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Mental imagery in dentistry: Phenomenology and role in dental anxiety

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Abstract

Dental anxiety is a prevalent problem with marked psychological, physical and public health implications. Based on cognitive theory and evidence, we hypothesized that vivid, sensory image-based cognitions play a role in dental anxiety. A quantitative online survey (N = 306) and qualitative semi-structured interviews (N = 18) found that vivid sensory images were common irrespective of dental anxiety levels, but that their content, associated distress and responses varied. Participants reporting higher anxiety experienced intense and intrusive fear-provoking dental imagery focusing on unpleasant sensations, which were associated with the intrusive recollection of negative past experiences and avoidance of dentistry. Participants with lower anxiety ratings, reported images that were less distressing and centered around reassuring aspects and positive appointment outcomes, potentially acting as protective factors against dental anxiety and facilitating appointment attendance. The inclusion of components aimed at reducing intrusive memories and dental imagery rescripting may help improve interventions for dental anxiety.

1 Introduction

Previous research suggests that mental imagery plays little or no role in dental anxiety (De Jongh & Ter Horst, 1993). This finding is anomalous because there is strong evidence that such cognitive processes contribute significantly to the development and maintenance of other anxiety disorders (Holmes & Mathews, 2010). In particular, vividly imagining feared situations can lead to patterns of avoidance that perpetuate and exacerbate the anxiety. We present the first in-depth study of people's experiences of imagery in relation to dentistry, with the aim of better understanding dental anxiety, of suggesting novel targets for interventions, and exploring the extent to which dental anxiety shares this key feature with other anxiety disorders.

Dental anxiety is highly prevalent in the general population (Hill, Chadwick, Freeman, O'Sullivan, & Murray, 2013; Oosterink, De Jongh, & Hoogstraten, 2009; Sohn & Ismail, 2005) and has profound implications for psychological and public health (Eitner, Wichmann, Paulsen, & Holst, 2006). It can have a substantial impact on everyday life, disrupting sleep, work and personal relationships (Cohen, Fiske, & Newton, 2000). As with other anxiety disorders, avoidance is a serious problem in dental anxiety. Anxious patients are more likely to have symptom-driven visiting patterns, increasing the likelihood of oral health problems and need for treatment. Anxious patients, who only visit the dentist when in pain and needing treatment, are more likely to experience pain during treatment, feeding their anxiety further (Armfield, 2013; Guentsch et al., 2017).

Relatively little research to date has investigated specific cognitive processes underpinning dental anxiety, even though they are assumed to be important for the development and maintenance of the problem (Armfield, 2013; De Jongh, Muris, Ter Horst, & Duyx, 1995; De Jongh & Ter Horst, 1993). Negative past experiences of dental treatments are to some extent predictive of dental anxiety (Davey, 1989; Eli, Uziel, Baht & Kleinhaus, 1997), but they do not provide a full explanation. De Jongh, Aartman, and Brand (2003) found that patients in general dental practice were just as likely to have experienced negative dental events as highly anxious patients attending a specialist dental fear clinic. Cognitive

processing of such events, and of dental experiences more generally, determine whether they trigger the development of dental anxiety. Consistent with our focus on cognition, Armfield (2010) found that perceptions about dental visits, for example seeing them as uncontrollable, unpredictable, dangerous or even disgusting, were superior predictors of dental anxiety scores than negative past experiences.

What patients imagine has been shown to be particularly important in several other anxiety disorders, including health and social anxieties (e.g. Holmes & Mathews, 2010; Holmes & Bourne, 2008; Hirsch & Holmes, 2007; Day, Holmes, & Hackmann, 2004; Ehlers & Clark, 2000; Borkovec & Inz, 1990). Mental images, are internal, often vivid, representations typically involving several sensory modalities including emotions and bodily feelings (Andrade, May, Deeptose, Baugh, & Ganis, 2013), which differentiates them from verbal cognitions that have a less experiential quality. Mental imagery activates similar neural circuits and bodily reactions to actual perceptions and experiences (Kosslyn, Ganis, & Thompson, 2001; Lewis, O'Reilly, Khuu, & Pearson, 2013). Experimental findings suggest that imagery distracts attention from the external world to the mental image, intensifying emotional experiences (Holmes, Geddes, Colom, & Goodwin, 2008).

In affective disorders, imagery may interfere with paying attention to other information, including information that could disprove imagined fears, and therefore contributes to the maintenance or even exacerbation of the problem (Holmes & Mathews, 2010). Imagery processes are also thought to contribute to the etiology of affective disorders (Brewin, Gregory, Lipton, & Burgess, 2010). For example, playing the computer game Tetris 30 minutes after exposure to aversive film material seems to block imagery development and reduces intrusive re-experiencing of the film in the form of flashbacks over the following week (Holmes, James, Kilford & Deeptose, 2010). As sensory-perceptual information processing and imagery cognitions compete for limited cognitive resources, concurrent cognitive tasks such as playing Tetris could interfere with further image elaboration and encoding processes otherwise leading to reoccurring intrusive imagery (Holmes & Mathews, 2010; James et al., 2015). In the case of dental anxiety, anxious patients have repeatedly been found to report memories of intense pain associated with dental treatments and related intrusive thoughts (Cohen et al. 2000;

Kent & Gibbons, 1987; Oosterink, De Jongh, & Aartman, 2009). However, no systematic investigation of dental imagery more broadly has been carried out to date even though examining disorder-specific patterns of emotional dysregulation is essential to develop effective interventions with clinical relevance (Tracy, Klonsky, & Proudfit, 2014).

