Scientific Article

Effect of Sensory Adaptation on Anxiety of Children With Developmental Disabilities: A New Approach

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Abstract: ***Purpose:*** *The aim of this study was to evaluate the effect of a sensory-adapted dental environment (SADE) on anxiety, relaxation, and cooperation of children with developmental disabilities (CDDs). Pharmacological treatment has been widely used to reduce anxiety, but nonpharmacological methods may be similarly effective. The standardized clinical situation chosen was a dental hygiene cleaning.* ***Methods:*** *A SADE was structured. Sixteen CDDs participated in an open cross-over intervention trial measuring behavioral and psychophysiological variables.* ***Results:*** *There was a substantial increase in relaxation and cooperation in the SADE as opposed to the regular dental environment (RDE). This was reflected by: mean duration of anxious behaviors (SADE=9.04 minutes vs RDE=23.44 minutes; P<.01); mean magnitude of anxious behaviors (SADE=8.49 vs RDE=15.50; P<.01); cooperation levels (SADE=3.31 vs RDE=1.94; P<.01); mean electrodermal activity (EDA; SADE=1,230 vs RDE=446; P<.001); and difference in degree of relaxation by EDA (SADE=2,014 vs RDE=763; P<.004).* ***Conclusions:*** *The findings indicate the potential importance of considering the sensory-adapted environment as a preferable dental environment for this population.* *(Pediatr Dent 2009;31:222-8) Received February 8, 2008 | Last Revision May 1, 2008 | Revision Accepted May 3, 2008*

KEYWORDS: DEVELOPMENTAL DISABILITIES, PEDIATRIC DENTISTRY, ENVIRONMENTAL ADAPTATION, ANXIETY

Anxiety symptoms in persons with developmental delays (**DD**) has been consistently documented.[1] The limited communication skills and varying behavior patterns of people with DD make the treatment of anxiety a challenging task.

According to the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV), DD has 3 essential features: (1) significantly subaverage general intellectual functioning; (2) significant deficits or impairments in adaptive functioning; and (3) onset before the age of 18.[2]

General intellectual functioning is defined as an intelligence quotient obtained by assessment with intelligence tests. There are 4 degrees of severity, reflecting the degree of intellectual impairment: (1) mild (50-55 to 65-70); (2) moderate (35-40 to 50-55); (3) severe (20-25 to 35-40); and (4) profound (<20-25).[2]

Sparse published scientific data exist on the subject of dental care in children with DD (**CDDs**).[3] Due to poor dental hygiene and an increased prevalence of gingivitis and caries, CDDs usually require more dental attention than the general population.[4] Periodic dental calculus removal is a normative recommendation in the maintenance of satisfactory dental health. The normally harsh sensory stimuli of light and sound particularly in the normal dental clinic may have the effect of arousing anxiety in CDDs. The combination of the dental clinic environment and the altered physiological predisposition of CDDs may make a dental visit stressful.

Earlier studies have shown that a controlled, multisensory environment (Snoezelen, Rompa, Chesterfield, UK) reduces maladaptive behaviors and stabilizes heart rate, and that adapted lighting reduces maladaptive behaviors and noise levels in a special needs' classroom.[5,6] Wigram and Dileo reported the use of low-frequency sinusoidal tones with relaxing music on reducing arousal and favorably influencing emotions.[7]

The aim of the present study was to evaluate the effect of sensory adaptation of an anxiety-provoking environment on participants' responses, based on the observation that the physical environment has a significant influence on the behavior of CDDs.[5,6] Specific objectives were to measure the effect of the sensory-adapted dental environment (**SADE**) on the number, duration, and magnitude of negative dental behaviors, on levels of dental cooperation, and on electrodermal activity during dental scaling and polishing, as compared with a regular dental environment (**RDE**).

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Methods

An adequate sample size was calculated based upon previous published data regarding anxiety caused by clinical dental stimuli, similar to the present study.[8-10] The number was computed to detect the difference in amount and duration of anxious behaviors between the 2 dental environment settings, with a desired power of 80% at a significance level of 5%. According to this calculation, a sample size of 16 was necessary.

