Anxiety, fainting and gagging in dentistry: Separate or overlapping constructs?

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Looking back at last weeks' treatment, it wasn't so bad. But now, when I hear the drill, my heart rate rises and I am beginning to sweat. You are very kind, but I can't help wanting to leave the treatment room.

CHAPTER 5

Memory characteristics of an arousing event are associated with the level of anxiety during the event: a clinical study among individuals with severe dental anxiety

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Introduction

Extensive evidence indicates that adrenal stress hormones such as epinephrine and cortisol are critically involved in the formation of memories of emotionally arousing events (McGaugh & Roozendaal, 2002; Roozendaal, 2002; McGaugh, 2000). That is, the release of endogenous stress hormones not only give rise to an immediate response to an emotional event, but also aids future responses by enhancing the declarative memory of the same event (de Quervain et al., 2009; Cahill & Alkire, 2003; Roozendaal, 2002; McGaugh & Roozendaal, 2002; McGaugh, 2000; Cahill & McGaugh, 1998).

In this way exposure to distressing events create disturbing, emotionally charged memories that get re-activated by confrontations with objects of fear, while the related stress response induces an elevated heart rate (Leutgeb et al., 2011), emotional distress (Veale et al., 2013), and return of fear (Leutgeb et al., 2011; de Quervain et al., 2009; De Quervain & Margraf, 2008; Cuthbert et al., 2003). It has been argued that through this type of re-experiencing of past disturbing events and subsequent fear activations, memory traces get more and more ingrained (de Quervain et al., 2009; de Quervain & Margraf, 2008; Mathews & MacLeod, 2005; Pratt et al., 2004; Fehm & Margraf 2002; Clark, 1999).

Support for the notion that disproportionate levels of fear and anxiety are associated with presence of emotionally charged memories has been found in a study among dental phobic individuals (van Houtem et al., 2015). Their memories were found to be significantly more vivid, disturbing and displayed more features of intrusiveness than memories of less anxious controls. Moreover, it appeared that the disturbance of the memory of their most terrifying dental event and the severity of their current levels of dental trait anxiety were significantly associated (r = 0.58; van Houtem et al., 2015). Thus, activation of vivid emotional memories of past distressing events may not only play an important role in the symptomatology of fears and phobias, but also in the process contributing to the maintenance and aggravation of these conditions.

The notion that particularly emotionally significant experiences tend to be well remembered, is based upon memory consolidation and memory retrieval research (e.g., De Quervain & Margraf, 2008) and in laboratory settings (Talarico & Rubin, 2003; Heuer & Reisberg, 1990; Reisberg et al., 1988). However, to our knowledge it has hardly been explored in a clinical relevant situation (i.e., dental treatment) whether highly anxious individuals when confronted with potentially fear eliciting stimuli consolidate more vivid and disturbing memories of this event than their low anxious counterparts.

The purpose of the present study was to investigate how vividness and disturbance of a memory of a dental treatment changes over a two week period following this event. It was hypothesized that the memories of participants with a disproportional level of anxiety undergoing dental treatment would be significantly more vivid and disturbing than the

memories of the low anxious reference group, not only immediately after this event, but also at two-week follow up. In addition, it was hypothesized that the level of state anxiety during dental treatment and these memory characteristics would be positively associated.

Materials and methods

Measures

Presence of dental phobia
Presence of dental phobia was assessed using the Phobia Checklist, a screening tool with four questions based on the DSM-IV-TR criteria for specific phobia, developed for the assessment of dental phobia (Oosterink et al., 2009). This checklist contains four questions, and has previously been validated and proven to be a valid diagnostic tool for this purpose (sensitivity = 0.95, specificity = 0.99, and an overall hit rate of 97%).

Severity of dental trait anxiety
Dental trait anxiety was assessed using the Dental Anxiety Scale (DAS; Corah, 1969). This four item measuring scale is the questionnaire most widely used in studies on dental anxiety (Corah et al., 1978). Responses are scored from one to five, providing total scores ranging from four (not anxious at all) to 20 (extremely anxious). DAS scores of 13 or higher are considered indicative of high dental trait anxiety. Cronbach's alpha in the current study was 0.75 for anxious group and 0.80 for the reference group (overall $\alpha = 0.96$).

