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The factor structure of dental fear

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There is limited empirical information as to whether or how stimuli associated with dental fear can be classified into distinct subtypes. The purpose of the current study was to develop a descriptive framework for the classification of dental fear. Data were collected using a survey among Dutch twin families (n = 11,771). The sample was randomly divided into two subsamples of, respectively, 5,920 and 5,851 individuals. An exploratory factor analysis (EFA) was performed on the first subsample to delineate the multidimensional structure of a set of 28 dental-fear-provoking objects and situations. The second sample was used to confirm the newly derived model using confirmatory factor analysis (CFA). The EFA yielded a three-factor solution with 70.7% explained variance pertaining to: (i) invasive treatment or pain; (ii) losing control; and (iii) physical sensations. The CFA showed an acceptable fit to the data, thereby confirming the stability of the three-factor structure. There are at least three different subtypes of dental fear. As these subtypes require a different treatment approach in clinical practice, it could be important to assess the severity of patients' fear response along these three dimensions.

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Fear of dental treatment is a relatively common fear in the general population. About 30–40% of the adult population in western societies report moderate levels of dental fear (1, 2), while 5–15% endorse high fear levels (3–6). High levels of dental fear are likely to induce avoidance behavior, thereby increasing the risk of negative effects on individuals' oral health (6–10).

Although the term 'dental fear' suggests a unidimensional construct, it in fact encompasses a broad constellation of fears of objects and situations within the dental setting (11, 12). Bearing the above in mind, it is important (13) to specify individuals according to their fears of objects and situations within the dental setting, and to classify them into distinct typologies (14) to optimize treatment success. To this end, Milgrom *et al.* and Locker *et al.* proposed a classification system consisting of dentally fearful patients having: (i) a simple conditioned fear of specific dental stimuli; (ii) somatic reactions during dental treatment; (iii) generalized anxiety states; or (iv) a distrust of dental personnel (14, 15). However, although the author used his broad clinical experience to classify patients into particular fear categories, use of a more sophisticated method, or model, to identify empirically groups of patients with similar response patterns is warranted.

Until now, only two studies have attempted to determine, using a statistical method, the underlying structure of fear of stimuli pertaining to different objects and situations present in the dental setting. Oosterink and colleagues (11) performed an exploratory factor analysis (EFA) on a set of 67 stimuli present in the dental setting using a sample of almost 1,000 individuals. They identified a two-factor solution: the first factor was an invasive treatment-related stimuli factor; and the second factor was a non-invasive treatment-related factor. However, close inspection of the findings suggested that the two factors were very general in nature, with only modest explained variance (51.4%). A possible explanation for the relatively low proportion of explained variance might be the small number of individuals in relation to the large number of stimuli included in the analyses. Moreover, a number of items showed low factor loadings and/or low communalities.

Building on the work of Oosterink *et al.* (11), Wong and colleagues (16) conducted EFA and confirmatory factor analysis (CFA), and performed these on 73 dental objects or situations. Their EFA revealed a seven-factor solution (i.e. dental check-up, injection, scale and drill, surgery, empathy, perceived lack of control, and clinic environment) explaining 71.3% of the variance. However, the sample was relatively homogeneous because it consisted of university students with average levels of dental anxiety and a narrow age range. Additionally, the use of statistical procedures that create optimized linear combinations of variables using a small sample size (i.e. 160 for the EFA and 300 for the CFA), in combination with a high number of items, have been found to yield problematic outcomes because these increase the probability of errors, minimize the accuracy of population estimates, and affect the generalizability of the findings (17).

Accordingly, the purpose of the current study was to develop a descriptive framework for the classification of dental fear by delineating the multidimensional structure of a set of common stimuli present in the dental setting using a large sample with a broad age range and diversity in education level. This was carried out using EFA, whereas a second, independent sample was used to confirm the newly derived model using CFA.

Material and methods

Data collection and participants

Participants were members of twin families (i.e. twins and their relatives) registered with the Netherlands Twin Register (NTR) (18). Those ≥18 yr of age (n = 27,892) received an invitation to participate in a study on lifestyle and personality, and 11,771 individuals (42.2%) answered the relevant questions in an online or offline version of the questionnaire [for a detailed description of the sample and data collection see Van Houtem *et al.* (19) and Ligthart *et al.* (20)].