The only study exploring dentally anxious patients' thoughts that explicitly refers to mental images found that such cognitions were reported by merely 26% and less frequently than thoughts about losing control or catastrophic thinking (De Jongh & Ter Horst, 1993). This may suggest that imagery is not as important in dental anxiety as in other anxiety disorders. However, this finding could also be due to the difficulties of verbalizing imagery cognitions. Anxiety patients frequently omit imagery because assessment questions often focus on verbal thoughts (Hirsch & Holmes, 2007). Complicating matters, De Jongh and Ter Horst (1993) based their interview protocol on a study by Butler et al. (1987), who found no reports of imagery in a sample with generalized anxiety disorder. Recent research however suggested that imagery is present in this disorder, albeit curtailed during episodes of worry (Hirsch, Hayes, Mathews, Perman, & Borkovec, 2012). The role of imagery in dental anxiety therefore remains inconclusive and dental imagery in non- or less anxious dental patients has been neglected entirely. Investigating this could help to identify protective factors that facilitate coping with a situation that potentially involves painful, invasive and costly treatments, which could be argued is intrinsically anxiety-provoking.

The present study addressed these uncertainties by identifying the phenomenology and role of dentistry related imagery, alongside assessments of thoughts about past and future dental visits in participants reporting lower and higher levels of dental anxiety. May et al. (2014; Kavanagh, Andrade, & May, 2005; May, Andrade, & Kavanagh, 2015) have argued that two aspects of imagery-cognitions may be important in determining affective states: the extent to which seemingly spontaneous thoughts intrude into awareness, and the vividness of elaborated images. Based on the evidence that imagery functions as an emotional amplifier (Holmes et al., 2008) and increases the likelihood of acting out an intention (Biondolillo & Pillemer, 2014; Gregory, Cialdini, & Carpenter, 1982; Knäuper, Roseman,

Johnson, & Krantz, 2009; Knäuper, McCollam, Rosen-Brown, Lacaille, Kelso, & Roseman, 2011), we hypothesized that imagery of past and future dental appointments, including images of instruments, smells and sounds, would influence anxiety associated with dentistry as well as the likelihood of attending or avoiding appointments. Given the novelty of the topic and to gain a comprehensive understanding of dental imagery, mixed methods research was carried out - an approach that to date has rarely been used to investigate dental anxiety and its underlying cognitive processes.

2 Materials and methods

2.1 *Participants and procedures*

A quantitative survey was used to assess the phenomenology and role of dental imagery and associations with anxiety, past negative experiences and avoidance. This was followed by qualitative interviews that investigated dental images and thoughts in purposively sampled participants with different levels of dental anxiety. Ethical approval was obtained from a UK university ethics committee for this research, which was carried out in accordance with the provisions of the World Medical Association Declaration of Helsinki.

To explore basic cognitive processes relevant for a clinical dysfunction that is, to varying degrees, highly prevalent in the general population (Hill et al., 2013), a non-clinical sample of students was recruited. They completed an online survey between 16th January and 15th February 2012 as part of a course requirement to participate in research. Students are as much dental patients as other groups, varying regarding their levels of dental anxiety, treatment experiences and avoidance behavior, and have been successfully used in prior dental research (e.g. Schüz et al., 2006).

The content and nature of dental imagery, intrusive memories and anticipations was subsequently investigated conducting in-depth semi-structured interviews. Similar interview methods have been used to explore imagery in previous research (Lockett, Hatton, Turner, Stubbins, Hodgekins, & Fowler, 2012; Muse, McManus, Hackmann, & Williams, 2010). Participants were recruited from the sample that completed the survey and indicated their willingness to take part in further research. They were

purposively sampled based on their survey scores according predefined criteria (dental anxiety, past experiences, imagery scores, dental service utilization), either because they were typical cases or outliers (Silverman, 2011). Recruiting positive as well as negative cases for each criterion prevented solely selecting participants that were likely to support prior assumptions. Potential participants were contacted with personalized email invitations. As for the survey, participation in this particular interview study was entirely voluntary and participants were ensured that they could withdraw at any point without being subject to negative consequences. It was further clarified in the introduction part that information would be treated confidentially, solely used for the purpose of researching dental experiences and not be shared with treating dentists. Interviews were carried out face-to-face from April to May 2012 by the first author, at the time a health psychology doctoral researcher with a background in psychology. She underwent extensive qualitative training and consulted regularly with a qualitative research expert (JP - see acknowledgments) throughout the interview and analysis process. Interviews were carried out without anyone else but the interviewer and participant present and had an average length of 20 minutes. Data saturation was reached with 18 interviews.

2.2 *Online survey measures*

2.2.1 *Participant characteristics*

Basic demographics (gender and age) and participants' dental anxiety levels were assessed. Overall dental anxiety was measured using a verbal rating scale (VRS) with the question 'How much do you fear dental treatment on a scale from 0 (not at all) to 10 (extremely)?'. Such single-item anxiety measures have been found to be useful tools for brief, reliable anxiety assessments in dentistry (Armfield, Stewart, & Spencer, 2007; Neverlien, 1990), but as they do not account for the various dimensions associated with dental anxiety, participants also completed the Dental Fear Survey (DFS: Kleinknecht, Thorndike, McGlynn, & Harkavy, 1984). The DFS uses 20 five-point Likert-scale items to assess dental anxiety and three sub-dimensions of dental fear (avoidance of dentistry; autonomic

arousal during dentistry; fear of situations and stimuli), for which cross-sample stability and reliability have been demonstrated.