Level of state anxiety
Directly following treatment (T1) and at two-week follow-up (T2) participants were asked to indicate the extent to which they felt anxious during dental treatment using an 11-point numeric rating scale (NRS; 0 = minimum level of anxiety, 10 = maximum level of anxiety).

Memory characteristics
Immediately following a conventional dental treatment (T1) and at two weeks follow-up (T2) disturbance and vividness of the memory about the dental treatment was indexed using an 11-point NRS (0 = not at all disturbing/vivid and 10 = maximum level of disturbance/vividness).

Participants

The study included two groups of participants: 1) those with severe levels of dental trait anxiety (i.e., participants with a DAS-score ≥ 13; further referred to as 'the anxious group')

and 2) those with low levels of dental trait anxiety (i.e., DAS <13; further referred to as 'the reference group'). Participants of the anxious group were attending a special dental fear clinic in Amsterdam, the Netherlands. They were referred to the clinic because they were extremely difficult or impossible to treat by a dentist in a general dental practice due to disproportionate anxiety levels, or showed anxiety-related avoidance of the dental treatment. The reference group consisted of participants who attended a regular dental practice in three different cities in the Netherlands. Participants were included in the study if they were 18 years or older, had sufficient control of the Dutch language and gave written consent to participate.

Study design and procedure

The study was conducted between March 2010 and June 2012 and was based on a prospective design with two assessment points (T1-T2). At baseline (T0), all participants of both groups were invited by telephone to take part in a study concerning autobiographical memories underlying dental anxiety. Those who were willing to participate were checked whether or not they fulfilled the inclusion criteria. The participants received a letter at home containing additional information, a consent form, and a request to fill out several measures on severity of dental trait anxiety or dental phobia. Prior to the current study the participants were included in a study that investigated the presence, content and characteristics of memories events underlying dental anxiety (for a comprehensive description of the data collection, sample and study design see van Houtem et al., 2015). For the purpose of the current study participants were asked to complete a self-report questionnaire that assessed the disturbance and vividness of their memory of an invasive (i.e., drilling and making a filling, carrying out a root canal treatment or an extraction) dental treatment as well as their level of state anxiety during treatment immediately following this treatment (T1). Two weeks later participants of both groups were contacted by telephone and were asked to bring up the memory of the treatment that was performed two weeks before. Then their memory characteristics were re-assessed (T2). Ethical approval for the study was granted by the local Ethical Committee (METc VU, protocol number 2007/262).

Statistical analyses

Descriptive statistics were used to characterize the sample. Chi-square tests (categorical data) or student's t-tests (continuous data) were used to examine group differences at T1 and T2. Two-way MANOVA's on the set of dependent variables (state anxiety, disturbance and vividness) were used to investigate the possible interaction between group and gender at T1 and T2. In order to test group differences in the changes over time between T1 and T2 on the set of dependent variables, a two-way repeated measures MANOVA (one-within [time] and one-between subjects factor [group]) was used. A MANCOVA was performed on

the difference score between T1 and T2, using the score at T1 as a covariate, thereby correcting the change score for differences at baseline. The Pearson correlation coefficient was used as a measure of linear association. Power calculation (G*Power 3.0; Faul, Erdfelder, Lang & Buchner, 2007) based on an independent samples T-test and based on a large effect size (0.8), alpha = 0.05, power = 0.80 and two-tailed testing, resulted in a minimum required total sample size of *n* = 52. For all statistical analyses, a p-value <0.05 was considered statistically significant.

Results

General differences between both groups

The final sample consisted of 114 participants (i.e., 47 anxious and 67 reference individuals) with a mean age of 44.6 years (SD = 12.4) and resp. 51.8 years (SD = 15.1). Table 1 shows the demographic characteristics in male and female participants of both groups at baseline (T0). There was no significant difference in terms of gender (*p* = 0.39) and a marginal significant difference in country of birth *(p* = 0.06) between the anxious individuals and the reference group of low anxious individuals.

