS also has severe restrictions. Although it is a good method for detection of e.g. prefrontal lobe activity changes, it is not well suited for examining subcortical regions (79). Thus, in order to analyze brain activity changes in limbic fear circuit structures it is not the best method available.

4.0. Meditation training

The term “meditation” comes from the Latin “meditatio” which originally indicated every type of physical or intellectual exercise. Meditation generically refers to an extremely wide range of practices including Buddhist, Christian, Islamic, Hindu, and Jewish traditions. Thus, defining meditation involves the need for a precise understanding of meditation as a scientific explanandum taking into account the importance of various traditions (80). Furthermore, certain aspects that have been described as “self-hypnosis” by one scientist might well be described as “meditation” by another scientist and vice versa (81).

Both, hypnosis and different forms of meditation practices show beneficial effects for coping with stress. It is possible to relax one’s mind, soul and body. The techniques can also be used as prevention methods to avoid harmful effects of stress induction.

At the neurobiological level, meditation decreases sympathetic activity, lowers cortisol and causes cortical thickening, and it leads to specific changes in the electroencephalogram (EEG) that correspond to mental relaxation and activates areas in the brain responsible for emotion regulation (82-84). Using a within-subject design, Halsband et al. (33) showed that brain plasticity changes in hypnosis can be clearly differentiated from neurophysiological changes in meditation. In the meditation condition, a highly significant increase in alpha 1 power was predominantly observed in the frontal

cortex. In contrast, under hypnosis significant increases were most pronounced in central and temporal locations. A significantly greater activity in theta 2 band was observed only under hypnosis, but not under Tibetan meditation. Theta band activity changes in hypnosis were observable in both hemispheres.

During meditation, sensory input is diminished (85, 86). In meditation, sustained concentration and heightened awareness can be achieved by focusing attention on mantra, breathing rhythm, or a number of other internal or external events (86-89). This is accompanied by changes in neuroelectrical activity and indicated by increases in alpha, gamma and theta waves (90, 91). Under meditation - as compared to relaxation - an increase in alpha amplitudes was observed (84, 92, 93) which appeared to be most pronounced in the frontal cortex (94, 95). An increase in theta power was reported by several authors in different types of meditation (Sahaja Yoga, Yoga Nidra, Zen breath counting and Qi Gong) (96-99). Lutz et al. (100) found in eight long-term practitioners of the Kagyüpa- and Nyingmapa- schools (compared to 10 non-practicing students) a high amplitude activity and a marked phase synchronization in the gamma-band (between 25 and 42 Hz), especially in lateral fronto-parietal locations (see also 92). Coromaldi et al. (101) investigated the EEG-activity in a Zen-master during deep meditation. The results of the deepest meditation stage showed an increase in the alpha band (8–13 Hz) and theta-power (4–7 Hz) at all locations and most prominent in the left parietal cortex. In contrast, there was a reduction of beta-activity (15–28 Hz) over the right hemisphere. Aftanas and Golosheikine (96) made an important point: in long-term meditators (Sahaja yoga tradition) changes in EEG activity were dynamical and dependent on the arousal level. Increasing the arousal level (viewing aversive video clips) desynchronized activities in theta and

alpha frequency bands. But taken together the results are controversial. There are different kinds of meditation techniques and therefore the findings are heterogeneous. The heterogeneity is additionally caused by the great variability in the degree of experience in meditation (33). It is also difficult to compare recent and older studies because technology and analytical procedures have changed.

There is an increasing interest in plasticity changes in the brain in hypnosis as compared to different types of meditation (33, 102-104). One of the main purposes of both hypnosis and meditation techniques are to understand and gain control of our emotions. Both methods show beneficial effects for stress reduction, but this common goal is achieved by different means. Whereas in hypnosis a special rapport with the hypnotist and suggestions play a central role, it is independence from needing social relationships that plays a key role in meditation exercises. Hypnosis and meditation show differences in terms of sensory input, processing, memory, and sense of time. Therefore, it is not surprising to find brain plasticity changes in hypnosis that can be differentiated from neurophysiological changes in meditation (33). Further research is needed to disentangle plasticity changes in hypnosis and different types of meditation and to systematically compare shared and non-shared neuronal substrates in different stages of hypnotic trance.

As yet, there are no systematic studies available on the effects of meditation on the treatment of patients with dental fear or phobias. However, there is most recent evidence (105) that meditation helps patients suffering from myofascial pain syndrome. These are promising findings. It would be worthwhile to test the effects of a mindfulness meditation training on the reduction of fear and dental phobia.

5.0. Plasticity changes in the brain in DP after psychological interventions

There is little evidence on the interesting topic what happens in the brain after psychological interventions in DP. Halsband and Wolf (11) published the first functional magnetic resonance imaging (fMRI) study on the effects of a brief dental hypnosis on the fear processing structures of the brain and the hippocampus in dental phobics and in healthy subjects. Using fMRI, DP patients and control subjects were presented animated video clips with strong phobic dental stimuli. Brain activation patterns were analyzed under hypnosis and in the awake state of the subjects. The authors reported that dental hypnosis alters the neural activation patterns in the amygdala, the ACC, insular and hippocampus. In DP, a significant reduction of neural activity after hypnotic induction was observed in the left amygdala, bilateral ACC, bilateral insula and bilateral hippocampus (R<L).