2.2.2 *Dental imagery*

Eleven items assessed intrusive and sensory dental cognitions according to May et al.'s (2014) distinction between intrusions and elaborated images. Participants rated the items on an 11-point scale (0 = not at all to 10 = extremely), for example '*Right now, when you think about dental treatment how intrusive are the thoughts?*' and '*Right now, how vividly are you imagining dental treatment?*' (See Table 1 for item wording). This assessment was inspired by questionnaires measuring imagery in different contexts (CEQ: May et al., 2014; ACE: Statham, Connor, Kavanagh, Feeney, Young, May, & Andrade, 2011) and a similar scale has been used by Tanja-Dijkstra et al. (2014) to assess intrusiveness and vividness of memories of simulated dental treatments in a study testing the effect of virtual reality distraction on dental anxiety.

2.2.3 *Negative past dental experiences*

Participants were asked to provide details of specific negative dental events in the past (open-ended question). If they indicated a negative dental experience, its impact was examined with the Impact of Event Scale (IES: Horowitz, Wilner & Alvarez, 1979). The IES consists of 15 items measuring commonly reported stress syndrome symptoms and the current degree of subjectively experienced distress due to traumatic events. Empirical research testifies that the IES and its two sub-scales, 'intrusion' and 'avoidance', have good validity and reliability (Horowitz et al., 1979; Sundin, 2002; Sundin, 2003).

2.3 *Semi-structured interview topic guide*

An interview topic guide was developed by an interdisciplinary team of cognitive, health psychology, public health and dental scientists based on prior anxiety and imagery research. This semi-structured interview approach ensured important topics were covered while allowing participants to

raise additional issues important to them (Forrester, 2010; Lyons & Coyle, 2007). The topic guide was piloted with two participants to check the questions' comprehensibility and its scope to uncover new themes (Silverman, 2011; Adams & Cox, 2008; Guest, MacQueen, & Namey, 2012). Considering participants' feedback from the pilot review, the topic guide was revised and then continuously adapted over the course of the interviews as new insight emerged (Creswell, 2013). The following topics were covered in the interviews:

2.3.1 Dental imagery and anxiety

Interviews started with a general question concerning participants' thoughts about dentistry, asking '*What comes to your mind when think about going to the dentist?*'. It was a starting point to explore first impressions concerning dentistry without directing participants' answers. If dental images were mentioned, they were further explored using follow-up questions based on insight from a longitudinal study of the relationship between test anxiety and intrusive thoughts (Kent & Jambunathan, 1989). Follow-up questions focused on distress associated with imagery, its strength and frequency, control efforts and perceived probability of the anticipated scenarios to occur. Participants were also asked about their worst fears concerning dental care, avoidance behavior and potential interferences with daily life.

2.3.2 Past experiences and related intrusive thoughts and imagery

Past experiences and avoidance behavior were explored, in particular participants' worst dental experiences and memories of their last appointment. The focus was on the vividness of mentioned incidents and intrusiveness of related thoughts. If applicable, participants were prompted to consider visual details, smells and sounds.

2.3.3 Expectations for future appointments and coping strategies

A further reference point to investigate dental imagery was up-coming appointments and participants' anticipations of what would happen then. Participants were asked how they felt about their next

appointment and the characteristics of related imagery, again focusing on frequency, vividness and intrusiveness. Finally, participants' coping approaches were explored by asking '*What helps you deal with this situation?*' and '*What would make it easier to attend appointments and treatments?*'.

2.4 Data analyses

As dental imagery has not been systematically investigated before, no precise sample size could be calculated. We aimed to recruit 300 participants in order to establish instances of imagery, its link to past experiences and avoidance and as a basis for purposively recruiting participants for follow-up interviews. The online survey data were analyzed with the program SPSS Statistics version 21, calculating descriptive statistics, non-parametric tests, Spearman's correlations and Odd Ratios (OR), including associated 95% Confidence Intervals (CI). The properties of the imagery scale were examined calculating Cronbach's Alphas and conducting factor analyses after testing data suitability with Kaiser-Meyer-Olkin and Bartlett's tests. As items assessing dental imagery constituted a non-validated scale adapted from assessment tools used in other settings and due to the lack of prior systematic explorations of the role and nature of imagery in dentistry, there were no conclusive evidence-based or theoretical indications for the unique structure of dental imagery in particular. We therefore conducted an exploratory analysis in the first instance extracting factors based on the scree-plot, eigenvalue and a parallel analysis (O'Connor, 2000) with 1000 simulated random data sets. We further checked for similarities with three-factor structures found in other settings (e.g. May et al., 2014; Statham et al., 2011). Similar to prior research (Kent & Gibbons, 1987), a median split was used to divide participants into a group reporting lower levels of dental anxiety and a group reporting higher dental anxiety. To avoid missing data, the online survey was programmed in a way that required answering all questions to proceed. Survey drop-outs were included through available case analysis, minimizing loss of information and increasing analysis power.

The interviews were audio-recorded and transcribed verbatim. The material was analyzed with the software NVivo 9 using Thematic Analysis according to Braun and Clarke (2006). All interviews,

including the pilot material, were considered for analysis to treat data comprehensively (Silverman, 2011). An initial coding framework was developed by AS by coding all transcripts line-by-line. This framework was discussed within the research team and tested with a group of dentists, who double-coded one transcript and provided feedback. An agreed coding framework was again applied to all interviews, constantly comparing transcripts to highlight similarities and differences between participants and checking for deviant cases. Overarching themes were developed based on those codes. To verify the analysis, findings were discussed with one of the original interview participants and with dental and psychology researchers. A decision log was kept throughout the process and AS maintained a reflective log to disclose and account for her own perspective and potential biases. The described steps as well as triangulation with the survey results should increase validity and reliability of the interview findings.