Of the participants in the anxious group 60.1% (n = 25) fulfilled all screening criteria for dental phobia, whereas none of the reference group fulfilled these criteria (0.0%; $\chi^2(1)$

Table 1. Demographics and mean level of dental trait anxiety of the anxious and low-anxious reference participants at baseline (T=0)

	Anxious (n=47)			**Reference (n=67)**				
	Percentage		**n**	**Percentage**		**n**	***P***	**χ2**
Gender								
Male	42.5		20	50.8		34	0.39	0.74
Female	57.5		27	49.3		33		
Country of birth								
Dutch	83.0		39	94.0		63	0.06	3.58
Other	17.0		8	6.0		4		
	Mean	**±SD**	**n**	**Mean**	**±SD**	**n**	***p***	**T**
Age in years								
Total	44.6	12,4	46	51.8	15,1	67	<0.01	-2.76
Male	42.1	9,4	19	53.5	14,7	34	<0.01	-3.46
Female	46.3	14,1	27	49.9	15,6	33	0.35	-0.93
Dental trait anxiety (4-20)								
Total	17.6	2.3	47	7.2	1.9	67	<0.01	25.8
Male	17.2	2.6	20	7.2	2.0	34	<0.01	14.9
Female	17.9	2.0	27	7.3	1.7	33	<0.01	21.6

= 53.16, p = 0.01). Participants of the anxious group showed significantly higher levels of dental trait anxiety (17.55 ± 2.26), than individuals of the reference group (7.22 ± 1.87; t (86.58) = 25.75, p < 0.001).

State anxiety, vividness and disturbance of the memory of dental treatment at T1 and T2

The anxious and reference group were compared immediately after treatment (T1) on state anxiety, disturbance and vividness using a two-way (group by gender) MANOVA. Mean scores are presented in Table 2. A significant multivariate effect for group was found, F (3, 106) = 26.47, p < 0.001, and no significant effect for gender, F (3, 106) = 1.31, p = 0.28, nor an interaction between group and gender, F (3, 106) = 1.30, p = 0.28. The significant group effect resulted from a higher mean score of the anxious group on state anxiety, F (1, 108) = 51.53, p < 0.001, on disturbance, F (1, 108) = 55.07, p < 0.001, and on vividness, F (1, 108) = 39.20, p < 0.001, than the reference group.

Another two-way MANOVA was performed (T2) to compare both groups on disturbance and vividness at two weeks follow up (see Table 2). The results showed a significant multivariate main effect for group, F (2, 92) = 18.80, p < 0.001, no significant effect for gender, F (2, 92) = 0.71, p = 0.493, nor an interaction between group and gender, F (2, 92) = 1.35, p = 0.266. The significant group effect resulted from a higher mean score of the anxious group on disturbance, F (1, 93) = 27.07, p < 0.001, and on vividness, F (1, 93) = 29.25, p < 0.001, than the reference group.

A two-way (time by group) repeated measures MANOVA was performed to compare the anxious and reference group in changes in disturbance and vividness over time. The results showed a significant multivariate main effect for time, F (2, 91) = 14.94, p < 0.001, but no significant interaction, F (2, 91) = 0.25, p = 0.781. The main effect for time resulted

Table 2. Mean scores* of disturbance and vividness immediately after treatment (T1) and after two weeks (T2) in the anxious and reference group

	Measure	T1			T2		
		Mean	SD	N	Mean	SD	N
Anxious	State anxiety	4.83	2.98	46	-	-	-
	Disturbance	3.96	3.04	46	3.85	2.65	41
	Vividness	7.13	3.22	46	5.22	3.02	41
Reference	State anxiety	1.35	2.04	66	-	-	-
	Disturbance	.64	1.62	66	1.27	2.21	56
	Vividness	3.09	3.33	66	2.00	2.81	56
Total	State anxiety	2.78	3.00	112	-	-	-
	Disturbance	2.00	1.62	112	2.36	2.72	97
	Vividness	4.75	3.83	112	3.36	3.30	97

* Mean scores and standard deviations are based on all available data at T1 and T2

from a significant decrease in disturbance, F (1, 92) = 6.03, *p* = 0.016, and vividness, F (1, 92) = 14.62, *p* < 0.001. In the anxious group a non-significant increase for disturbance (t (38) = 1.33, *p* = 0.19) was found and a significant decrease for vividness (t (38) = -2.55, *p* = 0.015) over time. In the reference group a significant increase in disturbance (t (55) = 2.46, *p* = 0.17) and a significant decrease in vividness (t (54) = -2.67, *p* = 0.006) was found.