Measures

Sociodemographic variables: The survey included questions regarding age and sex. Based on previous questionnaires (18), information on country of birth (i.e. the Netherlands vs. other country of birth) was available for 10,781 (91.6%) participants, and information on the level of education (i.e. primary-low vs. intermediate-high) was available for 8,500 (72.2%) individuals.

Dental trait anxiety: Dental trait anxiety was assessed using the Dental Anxiety Scale (DAS) (21). Responses were scored on a scale from 1 to 5, resulting in total scores ranging from 4 (not anxious at all) to 20 (extremely anxious). Dental Anxiety Scale scores of 13 or higher have been interpreted elsewhere as indicating high dental fear (22).

Fear of stimuli comprising the dental setting: To assess the fear of objects and situations related to the dental setting, a set of 28 potentially fear-provoking stimuli present in the dental setting were used. These consisted of the most frequently feared stimuli from the set of 67 used in our previous study (11), supplemented with three more physically related and clinically meaningful stimuli (i.e. the sense of gagging, vomiting and fainting) not used in previous studies. For the complete set of stimuli, we refer to Table S1 or Van Houtem *et al.* (23). The fear-provoking nature of each stimulus was scored on a 4-point scale, from 1 ('not at all fear provoking') to 4 ('extremely fear provoking').

Statistical analyses

Descriptive statistics were obtained using IBM SPSS Statistics Version 20 (IBM, Armonk, NY, USA). The chi-square test was used to analyze associations between categorical variables, and the independent-samples t-test was used to for comparison of continuous variables between groups. In order to explore the underlying structure of the most prevalent fears related to dental treatment, an principal components analysis (PCA) was performed on a random half of the sample. Factors with eigenvalues >1 were extracted and a varimax rotation was performed to increase interpretability of the factor solutions. In order to derive a stable factor structure, the following stepwise procedure was followed. First, factor analysis was performed on the entire set of items. Factor loadings in the rotated component matrix were examined. An item with either a primary factor loading (i.e. the highest factor loading on a given factor) below 0.50 or an ambiguous item (a difference of less than 0.20 between the highest factor loading and the factor loading on a different factor) was deleted from the set of items. Next, a factor analysis was performed on the remaining set of items. This procedure was repeated until all items were non-ambiguous and showed a strong primary factor loading on one factor. Subsequently, factors were interpreted by looking at the content of the items with the highest factor loading on the respective factor. This factor structure was then fitted to the data on the other random half of the sample using CFA performed using AMOS (Version 22.0; IBM SPSS, Chicago, IL, USA). Model fit was evaluated using the traditional chi-square statistic with degrees of freedom and P-value, root-mean-square error of approximation (RMSEA) (<0.07), root-mean-square residual (RMR) (<0.05), Comparative Fit Index (CFI) (>0.95), and Goodness-of-Fit Index (GFI) (>0.95) (24). For all statistical analyses, a value of $P < 0.05$ was considered statistically significant.

Results

Table 1 presents data on the sociodemographic characteristics of the entire sample (n = 11,771 individuals). Of the participants, 61.8% (n = 7,260) were women. Women had a significantly lower mean age than men (t = 10.28; $P < 0.001$). Most participants had been born in the Netherlands (97.9%) and had an intermediate or high level of education (79.7%). Women showed higher mean levels of dental trait anxiety than men (t = −23.49; $P < 0.001$).