3 Results

3.1 Participant characteristics

A total of 306 students completed the survey with an average completion time of 30 minutes and a drop-out rate of under 1%. The sample consisted of 239 female and 67 male participants. This proportion of 21.9% male participants was only slightly below the percentage of available male participants in the participant pool (29.6%) used for recruitment. Age ranged from 18 to 47 years (mean = 20.75; SD = 3.9) and did not differ by gender ($U = 7961.0$; $p = 0.942$). Consistent with the survey sample and because 80% of the subsample providing their contact details for further research were females, more women ($N = 16$) than men ($N = 2$) were recruited for the interviews. Interview participants' age ranged from 18 to 44 ($M = 25.11$; $SD = 6.54$).

Two questions measured overall dental anxiety: the single item VRS and the last item of the Dental Fear Survey. Mean ratings were 4.43 out of ten on the VRS and 3.31 out of five on the DFS. The two measures correlated strongly ($r_s = 0.81$; $p < 0.001$). For subsequent comparisons of participants with lower and higher anxiety, a median split was performed using the VRS (median = 4) as it assessed

dental anxiety in more detail than the five-point DSF item and featured a clear bimodal dispersion. This median split resulted in 145 (47%) participants being classified as having relatively lower dental anxiety and 161 (53%) participants as having relatively higher dental anxiety. Sensitivity analysis dividing participants into groups based on the DSF item resulted in similar groups sizes. Descriptive statistics of all variables assessed with the online survey for both groups and the total sample are summarized in Table 2.

3.2 Phenomenology of dental imagery

The dental imagery scale was highly homogenous ($\alpha = 0.91$) and therefore an overall imagery score referred to as 'dental imagery' was calculated. Participants' overall scores ranged from zero ($n = 3$) to 106 ($n = 1$) with a mean of 40.66 (Table 2). Graphical and statistical tests (Shapiro-Wilk = 0.98; $p < 0.001$) suggested a non-normal distribution of dental imagery in the total sample. The imagery scale differed between participants reporting lower and higher anxiety ($U = 5219.5$; $p < 0.001$), with an effect size of this difference of $r = -0.47$. Less anxious participants' scores ranged from zero to 79 ($M = 28.59$; $CI = 25.62 - 31.55$) compared to the higher anxious ones with a minimum of one to a maximum of 106 ($M = 51.67$; $CI = 47.98 - 55.35$). Dental images were mentioned in various forms (Table 3) by each one of the 18 interview participants irrespective of their dental anxiety level.

3.3 Intrusion, strength and vividness of dental imagery

To test if distinct components contributed to dental imagery, an exploratory factor analysis of the dental imagery scale was conducted. The scree-plot and eigenvalue criterion suggested two disparate but correlating subscales ($r_s = 0.53$; $p < 0.001$), whose loading patterns are illustrated in Table 1. Factor one, 'intrusion and strength', related to the strength of such image-based cognitions, resulting distress and repression efforts. Factor two, 'vividness', referred to how vividly different sensory aspects of dentistry, including tastes, smells and bodily sensations, can be imagined. The two-factor structure was confirmed by a parallel analysis. Since analysis of previous imagery questionnaires (e.g., CEQ: May et al., 2014; ACE: Statham et al., 2011) suggested three factors, 'imagery', 'intensity' and 'intrusion',

this alternative model was tested by forcing the data into a three-factor structure. Thereby, two items that were in the two-factor model part of 'vividness' (1 and 2, imaging and picturing dental treatment) were separated into a third factor, which possessed high reliability ($\alpha = 0.95$) but explained merely an additional 7.7% of the total variance of dental imagery. This third factor was dropped because of its low potential to improve the model's explanatory value in the current sample.

Participants' average scores on the two imagery subscales (Table 1) differed between participants with lower or higher dental anxiety (Intrusion and strength: $U = 3189.0$; $p < 0.001$; $r = -0.63$; Vividness: $U = 8280.5$; $p < 0.001$; $r = -0.24$) and this was further expounded by the score distributions. Distribution differences were particularly pronounced for the first subscale. The group reporting higher dental anxiety featured an ambiguous distribution with a tendency of higher scores whereas the graph of the lower anxious group was clearly left skewed, indicating much less 'intrusion and strength' associated with dental imagery. The distribution for 'vividness' (subscale 2) on the other hand was similar in both groups resembling a normal distribution. Dental imagery and in particular the 'intrusion and strength' subscale correlated with participants' estimated physical arousal during dental appointments as assessed with the DFS 'automatic arousal during dentistry' subscale (Dental imagery: $r_s = 0.54$; $p < 0.001$; Intrusion and strength: $r_s = 0.66$; $p < 0.001$; Vividness: $r_s = 0.33$; $p < 0.001$).

3.4 Subject matters of dental imagery

Fear of various dental stimuli and procedures was assessed with the DFS-subscale, providing initial insight into potential themes of dental imagery. The lower anxious subsample indicated some degree of fear concerning all of the mentioned dental scenarios with means ranging from 2.08 (SD = 0.92) for 'making an appointment' to 3.62 (SD = 0.93) for 'injections'. Participants reporting higher dental anxiety scored more highly on all items (U ranges from 3797.00 to 7014.00; p for every test < 0.001) and they were particularly fearful of the following aspects, all related to sensory details: 'hearing the drill' (DFS-item 17; $M = 4.29$; $SD = 0.81$), 'feeling the needle injected' (DFS-item 15; $M = 4.28$; $SD = 0.92$), 'seeing the drill' (DFS-item 16; $M = 4.2$; $SD = 0.85$), 'feeling the vibration of the drill' (DFS-item 18; $M =$

4.24; SD = 0.85), 'seeing the anesthetic needle' (DFS-item 14; M = 4.28; SD = 0.88) and 'being seated in the dental chair' (DFS-item 11; M = 4.04; SD = 0.74). The DFS subscale correlated positively with 'dental imagery' and its subscales (Dental imagery: $r_s = 0.59$; $p < 0.001$; Intrusion and strength: $r_s = 0.76$; $p < 0.001$; Vividness: $r_s = 0.33$; $p < 0.001$).

