Eur J Oral Sci 2007; 115: 479–483

European Journal of
Oral Sciences

Behavioural and physiological effect of dental environment sensory adaptation on children's dental anxiety

Michele Shapiro[1,2], Raphael N. Melmed[3], Harold D. Sgan-Cohen[4], Ilana Eli[5], Shula Parush[2]

[1]Beit Issie Shapiro, Raanana, Israel; [2]School of Occupational Therapy, Faculty of Medicine, Hebrew University-Hadassah, Jerusalem, Israel; [3]Department of Medicine, Faculty of Medicine, Hebrew University-Hadassah, Jerusalem, Israel; [4]Department of Community Dentistry, Faculty of Dental Medicine, Hebrew University-Hadassah, Jerusalem, Israel; [5]The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel

Shapiro M, Melmed RN, Sgan-Cohen HD, Eli I, Parush S. Behavioural and physiological effect of dental environment sensory adaptation on children's dental anxiety. Eur J Oral Sci 2007; 115: 479–483. © 2007 The Authors. Journal compilation © 2007 Eur J Oral Sci

Dental anxiety is a serious obstacle in conventional oral healthcare delivery. A sensory adapted dental environment (SDE) might be effective in reducing anxiety and inducing relaxation. This study aimed to assess the efficacy of a Snoezelen SDE in reducing anxiety among children undergoing scaling and polishing by a dental hygienist. The Snoezelen environment consists of a partially dimmed room with lighting effects, vibroacoustic stimuli, and deep pressure. Nineteen children, aged 6–11 yr, participated in a cross-over intervention trial. Behavioral parameters included the mean number, duration, and magnitude of anxious behaviors, as monitored by videotaped recordings. Physiological parameters reflecting arousal were monitored by changes in dermal resistance. Results, by all measures, consistently indicated that both behavioral and psychophysiological measures of relaxation improved significantly in the SDE compared with a conventional dental environment. The findings support recommending the SDE as an effective and practical alternative in oral healthcare delivery to anxious children.

Michele Shapiro, Beit Issie Shapiro, PO Box 29, Raanana 43100, Israel

Telefax: +972–9–7717139
E-mail: micheles@beitissie.org.il

Key words: dental anxiety; dental behaviour management; dental environment; paediatric dentistry; sensory adaptation

Accepted for publication September 2007

Traditional dental care comprises regular recall visits (1), which include screening, preventive and curative treatment, and enhancing the ability of patients to perform self-care measures. Children, by the ages of 6–12 yr, should be capable of maintaining optimal oral hygiene (2). Fear of dental treatment has been recognized as a serious public health obstacle (3). A US study of children showed that 43% exhibited 'low to moderate' 'general dental fear', whereas 10% showed 'high dental fear'. The sight and sensation of the anaesthetic needle, and the sight, sound and sensation of the drill, were rated as the most fear-eliciting stimuli (4). A Finnish study observed that 15% of the children did not seek care because of fear of dental treatment (3). Dental anxiety has been indicated as a potential predictor of dental caries incidence (5).

Patients often associate the dental office as an unfriendly, offensive, and anxiety-provoking environment, distinguished by loud noises, distinctive odours, bright lights, invasive contact in the mouth, and the probability of pain. Because of potential anxiety, paediatric dentists require a repertoire of techniques to assist in child management. These comprise 'tell-show-do', language euphemisms, voice control, and distraction, combined with anxiety/fear control (such as nitrous oxide sedation, passive restraint, premedication, general anaesthesia, hypnosis, and behavioral management) (6–8).

The Snoezelen environment consists of a multisensory adapted environment coupled with 'client-centred' therapy. It has been proposed to improve the quality of life of varied populations suffering from anxiety, pain, and unrest, including individuals with developmental disability, Alzheimer's disease, or traumatic brain injury (9–12). The physical environment consists of a combination of a partially lit room with special lighting effects, relaxing music, vibration, and aromas. Research documenting the outcome of the Snoezelen environment reports reduction of pain, behavior facilitation, and balance of theheart rate (e.g. reduction of the heart rate amongst hyperactive children and increase of the heart rate amongst passive children) (9–12). Further research has demonstrated reduced maladaptive behaviors and noise levels in a classroom for special needs children, when adapting overhead lighting (13).