The entire sample was randomly divided into two subsamples. The first sample consisted of 5,920 individuals, and the second sample consisted of 5,851

Table 1

Sociodemographic characteristics and mean level of dental trait anxiety of the entire sample

Variable	n	Proportion (%)	Mean ± SD	P
Gender	11771			
Male	4501	38.2	–	–
Female	7270	61.8	–	
Mean age	11771	–	44.4 ± 15.7	
Male	4576	–	46.4 ± 16.1	<0.001
Female	7366	–	43.4 ± 15.4	
Country of birth	10781			
the Netherlands	10556	97.9	–	–
Any other country	225	2.1	–	
Level of education	8500			
Primary or Low	1729	20.3	–	–
Intermediate or High	6771	79.7	–	
Mean level of dental anxiety (4–20)	11572	–	7.5 ± 2.7	
Male	4420	–	6.8 ± 2.3	<0.001
Female	7152	–	7.9 ± 2.9	

Table 2

Final rotated factor solution for the three-factor model

Item no.	Item description	Factor loadings*			Communalities
4	Having surgery	0.75			0.67
5	Dentist drilling a tooth or molar	0.76			0.73
8	Extractions of tooth or molar	0.81			0.74
18	Having a root canal treatment	0.79			0.74
21	Cutting or tearing in soft tissue	0.74			0.69
23	Pain	0.70			0.63
25	Insufficient anesthetic	0.65			0.67
3	Lying in the dental chair (position)		0.68		0.51
6	Not knowing what's happening in the mouth		0.75		0.73
12	The fact that you don't know what is going to happen	0.40	0.74		0.73
15	Objects in the mouth		0.66		0.63
16	Lack of explanation by the dentist		0.67		0.65
17	Feeling helpless		0.67		0.67
26	Gagging			0.87	0.86
27	The sense of vomiting			0.89	0.90
28	Fainting			0.81	0.76

*Factor loadings of <0.40 are not displayed.

individuals. First of all, the sociodemographic distributions of the two subsamples were compared. It appeared that the samples differed in gender [$\chi^2(1) = 4.30$; $P = 0.038$]; that is, the first subsample consisted of 37.3% men compared with 39.2% of men in the second subsample. Although this difference was relatively small, it was significant as a result of the large sample size. Accordingly, no further analyses were done to correct for the small difference in male participants between both samples. No differences in the mean level of dental trait anxiety were found between the first and second samples (mean ± SD DAS score: 7.48 ± 2.73 for the first sample and 7.44 ± 2.73 for the second sample). For the fear-provoking stimuli 'dentist drilling your tooth or molar' ($t = 2.42$; $P = 0.016$) and 'the sound of the drill' ($t = 2.14$; $P = 0.032$), significantly higher mean scores were observed among the individuals in the first subsample. The two subsamples did not differ in any other variable, including the remaining 26 stimuli comprising the dental setting.

Exploratory factor analysis was performed on the set of responses to the 28 fear-provoking stimuli from a random half of the sample (subsample 1). The Kaiser-Meyer-Olkin (KMO) Test measure of sampling adequacy was 0.97. The Bartlett's test of sphericity was significant ($P < 0.001$), indicating that the data were suitable for factor analysis. The initial solution of the EFA revealed four factors with an eigenvalue of >1, explaining 64% of the variance. Next, the stepwise procedure was followed until all items had a primary factor loading of >0.50 and a second loading of at least 0.20 less than the primary factor loading. The final solution yielded a three-factor solution with 70.7% explained variance (see Table 2 for the rotated factor solution). When looking at the content of the items for each factor, the following interpretation was made: (i) an invasive treatment or pain-related factor (eigenvalue = 4.64; explained variance = 29.0%); (ii) a factor associated with losing control (eigenvalue = 3.66; explained variance = 22.9%); and (iii) a factor associated with physical (internal) sensations (eigenvalue = 3.01; explained variance = 18.8%). Cronbach's alpha values, reflecting the intercorrelations between items loading on the first, second, or third factor, were 0.92, 0.88, and 0.91, respectively. Pearson's correlation coefficient between the sum scores of items loading on the first and second factors was 0.727 ($P < 0.001$). Pearson's correlation coefficient between the sum scores of items loading on the second and third factors was 0.591 ($P < 0.001$), and between the first and third factors it was 0.560 ($P < 0.001$). Furthermore, additional analyses revealed that our identified factor structure was consistent in a subgroup of male and female individuals, as well as among those with an intermediate or high level of education. However, the factor structure was not apparent among individuals with a low level of education. In that group, a two-factor solution was found. The items that loaded on the first factor belonged to both invasive treatment and lack of control (explained variance = 45.4%). The items that loaded on the second factor were the same items that loaded on the original third factor (explained variance = 21.8%).