Interview participants mentioned dental imagery as general ideas about the dentist, memories of past experiences, or expectations for future visits (Table 3). They could picture dental visits typically in great detail, involving various senses whose interplay and features are illustrated in Figure 1. Participants reporting higher dental anxiety found it most difficult to tolerate anything being put in their mouth (P4: *'I still don't like to have things put in my mouth.'*; P5: *'It's just the feeling some kind of digging around in your mouth.'*), injections (P17: *'I suppose that I'm scared of needles and injections.'*; P12: *'Needles stress me a lot.'*) and pain (P3: *'And then I get to have another painful experience.'*; P9: *'And obviously, I just remember the pain of it.'*). For some, merely thinking about dental visits was challenging and provoked considerable distress (P15: *'I don't like it at all (voice starts trembling). My hands are starting to go a bit clammy now (shows shaking hands), it's really unpleasant!'*). This interview participant would usually avoid thinking about the dentist altogether ('I don't think about it if I can help it.') and kept answers short and less detailed than other participants.

Participants indicating higher dental anxiety described their dental experiences differently to lower anxious ones, particularly in terms of mentioned details and the emotional color of their accounts and interpreted stimuli divergently. For example, the whiteness of a dental surgery and its clinical feel and smell. Participants reporting higher dental anxiety saw this as alien and fear-provoking (P9: *'It's the smell. Because if I smell... if I am in the streets, I could really freak out.'*), whereas this reassured lower anxious ones that the surgery was clean (P18: *'It is clinical. It's nice because... you know it's clean.'*). Also, the focus of dental imagery varied considerably between the two groups. Participants with higher dental anxiety mainly concentrated on the actual appointment and associated procedures, including pain sensations and treatment sounds (P5: *'Sucking and then the drilling are the main sounds when I think about the dentist.'*). Participants with lower dental anxiety focused on

calming characteristics of the environment (P2: *'And music. So it's more or less ok.'*) and appointment outcomes (P7: *'I have shiny teeth at the end of it. So everything is clean and nice. I really, really like the sensation of having really like squeaky clean teeth.'*).

3.5 Relationship of dental imagery to negative past experiences

Negative past dental experiences were not only a common theme in the interviews (Table 3), but also about half of the survey sample (51.6%) reported such incidences and described them vividly, involving various sensory components (e.g. *'As the dentist was pulling out a tooth, the tooth snapped in half, making a horrendous cracking sound'*). Vividness was reflected in harsh language and descriptions such as *'agonizing pain.'*, *'blood splattered on goggles'*, *'had been butchered'*.

Both groups reported negative dental experiences (30% of the lower anxiety group; 71% of the higher anxiety group), but participants reporting higher dental anxiety were almost six times more likely to do so (OR = 5.57; 95% CI = 3.41 - 9.1). A major difference was found for the subjectively experienced severity associated with those experiences and related distress as measure by the IES (Table 2; IES-Total: U = 1850.00, p = 0.009; r = -0.21). Participants reporting higher dental anxiety were more likely to experience thoughts about past events as intrusive (IES-Intrusion: U = 1940.50, p < 0.022; r = -0.18) and tried to suppress them (IES-Avoidance: U = 1843.00, p = 0.006; r = -0.22). The time distance to the experience, ranging from one month to 32 years ago, did not correlate with IES-scores (r = -0.03; p = 0.73) but overall dental imagery scores (r = 0.27; p = 0.001) and imagery 'intrusion and strength' (r = 0.35; p < 0.001) did. Dental imagery 'vividness' was only associated with memory avoidance (IES-Avoidance: r = 0.19; p = 0.018) whereas 'intrusion and strength' correlated with memory avoidance (IES-Avoidance: r = 0.38; p < 0.001) and intrusion (IES-Intrusion: r = 0.32; p < 0.001).

3.6 Responses to dental imagery and impact on dental service utilization

Dental imagery correlated with avoidance of dental appointments as assessed with DFS 'avoidance' subscale (r = 0.53; p < 0.001). This association was particularly pronounced for the 'intrusion and strength' subscale (Vividness: $r_s = 0.28$; p < 0.001; Intrusion and strength: $r_s = 0.67$; p <

0.001). Interview findings further helped to separate out the responses to dental imagery and their impact on appointment attendance between participants reporting lower and higher dental anxiety (Table 3 – in particular ‘Expectations for future visits’). Interview participants with higher dental anxiety experienced unpleasant negative dental images and reacted with rumination and trying to control them by engaging in avoidance of dentistry altogether (P12: ‘I think I got a mental block on it in a way.’) or seeking reassurance and distraction when undergoing treatments (P10: ‘Taking long breaths and trying not to think about being at the dentist.’). Participants reporting lower dental anxiety agreed that dental visits were not pleasant experiences, but their dental images centered around positive outcomes and they had positive expectations of their visits (P7: ‘*It’s not like I like going to the dentist. I like the outcome of going to the dentist.*’). They imagined for example the feeling of cleaned teeth after seeing a dental hygienist and satisfaction, which helped them to cope with an otherwise potentially anxiety-provoking situation.