A sensory adapted dental environment (SDE) has been developed, based upon the Snoezelen environment, and may potentially be suitable in reducing dental anxiety and maladaptive behaviors and facilitating a calming effect in the dental clinic among children.

Several dental studies have attempted to evaluate the use of audio and video distraction as an adjunct to local anaesthesia (14). CORAH *et al.* found that adult dental patients reported reduced pain and reduced anxiety with video distraction and audiotaped relaxation instructions, but not with music (15). The study by AITKEN *et al.* (14) concluded that music alone did not produce any quantifiable distraction affecting pain, anxiety or patient behavior in dental patients. A study by FRERE (16) reported benefits in adults of using a virtual image audiovisual eyeglass system to reduce fear and pain.

The purpose of the present study was to determine the effect of an SDE, based upon the Snoezelen environment, in children during a routine scaling and polishing appointment with a dental hygienist. It was hypothesized that the SDE would have a favourable effect in calming the subjects during calculus removal (CR). Both behavioral and psychophysiological measures were utilized for assessment. Specific objectives were to measure the effect of the SDE on the number, duration, and magnitude of negative dental behaviors, on the levels of dental anxiety and cooperation, and on electrodermal activity (EDA), during CR, compared with a regular dental environment (RDE).

Material and methods

The variables that were chosen to evaluate the effect of the SDE during CR were: (i) the child's behavior, assessed by filming the subjects during dental care and coding their anxious behaviors; and (ii) physiological arousal states, evaluated by the assessment of EDA changes in the electrical conductance of the skin. This is a sensitive way of monitoring autonomic responses to external stimuli (17). The responses result from sympathetic modulation of skin eccrine sweat gland secretions, a function particularly relevant to arousal states (18).

Participants

The present research was a pilot study of a new dental-adapted concept. The initial study population was relatively small, in order to test the feasibility and significance of the approach. The sample size was computed in order to detect the difference in the amount and duration of stressful behaviors, with a desired power of 80% at a significance level of 5%, employing previous data levels (19–21). Accordingly, a sample size of 19 was required. The study participants were children of employees at the Issie Shapiro Centre, Raanana, Israel, which offers educational and therapeutic services for developmentally disabled children and is also the location of a special needs dental clinic.

Nineteen participants (13 boys, six girls) were included in the study. Their ages ranged from 6–11 yr, with a mean of 8.8 yr [standard deviation (SD) = 1.74]. Fifteen children had previously experienced some form of dental care at least 6 months before the start of the study. The study was approved by the Ethics Committee on Human Experimentation of the Tel Aviv University. Parental informed consent was granted in writing.

Dental settings

The dental treatment procedure used in the study was a routine dental prophylactic appointment, performed by a dental hygienist, including manual dental scaling and tooth cleaning with a low-speed dental handpiece and a rotary bristle brush. No local anaesthesia or sedation was applied.

The SDE was structured specifically for the present research. The sensory stimuli addressed were visual, auditory, somato-sensory, and tactile, as follows:

(i) Visual sensation. All direct overhead fluorescent lighting (50 Hz) was removed, including the regular dental overhead lamp. The adapted lighting consisted of dimmed upward reflective fluorescent lighting (30–40,000 Hz). In addition, slow-moving, repetitive visual colour effects were created by a 'Solar Projector' (Rompa, Chesterfield, UK), shining onto off-white netting, in the child's visual field. The dental hygienist wore a head-mounted LED narrow-spectrum light-emitting diode source lamp (Black Diamond Zenix 1Q; Salt Lake City, CO, USA) directed into the patient's mouth.

(ii) Auditory and somato-sensory stimuli included rhythmic music, which was heard via loudspeakers (Dan Gibson's Solitudes: Exploring Nature with Music; Somerset Entertainment, Essex, UK) at 75 db (digital sound level meter Model 33-2055; RadioShack, Fort Worth, TX, USA), while a bass vibrator (Aura, Bass Shaker, Model AST-1B, 4 Ohms; Unical Enterprises, Michigan, CA, USA), connected to the dental chair, produced soma-sensory stimulation.