However, since the differences at T1 between the anxious and the reference group on the variables disturbance and vividness may have affected the change over time, the two groups were compared on the difference score between T1 and T2 on the variables disturbance and vividness, using the scores at T1 as covariates in a MANCOVA. The results from this analysis showed that disturbance was a significant covariate for the disturbance, F (1, 90) = 11.51, p <0.001, and vividness, F (1, 90) = 5.28, p = 0.024 change score, and vividness was a significant covariate for the vividness change score, F (1, 90) = 76.91, p < 0.001, but not for disturbance, F (1, 90) = 1.33, p = 0.25. As a result, mean change scores on both variables were adjusted for differences on the score at T1. In this adjusted analysis, a significant multivariate group effect was found, F (2, 89) = 3.93, p = 0.023, indicating that both groups differ in the changes in mean scores over time. Inspection of the adjusted mean scores reveals that the anxious group (mean difference = -0.46, 95% CI [-1.40 – 0.47]) reported a significantly smaller reduction of vividness than the reference group (mean difference = -1.98, 95% CI [-2.7 - -1.22]), and a larger increase in disturbance (mean difference = 1.17, 95% CI [0.50 – 1.83]) than the reference group (mean difference = 0.01 95% CI [-0.53 – 0.55]). Changes on the outcome variables between T1 and T2 for each group are presented in Figure 1.

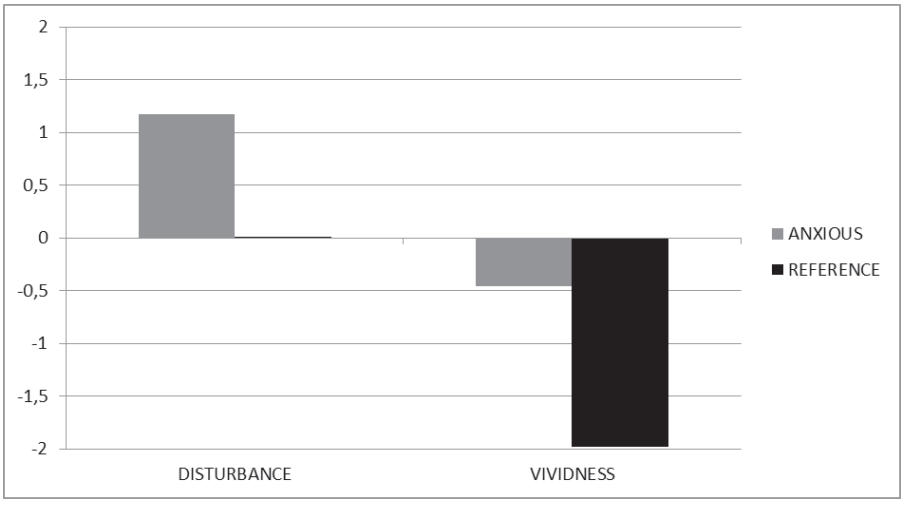

Figure 1. Adjusted mean difference scores between T1 and T2 for the variables disturbance and vividness for the anxious and the low-anxious reference group*
* The difference in disturbance between T1 n T2 in the control group is not visible, since the difference was only 0.01 on an 11 point NRS.

Relation between state anxiety and memory characteristics of the disturbing memory

Among the anxious participants the correlations between state anxiety during dental treatment, and either vividness or disturbance of the memory two weeks following treatment did not reach significance ($r = 0.19$, $p = 0.24$ and $r = 0.20$, $p = 0.24$, respectively). Among the reference group positive significant correlations were found between state anxiety during treatment and both memory characteristics two weeks later ($r = 0.60$, $p < 0.001$ and $r = 0.31$, $p = 0.021$, respectively). To avoid a lack of variance as a result of both floor effects and ceiling effects both groups were combined. A normality test showed that the data were well modeled by a normal distribution. Table 3 displays the correlation coefficients at both time points among the variables state anxiety during dental treatment, vividness and disturbance for both groups combined (total n at T1 = 112 and total n at T2 = 93). As can be seen, level of state anxiety during dental treatment significantly predicted the extent to which participant' memories were experienced as vivid ($r = 0.46$, $p < 0.001$) and disturbing ($r = 0.55$, $p < 0.001$) two weeks following treatment.