Inclusion criteria were: children attending the Issie Shapiro Center, Raanana, Israel, which offers educational and therapeutic services and is also the location of a special needs pediatric dental clinic; 6 to 11 years old; and moderate to severe DD (according to the DSM-IV). Children diagnosed with autism were excluded. The degree of impairment in adaptive functioning of the subjects included nonverbal communication and deficits in daily living skills, socialization, motor skills, and behavior skills.

A convenience sample of 16 participants (11 males, 5 females) were included in this study. Mean age was 8.25 years (±1.25 years SD). Four males had severe mental retardation, and 7 had moderate mental retardation. The 5 females had moderate mental retardation (Table 1). Nine children had previously experienced some form of dental care at least 6 months before the study commenced, which was approved by the Ethics Committee on Human Experimentation of Tel Aviv University, Israel. Informed consent was granted in writing from all parents after the study was explained.

Dental treatment. Dental scaling and polishing included manual (not ultrasonic) cleaning of the calcified deposits off teeth and brushing with a low-speed, power-driven dental handpiece with a rotary bristle brush. This dental prophylactic treatment was chosen because it allows a uniform and standard procedure for all patients.

Sensory-adapted dental environment (SADE). The SADE was structured specifically for this study. The sensory stimuli addressed were visual, auditory, somatosensory, and tactile.

Table 1. DISTRIBUTION OF GROUPS BY GENDER AND SEVERITY OF RETARDATION

Group		1* (N=8)	2† (N=8)	*P*-value ‡
Gender	Male	5	6	.59
	Female	3	2	
Retardation level	Moderate	5	6	.59
	Severe	3	2	

* Treatment sequence: sensory-adapted environment (SADE) first; regular dental environment (RDE) second.
† Treatment sequence: RDE first; SADE second.
‡ Significance according to chi-square.

For visual sensation, the first action regarding visual stimulus was to remove all direct overhead fluorescent lighting (50 Hz). The regular dental overhead lamp was not used. The adapted lighting introduced consisted of dimmed upward reflective fluorescent lighting (30-40,000 Hz) and slow-moving, repetitive visual color effects created by a "solar projector" (Rompa Co, Chesterfield, UK) shining onto off-white netting, in the child's visual field. The dental hygienist wore a head-mounted, narrow-spectrum light-emitting diode source lamp (Black Diamond Zenix IQ, Salt Lake City, Colo) directed into the patient's mouth.

Regarding auditory and somatosensory stimuli, rhythmic music was played through loudspeakers (Dan Gibson's Solitudes: Exploring Nature with Music, Somerset Entertainment, Essex, UK) at 75 db level (digital sound level meter model no. 33-2055, RadioShack, Fort Worth, Texas), while a bass vibrator (Aura, Bass Shaker, model no. AST-1B, 4 ohms, Unical Enterprises, Michigan, Calif), connected to the dental chair, produced somasensory stimulation.

Both the solar projector and rhythmic music components have been employed and tested in previous research on the Snoezelen method and have been found to be effective in relaxing DD patients.[5]

Concerning tactile stimulus, for purposes of the study a "friendly" immobilization wrap was specially developed by the research team. It was shaped like a butterfly, with a smiling face and wings that envelope and "hug" the child when wrapped around. The wrapping material was soft and pliable, with the aim of rendering optimal comfort. The butterfly hugged the child tightly to ensure safety and as a means of deep pressure.

The regular dental environment (RDE). The RDE utilized fluorescent lighting (50 Hz on the ceiling and in the overhead dental lamp), without special visual effects, music, or somatosensory stimulation. The butterfly hugged the child less tightly to ensure safety, but not as a means of deep pressure.

Measures

The children's cooperation level during the treatment was recorded by the dental hygienist on completion of each treatment using the anxiety and cooperation scale developed by Veerkamp et al.[11] This standardized scale has been used by dentists to rate cooperation during dental care. A score of 0 through 5 is given according to the child's behavior: 0=extreme behavior, loud and constant crying, and resistance throughout; to 5=relaxed, interested in communicating, demonstrates desired behavior, or complies with demands. The hygienist had been previously trained and tested by the first author in the use of this scale.