Given that this study was conducted among twin family members, we also tested the possible presence of some degree of dependence between the observations by repeating the EFA in a subsample comprising a random selection of only one person per family ($n = 5{,}246$). This analysis gave identical results to the EFA conducted in the original sample with a three-factor solution, with 70.1% explained variance and the same items loading on each factor.

Using the individuals in the second subsample, a CFA was performed to fit the three-factor structure model to the data. Statistics concerning model fit are reported in Table 3. The first model showed an acceptable fit to the data. Fit indices in general were just below the criteria for a good fit. Inspection of the modification indices showed that the model could be improved by correlating a number of error terms. The following items were considered to be comparable in content and were therefore allowed to correlate: (i) 'having surgery' (item 4) and 'extractions of tooth or molar' (item 8); (ii) 'pain' (item

Table 3

Confirmatory factor analyses (CFA) on the severity ratings of the fear-provoking stimuli

Model	RMR	GFI	CFI	RMSEA
Three-factor	0.030	0.913	0.943	0.081
Three-factor adjusted*	0.029	0.941	0.961	0.069

*In this model a number of error terms were allowed to correlate. CFI, Comparative Fit Index; GFI, Goodness-of-Fit Index; RMR, root-mean-square residual; RMSEA, root-mean-square error of approximation.

23) and 'insufficient anesthesia' (item 25); (iii) 'having surgery' (item 4) and 'pain' (item 23); (iv) 'lying in the dental chair (position)' (item 3) and 'objects in the mouth' (item 15); and (v) 'the fact that you don't know what is going to happen' (item 12) and 'not knowing what's happening in the mouth' (item 6). These modifications led to a slight improvement of model fit (Table 3). Overall, the model showed acceptable fit to the data. Thus, the three-factor structure underlying these data can be considered as stable. Figure 1 shows the factor structure of the CFA model.

Discussion

The findings of the present study, using a sufficiently large sample with a broad age range, showed a factor structure reflecting three different constructs underlying dental fear, namely 'fear of invasive treatment or pain', 'losing control', and 'physical sensations', together explaining about 70% of the variance of in 16 potentially anxiety-provoking stimuli. The CFA carried out on the data of the second sample resulted in an acceptable fit for the two models that were examined. This suggests that the three-factor structure which was identified as underlying our data is stable, thereby supporting the notion that fears related to dental treatment have a heterogeneous, rather than a unidimensional, nature (11). Additional analyses among various subgroups in this sample (male and female participants and moderate-to-highly educated individuals) showed virtually the same findings, which further supports the stability of our factor solution. Only in individuals of low education level did we find a different factor solution. A possible explanation for this finding is that the number of individuals of low education level in the EFA (n = 649) was low relative to the number of items included in the analyses. In addition, it cannot be ruled out that some of these people may have had some difficulties with understanding the questionnaire.

At first glance, the three factors identified seem at odds with those described by Wong *et al.* (16), who identified seven factors, and Oosterink *et al.* (11), who found only two independent factors. Some of these differences can probably best be explained by variation in the description of the items included in the factor analyses, the cut-off point of the factor loadings and cross-loadings, the subjective interpretation of the findings, and the relatively small sample sizes in relation to the large number of stimuli, which could have incurred relative limitations on the statistical power to detect the presence of other, overall, or independent factors of smaller magnitude. The items that loaded on the third factor of our model (i.e. 'physical sensations'), which relate to typical internal (i.e. bodily) sensations, were all added for the purpose of the present study, and had never been part of any previous study (11, 16). Although the items belonging to the third factor represent aversive physical responses, they also can be considered as conditioned stimuli. For instance, the conditioned stimulus 'vomiting' is, in fact, a stimulus that potentially may evoke an unconditioned stimulus (i.e. the disaster image of choking) or an inappropriate negative response of the dentist. The same holds true for 'gagging' and 'fainting'. For example, the situation that one faints may give rise to fear of being observed and negatively evaluated or getting hurt. However, there are a number of clear similarities between our framework and the previous ones. For example, both earlier studies identified factors related to invasive treatments. More specifically, the items that loaded on the 'injection', 'scale and drill', and 'surgery' factor, identified by Wong *et al.* (16), and most of the items used by Oosterink *et al.* (11) that loaded on their 'invasive treatment-related stimuli' factor, can be subsumed under our 'fear of invasive treatment or pain' factor. Similarly, the 'lack of control' factor, identified by Wong *et al.* (16), corresponds, by and large, with the 'losing control' factor of our model.