4 Discussion

Our findings provide first insight into the phenomenology and role of mental imagery for dental anxiety and dental service utilization. They support the previously suggested importance of cognitive processes for dental anxiety (Armfield, 2010; De Jongh et al., 2003) and recommend dental imagery as a specific underlying mechanism, advancing research that established a general link between mental imagery, emotions and anxiety disorders (Blackwell et al., 2015; Hirsch, Perman, Hayes, Eagleson, & Mathews, 2015; Lewis et al., 2013). The survey questions assessing dental imagery formed a highly homogenous scale that consisted of two distinct but correlating factors referring to dental imagery ‘vividness’ and ‘intrusion and strength’. This is in line with May et al. (2014; Kavanagh, Andrade, & May, 2005; May, Andrade, & Kavanagh, 2015) arguing that those aspects play a role in determining affective states.

A variety of vivid, sensory dental images were reported by all interview participants whereas De Jongh et al. (1993) identified images only in a small subsample of their interviews exploring cognitions

of dentally anxious patients. With their initial question (*'When you think of going to the dentist, what thoughts go through your mind?'*) and throughout the interviews, De Jongh et al. seem to have emphasized verbal thoughts instead of image-based cognitions, which is often the case in anxiety interviews (Hirsch & Holmes, 2007). We avoided using the word 'thoughts' and asked broadly about dental experiences. The vivid responses, involving a variety of detailed sensory perceptions, go beyond verbal cognitions and indicate the usefulness of an open inquiry for interviews aimed to investigate imagery. Survey measures assessing dental imagery in the larger sample also found frequent dental imagery, especially in participants reporting higher dental anxiety. A few higher anxious interview participants found it difficult to discuss dental visits and imagery in detail. This does not necessarily mean that imagery was completely absent, but could indicate avoidance of thinking and talking in-depth about them due to their distressing nature.

Group differences between participants with lower and higher dental anxiety were particularly pronounced for the strength and intrusion component of dental imagery, but far smaller for imagery vividness. Both groups seemed to be able to vividly imagine dental visits while associated distress and intrusiveness varied. At first sight, the finding that participants could typically imagine dental visits vividly no matter if they indicated dental anxiety or not is at odds with previous findings of a close association between emotional responses and imagery (Holmes & Mathews, 2010; Kavanagh et al., 2005), which would lead us to expect more vivid imagery for more anxious participants. However, the inclusion of the less anxious group shows the importance of considering the imagery content and not merely assessing its presence or absence to help understand a potential association. Qualitative results revealed emotionally negative images of dental procedures in the more anxious group and a mix of positive and negative images in the less anxious group with a focus on positive outcomes and reassuring factors. Research investigating the role of imagery in anxiety disorders often focuses only on anxious participants (e.g. Pratt, Cooper, & Hackmann, 2004; Muse et al., 2010), missing out on the opportunity to compare those to less anxious ones to explore which imagery aspects are most closely related to anxiety. The ease of recalling vivid images might be specific to the dental setting as research

with dental phobic and low anxiety patients found that everyone could easily imagine dental procedures and other aspects of dentistry (De Jongh et al., 1995).

The current study did not replicate a three-factor imagery structure as indicated in other contexts (May et al., 2014; Statham et al., 2011), but in dental imagery, distress was intimately linked with intrusiveness. Imagery strength and intrusiveness was associated with self-rated arousal during dentistry. These findings mirror those from psychophysiological research that found increased cardiac responses in dental phobic participants viewing images linked with their fears (McNeil, Vrana, Melamed, Cuthbert, & Lang, 1993). Instead of further separating out items of the 'intrusion and strength' subscale, forcing the data into a three-factor structure suggested a third factor that referred to visual imagery specifically. As this factor, consisting of two items, did not explain much of the imagery variance in the current sample and factors with fewer than three items are deemed weak and unstable (Costello & Osborne, 2005), it was dropped for further analysis. However, considering findings that visual fear cues provoke more pronounced fear responses in dental phobic individuals compared to auditory cues (Wannemueller, Adolph, Joehren, Blackwell, & Margraf, 2017), modality-specific dental imagery effects and the role of visual dental imagery in particular should be investigated further. Developing an item catalogue with multiple items per sensory modality could be useful for this purpose.

As for posttraumatic stress disorders, where flashbacks of past negative events contribute to onset and maintenance (Brewin, Dalgleish, & Joseph, 1996; Ehlers & Clark, 2000; Holmes & Bourne, 2008), intrusive recall of highly affect-laden images might be an important mechanism in dental anxiety. In line with previous findings (De Jongh et al., 2003; Kent & Gibbons, 1987), we found that a higher proportion of participants with higher dental anxiety reported intrusive recollections of negative dental experiences compared to participants with lower dental anxiety. Oosterink et al. (2009) established that dental phobia was more strongly associated with re-experiencing of such intrusive thoughts than any other phobia they examined. The strong association between dental anxiety and the imagery intrusion and strength, in particular related to past experiences, could explain why dental anxiety is such a stable condition where new positive experiences do not necessarily change patients'

general view of dentistry and expectations (Arntz, Van Eck, & Heijmans, 1990). Distressing images and memories that intrude into patients' awareness could lead to recall bias for threatening dental stimuli (Bodner & Iancu, 2013) and could shape appointment anticipations, ultimately upholding dental anxiety. What remains unclear is the potential role appraisal processes play for the suggested association between distressing intrusive dental images and anxiety. Research on intrusive memories experienced in depression and posttraumatic stress disorders found that negative interpretations of intrusive memories correlated with intrusion related distress, symptom severity and cognitive avoidance (Starr & Moulds, 2006; Williams & Moulds, 2008). This could also be the case for dental imagery and should be examined further.