The negative dental behaviors checklist (**NDBC**) was developed the research team in the year preceding the study. Content validity was determined by viewing videos

Negative dental behavior checklist

Patient: ______________________________ Date of birth: ________________

Date: __________________________ No. _____________________

Visit: 1 ☐ Regular environment ☐

2 ☐ Adapted environment ☐

	Behavior description	No. of behaviors (1 or 0)	Duration of each behavior (mins)	Grading of behavior (magnitude)
1	Head movements	________	_ _ : _ _ : _ _	1 2 3 4 5
2	Eye movements	________	_ _ : _ _ : _ _	1 2 3 4 5
3	Mouth movements	________	_ _ : _ _ : _ _	1 2 3 4 5
4	Forehead	________	_ _ : _ _ : _ _	1 2 3 4 5
5	Coughs/gag reflex	________	_ _ : _ _ : _ _	1 2 3 4 5
6	Crying/screaming	________	_ _ : _ _ : _ _	1 2 3 4 5
7	Other ________	________	_ _ : _ _ : _ _	1 2 3 4 5
		Total no. of behaviors	**Total duration of all behaviors**	**Total grading of all behavior**
		________	_ _ : _ _ : _ _	________

Figure 1. Negative dental behavior checklist.

of negative behaviors of 30 CDDs in the dental intervention situation. To achieve a high level of reliability, training was provided by the researcher to 2 coders. Interexaminer agreement was measured using interclass correlative coefficients for all behaviors and conditions, yielding alpha= 0.88 and standardized alpha=0.93. Thereafter, one coder participated in the actual study. The NDBC contains the following behavioral descriptors: movements of head, forehead, eyes, and mouth; coughing/gagging; crying/screaming; and other. All behaviors were videotaped. Utilizing NDBC, we measured duration of anxious behaviors, in minutes, as measured by a stop-watch. The number was recorded by noting which of the 7 potentially anxious behaviors was exhibited (maximum score=7). The magnitude of negative behaviors was graded on a 5-point Likert scale (score range=0-30; Figure 1). The coder was able to record each of the 7 behaviors and their magnitude and duration (with a stop-watch), meticulously watching the video and rewinding when necessary.

Electrodermal activity (**EDA**) was monitored by changes in the skin conductance. Two 5-mm diameter electrodes (MindLife Co, Jerusalem, Israel) were applied to the fingertips of the right hand's second and fourth digits and secured with a Velcro band. Electrodes were connected to a sensor and receiver and applied gently and quickly, avoiding any potential extra anxiety to the children. An isolated skin conductance coupler (MindLife Co) applied a constant 0.5-volt potential across the electrode pair. The sample rate was 10 samples per second. We used the graphed results of each EDA study to evaluate 3 cardinal parameters during each treatment.

Skin resistance to electric current (EDA) is directly related to the presence (reduced resistance, that is, increased arousal) or absence (increased resistance, that is decreased arousal) of perspiration.[12] To provide an identifiable, objective parameter that was easily recognizable with each subject, the troughs and peaks were chosen for every tracking. Mean EDA was measured by averaging the skin resistance along the entire treatment (a higher score= more relaxed). "Relaxation" was determined by averaging the peaks (increase in kohms) reflecting raised skin resistance due to decreased perspiration (a higher score=more relaxed). Increased arousal was calculated from averaging troughs of skin resistance change, according to decreased kohms due to enhanced perspiration (a lower score=patient more aroused, less relaxed).

Procedure

Before commencement of treatment, the children were introduced to the "butterfly" in their classrooms for familiarization purposes. The children were treated with 1 session in each dental environment, with a 4-month interim period between the 2 treatments (2 treatments in all). At each treatment, the same prophylactic dental procedures were applied. The durations of all dental treatments (RDE and SADE) ranged between 20 to 25 minutes. Four months is the regular time lapse for dental prophylaxis at this special needs clinic.

Table 2. MEAN ANXIOUS BEHAVIORS BETWEEN THE SENSORY-ADAPTED DENTAL ENVIRONMENT (SADE) VS THE REGULAR DENTAL ENVIRONMENT (RDE) IN CHILDREN (N=16)

Measure name	SADE Mean±(SD)	RDE Mean±(SD)	*P*-value
Duration of accumulative anxious behaviors (in mins)	9.04±11.58	23.44±16.67	<.01
Frequency of anxious behaviors (total no. of anxious behaviors per treatment)	4.06±1.12	4.56±1.26	.19
Magnitude of anxious behaviors (5-point Likert scale)	8.5±6.45	15.5±8.0	.011
Cooperation scale as measured by the dental hygienist	3.31±1.08	1.94±1.18	<.01

* The *P*-value relates to the difference between the 2 dental settings (sensory-adapted dental environment and regular dental environment).