(iii) Tactile stimulus consisted of the regular dental X-ray vest, which was placed on the child throughout the dental procedure, covering him/her from the shoulders to the waist. This provided a deep 'hugging' pressure effect.

The RDE utilized fluorescent lighting (50 Hz, on the ceiling and overhead dental lamp), without special visual effects, and neither music nor somato-sensory stimulation. The X-ray vest was not used.

Instruments

The anxiety and cooperation level of the child during CR was recorded by the dental hygienist on completion of each treatment using the anxiety and cooperation scale developed by VEERKAMP *et al.* (22). This standardized scale has been used by dentists to rate anxiety and cooperation during dental care. A score of 0 through 5 is given according to the child's behavior: 0 (extreme behavior e.g. loud and constant crying, and resistance throughout) to 5 (relaxed, interested in communicating, demonstrates desired behavior or complies with demands).

A questionnaire for parents, referring to their child's general anxiety and dental anxiety level, was developed for the present study by six professionals. In this general anxiety scale (GAS), parents were requested to rate, on a four-point Likert scale (1, extremely anxious to 4, relaxed) their child's general anxiety in new places, with new people, and in different dental situations (four questions in total). Internal consistency for continuous variables yielded Cronbach alpha = 0.93.

The negative dental behaviors checklist (NDBC) was developed by the research team in the year preceding the study. It was developed by reporting types of behavior seen while observing dental interventions of approximately 30 children with special needs. It contains seven behavioral descriptors: movements of head, forehead, eyes, and mouth, coughing/gagging, crying/screaming, and other. The number and duration of anxious behaviors was recorded and measured by means of a stopwatch. In addition, the magnitudes of the anxious behaviors were graded on a five-point Likert scale.

Training was provided by the researcher to two coders. Interexaminer reliability was measured using interclass correlative coefficients for all behaviors and conditions, and yielded alpha = 0.88 and standardized alpha = 0.93.

As the NDBC was a newly developed tool for analyzing the dental behavior of a special needs population, there was no similar and previously implemented measure available for comparison and validation.

Electrodermal activity was monitored by changes in the skin conductance. Two 5-mm-diameter electrodes (Mindlife, Jerusalem, Israel) were applied to the fingertips of the second and fourth digits of the right hand and secured with a velcro band. Electrodes were connected to a sensor and to a receiver. An isolated skin conductance coupler (Mindlife) applied a constant 0.5 V potential across the electrode pair. The sample rate was 10 samples per second. We used the graphed results of each EDA study to evaluate these two cardinal parameters during each treatment. 'Relaxation' was measured by averaging the peaks (increase in kiloohm) reflecting raised skin resistance caused by decreased perspiration. 'Arousal', indicating increased arousal, was calculated from averaging the troughs of skin resistance change (decreased kiloohm caused by enhanced perspiration).

Procedure

The study was designed as a random cross-over design. Half of the patients were initially treated under SDE (Time 1) and received RDE on the second encounter (Time 2) (group A, $n = 10$). For the second group (group B, $n = 9$), the procedure was reversed (RDE at Time 1 and SDE at Time 2). The children received CR, approximately 20–25 min per session, in each dental environment, with a 4 month interim period between the two appointments.

During the treatments, the children were filmed and their EDA was recorded from 1 min before the start of treatment until 1 min after completion. The examiner coded all videos according to the NDBC; number, duration (in minutes), and magnitude (e.g. whimpering as opposed to screaming) of anxious behaviors. Because of the nature of the study (one environment with sensory adaptation and the other without), the coding could not be blinded.

Statistical analysis

Repeated-measures analysis of variance (ANOVA) was applied to compare the SDE and the RDE for behavior and EDA, adjusted for sequence of treatment effect. Further analysis by the paired *t*-test compared the degree of the highest and the lowest level of relaxation/arousal, as measured by the EDA. All tests applied were two-tailed, and a value of $P < 0.05$ was considered statistically significant. Data were analyzed using the SAS software (SAS Institution, Cary, NC, USA).