Our survey and interview findings shed light on the specific content of dental imagery. More highly anxious participants focused on unpleasant sensations during dental visits, which might contribute to the maintenance and even aggravation of dental anxiety. Similarly, an excessive focus on pain sensations during dental hygiene visits has been suggested as one of the mechanisms by which catastrophizing leads to increased pain experiences (Sullivan & Neish, 1998). Images of participants with lower dental anxiety were centered on reassuring aspects of the setting such as cleanliness and positive outcomes and could act as protective factors against dental anxiety and may facilitate appointment attendance.

As this research was a first investigation of imagery-based cognitions specifically in the dental context and their role for dental anxiety, it was exploratory by nature with implications for the analytical strategy of the survey data. A number of hypotheses were tested without a statistical correction for the number tests, which might lead to spurious statistical significances. Results triangulation between the survey and the interviews should increase confidence in the presented findings (Silverman, 2011). Again, due to the novelty of the topic, the scale assessing dental imagery has not been applied in previous research. It was based on theoretical considerations and is an adaption of imagery scales used in other contexts (May et al., 2014; Statham et al., 2011, Tanja-Dijkstra et al. (2014). In the current sample, the dental imagery scale and its subscales possessed high

homogeneity and correlated in expected directions with other validated measures, including the DFS and IES. Further research is needed to confirm the factor structure, and establish the scale's reliability and validity.

The current student sample was deemed suitable as dental anxiety is at least as prevalent in this population as in the general population (Domoto et al., 1988) and might even be higher since dental anxiety is more common in younger age groups (Bellini, Maltoni, Gatto, Pelliccioni, Checchi, & Checchi, 2008; Nicolas, Collado, Faulks, Bullier, & Hennequin, 2007). To assure participants that their personal information would not be viewed by treating dentists, we refrained from involving dental surgeries in recruitment. Further research should test if the ideas generated in this study generalize to other patient populations.

This research relied on self-reports and was cross-sectional in nature. Participants' accounts might therefore be skewed by memory bias (Creswell, 2009) or recency effects (Coan & Allen, 2007) and we cannot establish the accuracy of their past recollections. It would be interesting to use longitudinal study designs to address questions about the contribution of dental imagery to the development and ongoing experiences of dental anxiety. We suggest that such studies should explore possible protective factors by including participants with lower levels of anxiety as well as those with high levels. Anxiety with a specific focus tends to increase as the feared event approaches. Future research should determine how dental imagery vividness and intrusiveness change with proximity to scheduled appointments and what role it plays in attendance at, and experiences of, dental treatments.

The presented findings on the phenomenology and role of dental imagery could have implications for developing novel dental anxiety interventions. Imagery interventions have been found to be inexpensive and effective treatment options for a number of health behaviors (Conroy & Hagger, 2017). Their usefulness to reduce dental anxiety and improve dental service utilization and associated physical and psychological health outcomes should be tested. For dental anxiety, cognitive behavioral therapy has been recommended (Gordon, Heimberg, Tellez, & Ismail, 2013; Heaton, 2013), which could include imagery and memory re-scripting techniques (Holmes, Arntz, & Smucker, 2007). Such

imagery manipulations can assist in reducing emotional distress or perceived threat caused by maladaptive images while positive images might counteract anxiety (Stokes & Hirsch, 2010). Brief, low-level interventions may be particularly useful for moderately anxious individuals, a substantial proportion of all dental patients (Hill et al., 2013), as they might not require or would be willing to engage with extensive therapy.

The current findings suggest a new focus for addressing dental anxiety, by reducing vivid, intrusive images of past dental experiences and shifting the focus from unhelpful, fear-provoking dental images to positive outcomes. A variety of imagery techniques exist that could be useful for this purpose, for example deliberately addressing maladaptive perceptual image-based cognitions through imaginal exposure (Ehlers, Mauchnik, & Handley, 2012), imagery re-scripting (Hunt & Fenton, 2007; Hunt et al., 2006), weakening intrusive images via competing tasks (May, Andrade, Panabokke & Kavanagh, 2010), and attentional diversion (May et al., 2010; Hamilton, Fawson, May, Andrade, & Kavanagh, 2013) or acceptance approaches based on mindfulness therapy (Jenkins & Tapper, 2013; Kabat-Zinn, 2003) that can help reduce the tendency for intrusive thoughts and images to capture attentional resources and amplify distress. Initial findings indicate that exposure to positive photographic dental images before appointments reduces anticipatory anxiety in children (Fox & Newton, 2006; Freeman, 2007; Gangwal, Badjatia, & Dave, 2014). Encouraging rehearsal of such images, in the days leading up to appointments, may increase their impact further and guided imagery can be a useful tool for distraction as well (Appukuttan, 2016; Armfield & Heaton, 2013; Guentsch et al., 2017; Lewis et al., 2013). For example, exposure to visual images using virtual reality technology was found to reduce pain experiences during dental treatments (Tanja-Dijkstra et al., 2017). Results from this proposed line of work could help broaden the application of imagery interventions not only to dental anxiety, but potentially to other situation-specific anxiety that are similar in temporal aspects, for example fear of public speaking or test anxiety (Kent & Jambunathan, 1989).

5 Conclusions

Dental imagery is associated with dental anxiety, has the potential to provoke great distress and might be a barrier for dental appointment attendance. Imagery techniques should be considered and tested when developing new dental anxiety interventions to address this highly prevalent anxiety problem.