A descriptive framework for the classification of dental-fear categories may be important because this might contribute to the development of new questionnaires for assessing dental-fear subtypes. Currently, most questionnaires for the assessment of dental fear and dental anxiety include only a small set (four to 15) of potentially anxiety-provoking stimuli [e.g. the Index of Dental Anxiety and Fear (IDAF-4C+) (25), the DAS (21), the Modified Dental Anxiety Scale (MDAS) (26), the short version of the Dental Anxiety Inventory (S-DAI) (27), and the Dental Fear Survey (28)]. Not only do they not fully cover all fears present in the dental setting [see Oosterink *et al.* (11)] but they also fail to provide enough information about the specific stimuli feared by individual patients.

The validity of the three-factor structure is further supported by the fact that this model seems to relate almost perfectly to the three distinct types of treatment strategies that are already applied to various subgroups of dental patients to tailor a specific treatment to patients' individual problems in clinical practice. For example, regarding the first factor in our model, for fear of invasive treatment or pain (with stimuli such as 'dentist drilling a tooth or molar' or 'having a root canal treatment') there is one primary, evidence-based treatment and that is in vivo exposure to patients' anxiety-provoking stimuli (29, 30). For losing control, the second factor in our model (with stimuli such as 'not knowing what is going to happen' or 'feeling helpless'), it is generally recommended to provide a sense of