Results

The behavior of the children was evaluated by the GAS. General anxiety was reported infrequently among these children: of the 19 children, only one child exhibited anxiety in new places, two exhibited above-average general anxiety levels, and 10 exhibited above-average dental anxiety.

Regarding the number of anxious behaviors as measured by the NDBC, ANOVA for repeated measures was applied to assess the sequence and treatment effects. A significant sequence effect ($P = 0.04$) was found. There was no significant treatment effect ($P = 0.09$), indicating that the mean number of anxious behaviors was not significantly reduced in the SDE compared with the RDE (Table 1).

Regarding the duration and magnitude of anxious behaviors as measured by the NDBC, ANOVA for repeated measures found the sequence effect to be non-significant ($P > 0.05$). The treatment effect was found to be significant ($P = 0.007$, 0.009), indicating that both the mean duration and the magnitude of anxious behaviors was significantly reduced in the SDE compared with the RDE (Table 1).

Regarding the levels of anxiety and cooperation as recorded by the hygienist, ANOVA for repeated measures found no sequence effect ($P = 0.42$) but a significant effect of treatment ($P < 0.004$), indicating that the

Table 1

Comparison of anxious behaviours of children (n = 19) treated in a sensory adapted dental environment (SDE) vs. a regular dental environment (RDE)

Name of measure	SDE Mean (95% CI)	SDE SD	RDE Mean (95% CI)	RDE SD	SDE-RDE Paired difference (95% CI)
Number of anxious behaviors (total number of behaviors per treatment)	1.37 (1.13; 1.61)	0.5	1.84 (1.33; 2.36)	(1.07)	−0.47 (−1.06; −0.11)
Duration of accumulative anxious behaviors (in minutes)	1.48 (−2.21; 5.18)	1.76	3.7 (−1.7; 9.1)	(3.72)	−2.22* (−3.76; −6.75)
Magnitude of anxious behaviors (five-point Likert scale)	1.84 (−0.22; 3.91)	1.12	3.63 (0.88; 6.38)	(3.18)	−1.79* (−3.07; −0.51)
Cooperation as measured by the dental hygienist	4.95 (4.84; 5.06)	0.23	4.42 (4.09; 4.75)	(.69)	0.53* (0.19;0.86)

CI, confidence interval; SD, standard deviation.
*Statistically significant at $P < 0.01$.

children showed significantly improved cooperation in the SDE as opposed to the RDE (Table 1).

The physiological parameters of arousal were assessed by measuring both the mean EDA and the degree of arousal/relaxation. For the mean EDA, ANOVA for repeated measures found no sequence effect ($P = 0.276$) but a significant effect of treatment ($P = 0.009$), indicating that the mean EDA was significantly reduced in the SDE as compared with the RDE (Table 2).

The paired *t*-test was applied to assess the degree of arousal/relaxation in each dental environment. There was a significant trend of higher relaxation in the SDE (mean = 673.79, SD = 510.67) as compared with the RDE (mean = 484.74, SD = 236.66), indicating that the children exhibited marginally statistically insignificant higher levels of relaxation in the SDE ($P = 0.053$). There was a significant difference in degree of arousal states between the two dental environments, with more arousal in the RDE (mean = 177.63, SD = 54.68) than in the SDE (mean = 235.65, SD = 119.51) ($P = 0.024$), indicating that the children showed greater degrees of anxiety in the RDE (Table 2).

Discussion

This was an initial pilot study of an innovative therapeutic behavioral approach adapted to the dental setting and based upon the Snoezelen multisensory environment. The study consistently demonstrated by means of both behavioral and physiological parameters that the SDE had a significant positive effect on children. Eighty per cent of the children expressed that they preferred the SDE. The only variable found to have a sequence effect (owing to the cross-over design) and no treatment effect was the 'number' of negative behaviors. For all other variables the sequence effect was not found to be significant, but treatment was a consistently significant contributor to variance.

A major assumption underlying this study is that modification of the dental environment, with a concomitant change in sensory stimuli, leads to more comfort and reduces anxiety. Modifying the sensory environment is believed to 'cushion' and thus 'protect' the subject from harsh stimuli, reducing aversive visual, auditory, and tactile intensity while offering soothing visual, auditory, and tactile stimuli. The modified sensory environment results in the subjects' attention being focused intently on the positive stimuli, causing an 'altered state' with a concomitant reduced awareness of discomforting or nocuous stimuli (23).