Author Contributions

All authors contributed to the study design. Data collection, analysis and interpretation was performed by A.S. under the supervision of J.A., K.T-D. and D.R.M. A.S. drafted the paper, and J.A., K.T-D. and D.R.M. provided critical revisions. All authors approved the final version of the paper for submission.

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Tables

Table 1. Imagery items' mean, standard deviation and factor loadings for the 2-factor solution of the dental imagery scale^a.

Imagery item ^b	M	SD	Factor 1	Factor 2
Factor 1: Intrusion and strength (eigenvalue = 5.89, variance = 53.50%, α = 0.91)				
Right now, when you think about dental treatment...				
10. ...how hard are you trying not to think about dental treatments?	2.97	3.23	0.89	-0.04
7. ...how unpleasant or distressing are the thoughts?	3.41	3.10	0.84	0.05
8. ...how guilty or worried are you about the thoughts?	2.40	2.80	0.82	-0.03
9. ...how much worse do you think things would be if you actually had treatment?	3.11	3.08	0.81	-0.12
11. ...how intrusive are the thoughts?	2.86	3.02	0.76	0.10
Factor 2: Vividness (eigenvalue = 1.88, variance = 17.13%, α = 0.89)				
Right now, how vividly are you...				
2. ...picturing it?	5.33	2.76	-0.06	0.86
5. ...imagining what it feels like in your mouth?	4.52	3.07	-0.01	0.85
1. ...imagining dental treatment?	5.13	2.80	0.01	0.80
3. ...imagining the taste?	3.44	2.94	-0.03	0.76
4. ...imagining the smell of a dental practice?	3.81	3.02	-0.01	0.75
6. ...imagining how your body would feel if you had a treatment?	3.69	3.04	0.39	0.43

Note: ^aPrincipal factor method with promax rotation.

^bItems are tabulated according to factor loadings while numbering indicates the order in the online survey.

Table 2. Mean and standard deviation of all variables assessed with the online survey investigating the phenomenology and role of dental imagery and associations with dental anxiety, past negative experiences and avoidance.

Variable	Lower dental anxiety group (N = 145)		Higher dental anxiety group (N = 161)		Total sample (N = 306)	
	M	SD	M	SD	M	SD
Age (years)	20.32	3.15	21.15	4.42	20.75	3.89
Dental fear survey (DFS)						
Avoidance of dentistry	2.21	0.50	4.52	2.35	3.42	2.08
Autonomic arousal during dentistry	8.06	2.84	14.87	5.69	11.64	5.69
Fear of situations and stimuli	36.83	9.28	50.31	7.91	43.92	10.90
Overall fear of dentistry	2.49	0.92	4.04	0.81	3.31	1.16
Dental imagery scale (DIS) – total	28.59	18.04	51.67	23.53	40.66	24.02
Intrusion and strength	6.36	7.61	22.40	12.35	14.75	13.09
Vividness	22.23	14.05	29.27	13.69	25.91	14.28
Impact of event scale (IES) - total	3.23	7.07	8.37	12.60	6.92	11.53
IES-Avoidance	1.70	4.02	4.80	7.27	3.93	6.65
IES-Intrusion	1.52	3.64	3.56	5.93	2.99	5.45

Table 3. The nature of intrusive dental imagery: Themes and example quotes.

Theme description	Example images ^a	
	Lower dental anxiety participants	Higher dental anxiety participants
General ideas about the dentist	<p>P18: 'If I think about the dentist I can imagine going in. I can go in, I can see the dentist. I can see the chair.'</p> <p>P2: 'It gives you kind of strange feeling on your teeth. Yeah, you know. But I don't really mind, because it means my teeth are cleaned. So that's fine. (...) It's very sterile and white. And that is kind of clinical.'</p> <p>P18: 'It smells clean which is reassuring really. Because you don't want to go in and smell wet feet and dirty socks and carpets and stuff. You wouldn't want to walk into your house and it smells like that. But it doesn't bother me.'</p>	<p>P5: 'I think I have a bad feeling. It's more like I just really don't want to go. Just thinking about it really winds me up to book an appointment or anything. I just don't like the feeling of it. I don't want to go.'</p> <p>P8: 'That horrible noise it makes. I don't know if it's like the air they have or something, but that sort of drilling sound I think. That's probably the first thing. And then this really obvious dentist smell, when you're there. It's just like (<i>pretending being thrown back</i>), it really hits you, I think. Ahm... yeah, like a mask, yeah it scares you (<i>laughs</i>)... Scary instruments and picking things (<i>laughs</i>).'</p>
Memories of past experiences	<p>P7: 'I remember needles, just being really big!'</p> <p>P18: 'When the braces were put in that was uncomfortable. But it didn't bother me. Because I knew it would have a nice effect in the end.'</p>	<p>P3: 'I still have very vivid images. I can remember the whole thing.'</p> <p>P15: 'I was set in the chair and I was shaking and my hands have gone sweaty. And my breathing was very shallow. It wasn't very nice for me.'</p>
Expectations for future visits	<p>P2: 'I kind of... I quite look forward to it. Because I think they gonna... I know that sounds really of weird... because... ahm... usually there's nothing wrong with my teeth and often when I go I know they will polish and clean them. And I know they will gonna clean them.'</p>	<p>P9: 'If I book it now I would expect treatment. That probably doesn't help.'</p> <p>P5: 'I often think about going to the dentist. And about the things they could do to me or I'll be thinking about what could be wrong with my teeth and that's painful.'</p>

Note: ^a P = participant. Identifying details have been removed to preserve participants' anonymity.