Table 3. Association between state anxiety during treatment and the memory characteristics 'vividness' and 'disturbance' at both time points for the total group (anxious and reference patients collapsed).

		state anxiety (T1)	disturbance (T1)	vividness (T1)
T1	state anxiety	1.00		
	disturbance	0.768**	1.00	
	vividness	0.499**	0.477**	1.00
T2	disturbance	0.551**	1.00	
	vividness	0.457**	0.577**	1.00

**$p < 0.001$

Discussion

The results of the present study indicate that individuals with severe levels of anxiety about dental treatment reported their memory of a dental treatment to be significantly more vivid and more disturbing than participants' memories with no or almost no anxiety. This was not only found immediately following treatment, but also at two weeks follow-up.

Both the anxious and the reference participants displayed changes in vividness of their memories in that these became significantly less vivid over a two-week period. This decline can probably best be explained by a logarithmic degrading of memories over time (Wixted & Carpenter, 2007; Talarico & Rubin, 2003). Interestingly, the disturbance of the memory showed a different pattern. While the disturbance of the memories in the reference group remained stable, the disturbance of the memories of the anxious individuals increased. Most

likely, the results of our study can best be explained in the light of findings of studies examining emotional arousal and memory performance in individuals with PTSD (e.g., Wilker et al., 2014; Paunovic et al., 2002), showing that subjects with PTSD display enhanced memory for emotionally arousing information compared with healthy controls (Wilker et al., 2014; Golier et al., 2003). Precisely this fact may explain the increased memory disturbance of anxious individuals in our study. In individuals with disproportionate levels of anxiety, exposure to a phobic stimulus almost invariably provokes retrieval of the fear memory, thereby triggering an adrenal stress response (De Quervain et al., 2011; Alpers et al., 2003) which would, in turn, lead to enhanced storage of emotional memories (McIntyre & Roozendaal, 2007).

Our most striking finding was that individuals' state anxiety level during dental treatment was significantly linearly associated with the extent to which the memories of this event were reported as emotionally charged. The best explanation for this phenomenon is that the more physiological arousal was elicited by the event, the more the memory was experienced as emotionally disturbing and vivid. This is in line with a wide array of laboratory (Anderson et al., 2006; Ochsner, 2000) and experimental studies showing a positive linear relationship between the degree of stress experienced during a fearful event, and the strength of the fear-conditioned memory that was formed in relation to the level of adrenal stress hormones (Laxmi et al., 2003; Cordero et al., 1998). To our knowledge, such a relationship for the effects of physiological and emotional arousal (in our study operationalized as state anxiety) in the formation of fear memories has not previously been demonstrated in a relevant clinical setting such as dentistry.

This study has some limitations. First of all, we were not able to match individuals of the anxious and reference group in terms of gender and age, since more anxious participants than we expected appeared to be unwilling to fill out the questionnaire immediately after the dental treatment. Next, the level of physiological or emotional arousal in this study was only assessed by a self-report measure indexing state anxiety (i.e., an 11-point NRS). Although self-reported state anxiety has been found to correlate significantly with heart rate (Kantor et al., 2001), in future studies it would be important to replicate the current findings using physiological and biological outcome variables in order to more specifically investigate the factors mediating the activation of the human stress response system. More general, and in relation to future research, translational studies in relevant clinical settings that examine possible individual differences in responsiveness to acute stress and emotional memory, are greatly needed. A possible direction would be to examine whether specific genetic variations (e.g. of the ADRA2B gene; Rasch et al., 2009; de Quervain et al., 2007) involved with noradrenergic neurotransmission are associated with elevated levels of dental trait anxiety and enhanced emotional memory of emotionally arousing events (Li et al., 2015).

In conclusion, the present results suggest that individuals' state anxiety level during a dental treatment is predictive of the extent to which the memory of such an event becomes

emotionally charged. Furthermore, the results provide evidence for a linear relationship between emotional arousal on the formation of fear memories entailing possible clues for the role of emotional responses induced by anxiety eliciting and potentially dangerous situations which enables us to remember the significance of such events. Our results may also have important clinical implications. Dental practitioners or other health care professionals should be cautionary that anxiety levels during their procedures may increase far above the normal or average range, thereby cementing new aversive memory traces (De Quervain et al., 2009), a process which may explain why existing anxiety levels are maintained or even further increase.

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