In primates, neurophysiological studies combining neuronal and behavioral measures have demonstrated that increasing attention to a stimulus enhances the responsiveness and selectivity of the neurons which process that stimulus and inhibit the activity of neurons not involved in the attention process (24–26). Similar processes have been reported among humans (27). This physiological explanation suggests that when attention is distracted, the processing of pain signals is correspondingly reduced (23).

Several study limitations cannot be evaded. The sample size was small ($n = 19$), with a power of only 80%. After having demonstrated the significance of this advocated approach, future research should aim at improving on this level. It also should be noted that the study population was not optimally representative and the dental procedure was minimally invasive. The basic statistical analyses excluded investigation of potential interactions, modifiers, and confounders. It was not possible in this study to ensure observer blindness during the recording (by video) of NDBC. This needs to be considered as an inescapable potential 'Rosenthal effect' source of variation, which could potentially affect reliability.

The preparations for the SDE *per se* might constitute an independent added calming effect on the patients by providing more close and personal attention and also time for explanations and mental preparation. Moreover, the procedure might have had a calming effect on the hygienist him/herself. These potential modifying factors were not within the realms of the present study evaluation, but should be considered. Parents, too, may be calmed by the SDE and thereby potentially indirectly effect their children. In the present study, however, parents did not accompany their children.

The Snoezelen environment is a 'package' concept and utilizes a controlled combination of sensory stimuli. While the present results clearly demonstrate a positive outcome, it is not clear, or within the restraints of the present research to determine, which of the components is more dominant or whether it is the combination of

Table 2

Comparison of the mean electrodermal activity (EDA) values (in kiloohm) of children (n = 19) treated in a sensory adapted dental environment (SDE) vs. a regular dental environment (RDE)

	SDE		RDE		SDE-RDE
	Mean (95% CI)	SD	Mean (95% CI)	SD	Paired difference (95% CI)
Mean EDA	430.37 (279.96; 580.77)	312.05	273.68 (240.04; 343.33)	(144.49)	156.69* (44.95; 268.42)
Arousal	235.63 (178.03; 293.24)	119.51	177.63 (151.28; 303.99)	(54.68)	58* (8.49; 107.51)
Relaxation	673.79 (427.65; 919.93)	510.67	484.74 (370.67; 598.8)	(236.66)	189.05* (−2.89; 380.99)

CI, confidence interval; SD, standard deviation.
*Statistically significant at $P \leq 0.05$.

components that results in the positive outcome. It is suggested that this should be a subject for further research.

The application of an SDE has demonstrated an important potential effect on the relaxation of children during dental hygiene care. This promising approach demands further research for more complex dental treatments.

Acknowledgements – The authors would like to thank the Lorraine White Trust for funding this research, Dr Dana Roth, Dr Yogev, Prof. Manfred Green, Mark Samuelson, Nomi Werbeloff, Ms Dvora Singer, the dental hygienist, staff, and the children of Beit Issie Shapiro employees, for their participation.