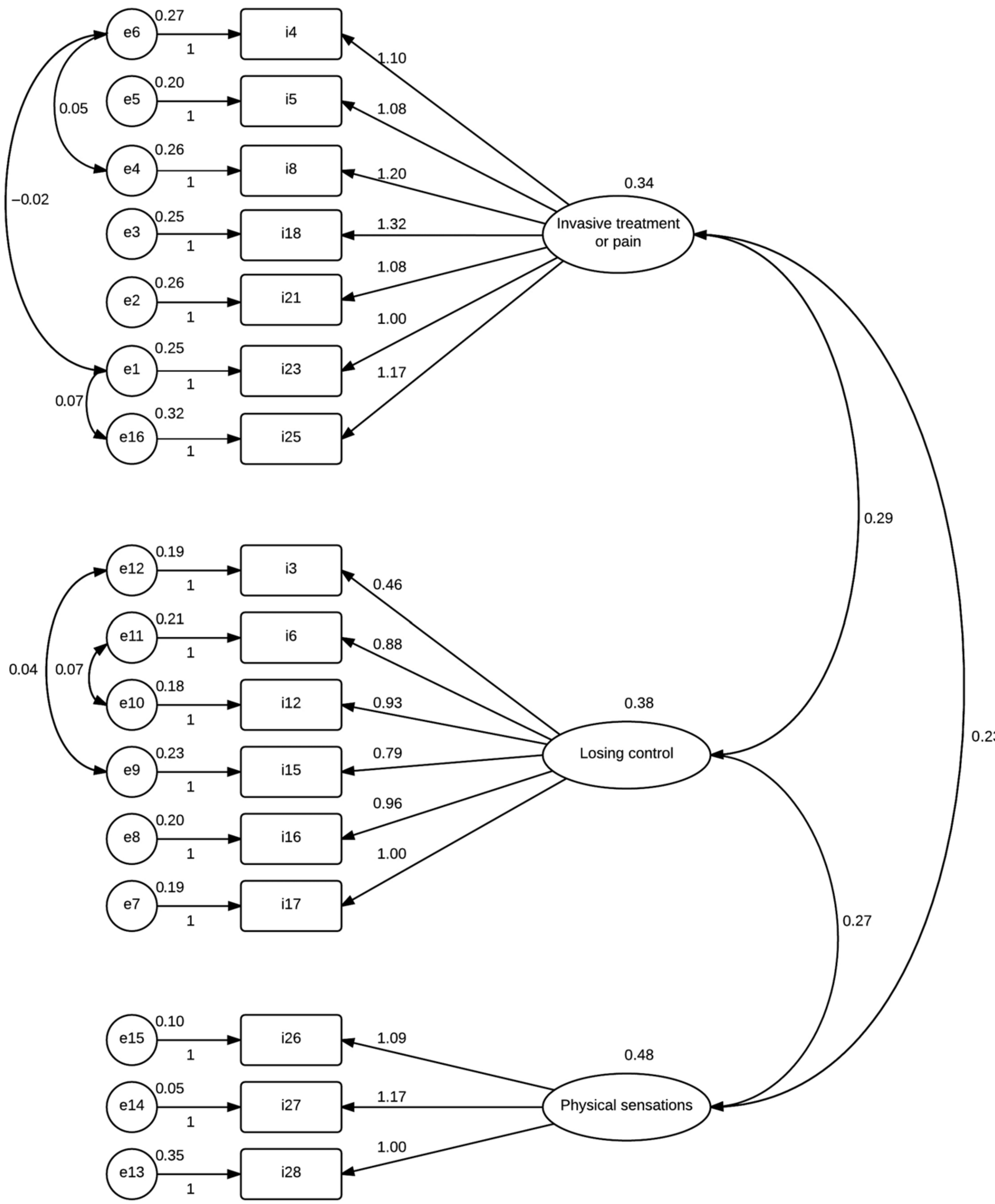

Fig. 1. Path diagram for the adjusted three-factor model of the confirmatory factor analysis with standardized regression weights. Note: ellipses are latent variables ('factors'); rectangles are observed variables; circles are residual standard errors; single-headed arrows indicate causal relationships; and double-headed arrows indicate correlations.

control and to heighten predictability during treatment, for instance by offering the patient the ability to use a stop signal, in order to initiate a break during treatment, and to provide the patient with information about the dental procedure, which helps to correct misconceptions about dental treatment (29, 30). For the third factor in our model, the experience of physical sensations which are related to, for example, 'fainting' or 'gagging', it is recommended to focus treatment on reducing these bodily sensations (29). For instance, the evidence-based approach to prevent fainting in response to being confronted with blood or injury during dental treatment is 'applied tension', which consists of tensing all muscles to increase blood pressure (31, 32). Hence, each factor in our newly derived model reflects a distinct type of fear related to dental treatment, requiring a specific intervention to treat that particular condition. To this end, by first of all identifying the stimuli of which someone is afraid, followed by classifying the patient according to the fear-evoking stimuli that could be identified as belonging to one of the factors of the three-factor structure model, oral health professionals may be facilitated in appropriate decision-making about tailoring particular interventions to individual patients. One point should be noted here. The pattern of three distinct fears may be too simplistic because, in clinical practice, people will not exclusively show a single source of fears but may rather respond to a variety of different objects and situations in the dental setting. This would mean that, in some instances, a combination of interventions is required. In order to inform the reader about the prevalence, distribution, and combination of the three fears, we performed additional analyses, which are presented in Tables S2–S5. In short, factor scores were calculated by summing item scores, and median cut-off values were used to create groups scoring low and high on each factor. Next, all factors were cross-tabulated and give information about how often people fear only one factor, or a combination of factors.

Given the heterogeneity of the dental fears as supported by the factor structure, the findings of the present study support the notion that the constructs, as indicated by the terms 'dental fear' or 'dental phobia' alone, are not tenable designations to classify individuals with fear of the dental setting (see also (11–13, 33, 34) as these fail to account for the broad spectrum of fear-evoking objects and situations present within the dental setting. Therefore, the present findings may be helpful in developing a new descriptive framework for the classification of dental fear by making distinctions among the various fear typologies, rather than by using the global term 'dental fear' or 'dental phobia' per se.