But changes were also found in the control group. Hypnosis reduced the neural activity patterns in CO in the insula and the ACC. Under hypnosis, no activation was found in the hippocampus, though a bilateral activation was present in the awake condition. Within the amygdala, no activation was found in the awake state or under hypnosis. Taken together, the findings seem to indicate that a hypnotic intervention is a powerful method to reduce the response patterns to fearful (DP) and/or unpleasant stimuli (CO) presentations.

So, both dental phobics and controls seem to benefit from a hypnotic induction when confronted with dental treatments. But before one can conclude about the efficacy of dental hypnosis on the fear circuits and memory structures of the brain more brain imaging studies are needed.

As yet, there are no systematic studies available on the effects of mediation or

VRET on plasticity changes of the brain in DP.

6.0. Psychological intervention versus pharmacological intervention

Based on specific indications, some patients might still have to be treated pharmacologically using either sedation or general anesthesia, but this should only be considered in situations where the patient is not able or willing to respond and cooperate with psychological interventions.

Patients with special needs (mental retardation, autism, mental illness, traumatic brain injury) and clinical situations might also necessitate pharmacological management (106). Risks, costs and indication must be considered thoroughly.

Psychological and pharmacological interventions are both equally effective in reducing dental anxiety and phobia. Though the response to psychological interventions is not as fast as to pharmacological treatments and often multiple sessions are needed to maintain an initial treatment response, studies have shown that dropout rates were lower and the effects were maintained over longer periods of time, with more patients reporting back for future treatment (107-109).

Another advantage of psychological interventions is the absence of risks caused by allergies and intolerances or the risk of intoxications and of course the long-lasting positive effects on the patient's life-quality.

7.0. General discussion and conclusions

Psychological intervention techniques are a most promising approach to help patients with dental phobias. However, as yet, there is very little evidence on the effects of non-pharmacological interventions on brain activity changes in DP. More data are needed regarding functional and structural connectivity in dental phobia to identify the

neural patterns underlying the sub-type of this disorder and for approaches under therapeutic interventions.

The work by Halsband and Wolf (11) on functional changes in brain activity after hypnosis in patients with dental phobia is one of the very few systematic studies on this topic. In summary, results showed that anxiety-provoking stimuli such as undergoing dental surgery or endodontic treatments as well as insufficient anaesthetics, which can trigger fear, can be effectively reduced under hypnosis and provide benefits to healthy subjects as well as to dental phobics. The study gives scientific evidence that hypnosis is a powerful and successful method for inhibiting the reaction of the fear circuitry structures and recall of unpleasant memory experiences.

However, a number of limitations in their study should be considered. First, all subjects were included on the basis of high hypnotic susceptibility. It needs to be examined whether subjects with low susceptibility-scores would also benefit from a dental hypnotic intervention and whether findings also apply to other treatment-seeking patients. Second, the amount of participants tested was relatively small which might limit a possible detection of small scale effects. Third, although in their preliminary investigations they carefully tested the parameters when planning this study, one cannot exclude the possibility that e.g. subjective ranking of the stimuli in terms of adversiveness can be generalized to all DP subjects. There may be large individual differences in responsiveness among them. Fourth, it needs to be examined whether significant effects of hypnosis in reducing neural activity patterns in DP can be generalized to other phobic patient groups.

Further research with larger samples of DP patients is urgently needed. It should be encouraged to carry out systematic studies

on the functional changes of brain activity in patients with DP after VRET and meditation techniques and to compare the results with the effects of hypnosis. Furthermore, it must be considered that neuroendocrine and subjective stress reactions may influence the resulting functional activation patterns (110).

There is also a need of differentiating the effects of psychological therapies on fear circuitry-processes across different phobic disorders.

Aside from psychological and conventional interventions, one might also consider worth mentioning alternative medicine treatment options such as acupuncture, since reports on the use of auricular acupuncture for treating dental anxiety have shown promising results, e.g. a randomized controlled trial comparing auricular acupuncture with intranasal midazolam for managing dental anxiety suggested that both treatment methods were similarly effective (111, 112). However, besides from not being helpful in treating phobics with additional fear of needles, the present results need to be tested in a larger randomised clinical trial in order to evaluate the effectiveness of the acupuncture treatment in patients with dental anxiety and dental phobia. Also, in terms of our original question of “what happens in the brain after the treatment”, there are as yet no data available specifically concerning the treatment of dental phobia.

Overall it can be said, that psychological interventions provide low risk, long-lasting and effective therapy for patients with dental phobia. They have a positive effect on the course and outcome of the dental treatment, which is beneficial for the patient as well as for the dentist, and additionally the patient’s life-quality in general can be improved. The various psychological treatment options still need more proof but research is on a good way to provide more evidence-based findings in the future and to become more and more established and acknowledged.

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