References

1. Sheiham A. How often should people go for routine dental recalls? *Community Dent Health* 2004; **21**: 257–259.
2. Sgan-Cohen HD, Adut R. Promotion of gingival and periodontal health from childhood. In: Bimstein E, Needleman HL, Karimbux N, van Dyke TE, eds. *Periodontal and gingival health and diseases*. London: Martin Dunitz, 2001; 207–225.
3. Alvesalo I, Murtomaa H, Milgrom P, Honkanen A, Karjalainen M, Tay MK. The dental fear study survey schedule: a study with Finnish children. *Int J Paediatr Dent* 1993; **3**: 293–300.
4. Milgrom P, Fiser L, Melnick S, Weinstein P. The prevalence and practice management consequences of dental fear in a major US city. *J Am Dent Assoc* 1988; **116**: 641–647.
5. Taani DQ, El-Quaderi SS, Abu Alhaija ESJ. Dental anxiety in children and its relationship to dental caries and gingival condition. *Int J Dent Hyg* 2005; **3**: 83–87.
6. Eaton JJ, Mctigue DJ, Fields HW Jr, Beck M. Attitudes of contemporary parents toward behavior management techniques used in paediatric dentistry. *Pediatr Dent* 2005; **27**: 107–113.
7. Eli I, Bar-Tal Y, Fuss Z, Silberg A. Effect of intended treatment on anxiety and on reaction to electric tooth pulp stimulation in dental patients. *J Endod* 1997; **23**: 694–697.
8. Eli I, Baht R, Blacher S. Prediction of success and failure of behavior modification as treatment for dental anxiety. *Eur J Oral Sci* 2004; **112**: 1–5.
9. Schofield PA. Snoezelen: an alternative environment for relaxation on the management of chronic pain. *Br J Nurs* 2002; **11**: 811–819.
10. Shapiro M, Parush S, Green M, Roth D. The efficacy of the Snoezelen in reducing maladaptive behaviors and facilitating adaptive behaviour in children with mental retardation. *Br J Dev Disabil* 1997; **43**: 140–153.
11. Staal J, Pinkney L, Roane D. Assessment of stimulus preferences in Snoezelen therapy for the elderly with dementia. *Br J Occup Ther* 2003; **66**: 542–551.
12. Hotz GA, Castelblanca A, Duncan R, Lara I, Weiss A, Kuluz J. Snoezelen: a controlled multi-sensory stimulation therapy for children with severe brain injury. *Brain Inj* 2006; **20**: 879–888.
13. Shapiro M, Roth D, Marcus A, Giladi G. The effect of lighting on children with developmental disabilities. *J Int Spec Needs Educ* 2001; **4**: 19–23.
14. Aitken JC, Wilson S, Coury D, Moursi AM. The effect of music distraction on pain, anxiety and behavior in pediatric dental patients. *Pediatr Dent* 2002; **24**: 114–118.
15. Corah NL, Gale EN, Pace LF, Seyrek SK. Relaxation and musical programming as means of reducing psychological stress during dental procedures. *J Am Dent Assoc* 1981; **103**: 232–234.
16. Frere CL, Crout R, Yorty J, Mcneil DW. Effects of audiovisual distraction during dental prophylaxis. *J Am Dent Assoc* 2001; **132**: 1031–1038.
17. Mcintosh DN, Miller LJ, Hagerman RJ. Sensory-modulation disruption, electrodermal responses, and functional behaviors. *Dev Med Child Neurol* 1999; **41**: 608–615.
18. Andreassi JL *Psychophysiology: human behavior and physiological response*, 4th edn. Mahwah, New Jersey: Lawrence Erlbaum Associates, 2000, 191–217.
19. Dupont WD, Plummer WD. Power and sample size calculations: a review and computer program. *Clin Trials J* 1990; **11**: 116–28.
20. Eli I, Uziel N, Baht R, Kleinhauz M. Antecedents of dental anxiety: learned responses versus personality traits. *Community Dent Oral Epidemiol* 1997; **25**: 233–237.
21. Dupont WD, Plummer WD. Power and sample size calculations for studies involving linear regression. *Clin Trials J* 1998; **19**: 589–601.
22. Veerkamp JSJ, Gruythuysen RJM, Van Amerogen WE, Hoogstraten J, Weerheijm KL. Dentist's ratings of child dental patients' anxiety. *Community Dent Oral Epidemiol* 1995; **23**: 234–240.
23. Melmed RN *Mind, body & medicine: an integrative text*. New York: Oxford University Press, 2001: 362–386.
24. Moran J, Desimone R. Selective attention gates visual processing in the extrastriate cortex. *Science* 1985; **229**: 782–784.
25. Richmond BJ, Sato T. Enhancement of inferior temporal neurons during visual discrimination. *J Neurophysiol* 1987; **58**: 1292–1306.
26. Spitzer H, Desimone R, Moran J. Increased attention enhances both behavioral and neuronal performance. *Science* 1988; **240**: 338–340.
27. Posner MI, Presti DE. Selective attention and cognitive control. *Trends Neurosci* 1987; **10**: 13–17.