A few limitations need to be mentioned here. Given that participants were asked to rate the fear-provoking nature of the stimuli, it is conceivable that some had never been exposed to at least some of the objects or situations listed in the questionnaire before the study. This could have resulted in either overestimation or underestimation of the fear-provoking nature of particular stimuli. Finally, as we included only 28 stimuli in our analyses, we cannot rule out the possibility that still other factors are underlying the construct of dental fear. However, given the stepwise procedure in which underperforming items were removed, and the fact that the three-factor structure was stable across male, female, and better-educated individuals, this lends the authors reasons to believe that is not the case in the present study.

In conclusion, these findings suggest that dental fear should best be considered a heterogeneous fear reflected by at least three separate factors: fear of invasive treatment or pain; losing control; and the experience of physical sensations. This classification in distinct fear typologies may improve our understanding of the nature of dental fear and might encourage the development of new measures to better guide clinicians in choosing appropriate fear-reducing interventions for individual patients.

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Conflicts of interest – The authors declare no conflict of interest.

References

1. Halonen H, Salo T, Hakko H, Räsänen P. The association between dental anxiety, general clinical anxiety and depression among Finnish university students. *Oral Health Dent Manag* 2014; **13**: 320–325.
2. Singer R, Cardenas G, Xavier J, Jeanty Y, Pereyra M, Rodriguez A, Metsch LR. Dental anxiety and the use of oral health services among people attending two HIV primary care clinics in Miami. *Public Health Rep* 2012; **127**(Suppl 2): 36–44.
3. Hill KB, Chadwick B, Freeman R, O'Sullivan I, Murray JJ. Adult Dental Health Survey 2009: relationships between dental attendance patterns, oral health behaviour and the current barriers to dental care. *Br Dent J* 2013; **214**: 25–32.
4. Humphris G, King K. The prevalence of dental anxiety across previous distressing experiences. *J Anxiety Disord* 2011; **25**: 232–236.
5. Nicolas E, Collado V, Faulks D, Bullier B, Hennequin M. A national cross-sectional survey of dental anxiety in the French adult population. *BMC Oral Health* 2007; **7**: 12.
6. Schuller AA, Willumsen T, Holst D. Are there differences in oral health and oral health behavior between individuals with high and low dental fear? *Community Dent Oral Epidemiol* 2003; **31**: 116–121.
7. Stouthard MEA, Hoogstraten J. Prevalence of dental anxiety in the Netherlands. *Community Dent Oral Epidemiol* 1990; **18**: 139–142.
8. Vermaire JH, De Jongh A, Aartman IH. Dental anxiety and quality of life: the effect of dental treatment. *Community Dent Oral Epidemiol* 2008; **36**: 409–416.
9. Mehrstedt M, John MT, Tönnies S, Micheelis W. Oral health-related quality of life in patients with dental anxiety. *Community Dent Oral Epidemiol* 2007; **35**: 357–363.
10. Cohen SM, Fiske J, Newton JT. The impact of dental anxiety on daily living. *Br Dent J* 2000; **189**: 385–390.
11. Oosterink FMD, De Jongh A, Aartman IHA. What are people afraid of during dental treatment? Anxiety-provoking capacity of 67 stimuli characteristic of the dental setting. *Eur J Oral Sci* 2008; **116**: 44–51.
12. De Jongh A, Bongaarts G, Vermeule I, Visser K, De Vos P, Makkes P. Blood-injury-injection phobia and dental phobia. *Behav Res Ther* 1998; **36**: 971–982.
13. De Jongh A, Oosterink FMD, Kieffer JM, Hoogstraten J, Aartman IHA. The structure of common fears comparing three different models. *Am J Psychol* 2011; **124**: 141–149.
14. Milgrom P, Weinstein P, Kleinknecht R, Getz T. *Treating fearful dental patients*. Reston, VA: Reston Publishing Co, 1985.
15. Locker D, Liddell A, Shapiro D. Diagnostic categories of dental anxiety: a population-based study. *Behav Res Ther* 1999; **37**: 25–37.
16. Wong HM, Mak CM, To WM. Development of a dental anxiety provoking scale: a pilot study in Hong Kong. *J Dent Sci* 2015; **10**: 240–247.

17. Osborne JW, Costello AB. Sample size and subject to item ratio in principal components analysis. *Pract Assess Res Eval* 2011; **9**: 1–9.
18. Willemsen G, Vink JM, Abdellaoui A, den Braber A, van Beek JHDA, Draisma HHM, van Dongen J, van't Ent D, Geels LM, van Lien R, Ligthart L, Kattenberg M, Mbarek H, de Moor MH, Neijts M, Pool R, Stroo N, Kluft C, Suchiman HE, Slagboom PE, de Geus EJ, Boomsma DI. The adult Netherlands twin register: twenty-five years of survey and biological data collection. *Twin Res Human Genet* 2013; **16**: 271–281.
19. Van Houtem CMHH, van Wijk AJ, Boomsma DI, Ligthart L, Visscher CM, De Jongh A. Self-reported gagging in dentistry: prevalence, psycho-social correlates and oral health. *J Oral Rehabil* 2015; **42**: 487–494.
20. Ligthart L, Visscher CM, van Houtem CMHH, Geels LM, Vink JM, De Jongh A, Boomsma DI. Pain symptoms in a Dutch population sample: relationship with sex, age and anxious depression. *J Pain* 2014; **15**: 945–955.
21. Corah NL. Development of a dental anxiety scale. *J Dent* 1969; **48**: 596.
22. Corah NL, Gale EN, Illig SJ. Assessment of a dental anxiety scale. *J Am Dent Assoc* 1978; **97**: 816–819.
23. Van Houtem CMHH, Aartman IHA, Boomsma DI, Ligthart L, Visscher CM, de Jongh A. Is dental phobia a blood-injection-injury phobia? *Depress Anxiety* 2014; **31**: 1026–1034.
24. Hooper D, Coughlan J, Mullen M. Structural equation modelling: guidelines for determining model fit. *EJBRM* 2008; **6**: 53–60.
25. Armfield JM. Development and psychometric evaluation of the Index of Dental Anxiety and Fear (IDAF-4C+). *Psychol Assessment* 2010; **22**: 279–287.
26. Humphris GM, Morrison T, Lindsay SJE. The modified dental anxiety scale: validation and United Kingdom norms. *Community Dent Health* 1995; **12**: 143–150.
27. Aartman IHA. Reliability and validity of the short version of the Dental Anxiety Inventory. *Community Dent Oral Epidemiol* 1998; **26**: 350–354.
28. Kleinknecht RA, Thorndike RM, McGlynn FD, Harkavy J. Factor analysis of the dental fear survey with cross-validation. *J Am Dent Assoc* 1984; **108**: 59–61.
29. De Jongh A, Adair P, Meijerink-Anderson M. Clinical management of dental anxiety: what works for whom? *Int Dent J* 2005; **55**: 73–80.
30. Armfield J, Heaton L. Management of fear and anxiety in the dental clinic: a review. *Aust Dent J* 2013; **58**: 390–407.
31. Ayala ES, Meuret AE, Ritz T. Treatments for blood-injury-injection phobia: a critical review of current evidence. *J Psychiatr Res* 2009; **43**: 1235–1242.
32. Öst LG, Fellenius J, Sterner U. Applied tension, exposure in vivo, and tension-only in the treatment of blood phobia. *Behav Res Ther* 1991; **29**: 561–574.
33. Milgrom P, Coldwell SE, Getz T, Weinstein P, Ramsay DS. Four dimensions of fear of dental injections. *J Am Dent Assoc* 1997; **128**: 756–766.
34. De Jongh A, Muris P, ter Horst G, Duyx MP. Acquisition and maintenance of dental anxiety: the role of conditioning experiences and cognitive factors. *Behav Res Ther* 1995; **33**: 205–210.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. The questionnaire regarding stimuli that may cause anxiety.

Table S2. Cross tabulation between the three factors; invasive treatment or pain, losing control and physical sensations.

Table S3. Cross tabulation between the factors physical sensations and losing control, for individuals with high and low scores on the factor 'invasive treatment or pain'.

Table S4. Cross tabulation between the factors physical sensations and invasive treatment or pain, for individuals with high and low scores on the factor 'losing control'.

Table S5. Cross tabulation between the factors losing control and invasive treatment or pain, for individuals with high and low scores on the factor 'physical sensations'.