In the present study, we adopted a cross-over design. The 16 children were randomly assigned to 2 groups by sequence of treatment: group 1 (N=8) and 2 (N=8). Group 1 underwent treatment in the SADE during the first stage and crossed over to the RDE for the second stage (SADE→RDE). Group 2 started with treatment in the RDE during the first stage and crossed over to the SADE for the second stage (RDE→SADE).

During the treatments, the children were filmed and their EDA was recorded. Filming and EDA commenced 1 minute before start of treatment, and ended 1 minute after completion of treatment. One coder recorded all videos according to the: behavior checklist; number of anxious behaviors; duration of the behaviors (in minutes); and magnitude of behaviors (ie, whimpering as opposed to screaming). The number, magnitude, and duration of behaviors were very carefully monitored, employing a stopwatch, by a coder who had undergone intensive previous training. EDA was scored manually from a graph-drawn recorder on the computer for each treatment session. The scoring established a mean, a degree of arousal, and a degree of relaxation of skin conductance. Because the EDA is very sensitive to movement, some artifact peaks were seen among children who moved excessively. Therefore, prior to statistical analysis, artifact peaks above and below a standard deviation of 2.2 were excluded. The cooperation scale was completed by the hygienist on completion of each session.

Statistical analysis. Repeated measures analysis of variance (**ANOVA**) was applied to compare the treatment effect and the sequence effect between the SADE and the RDE for behavior and EDA. A potential cross-over effect was controlled for by standardizing for sequence. Further analysis by paired *t* test compared the degree of relaxation and the degree of arousal as measured by EDA. All tests applied were 2-tailed, and a value of *P*<.05 was considered statistically significant. Data were analyzed using SAS software, version 9 (SAS Institution, Cary, NC).

Results

Parents of the children studied had reported a gamut of anxiety states which are typical for this population. Six children exhibited anxious behavior in new places, 2 children exhibited anxious behavior when meeting new people, and 10 children exhibited extreme general anxiety.

No clinical differences of interest were found in gingivitis and plaque levels between the 2 groups and, therefore, these data are not presented. All children displayed poor oral hygiene levels and moderate gingivitis, as expected among a population not competent to perform basic oral hygiene practices. The time factor of each of the dental treatments was consistent.

In all of the following analyses, the sequence effect was found to not be statistically significant. Therefore, we deduced that there was no cross-over effect. All groups were combined, and the independent treatment effect was examined.

In all analysis of NDBC, we refrained from differentiating the specific components (ie, eye and head movements). Regarding the duration of anxious behaviors measured by the NDBC, the means for SADE and RDE, respectively, were 9.04 and 23.44 minutes. ANOVA for repeated measures found a significant treatment effect: F=19.62, *P*<.01, indicating that the mean duration of anxious behaviors was significantly reduced in the SADE compared to the RDE (Table 2).

Regarding the number of anxious behaviors measured by the NDBC, the total numbers of behaviors per treatment for the SADE and RDE, respectively, were 4.06 and 4.56. ANOVA for repeated measures found no significant treatment effect: F=1.88, *P*=.19, indicating that the mean number of anxious behaviors was not significantly reduced in the SADE compared to the RDE (Table 2).

Regarding the magnitude of anxious behaviors measured by the NDBC, the scores for SADE and RDE, respectively, were 8.5 and 15.5. ANOVA for repeated measures found a significant treatment effect: F=8.49, *P*=.011, indicating that the magnitude of anxious behaviors was significantly reduced in the SADE compared to the RDE (Table 2).

Concerning the cooperation levels recorded by the hygienist, the Likert scale scores for SADE and RDE, respectively, were 3.31 and 1.94. ANOVA for repeated measures found a significant treatment effect: F=33.00, *P*<.01, indicating that the cooperation (as seen by the dental hygienist) showed a significant increase in the SADE vs RDE (Table 2).

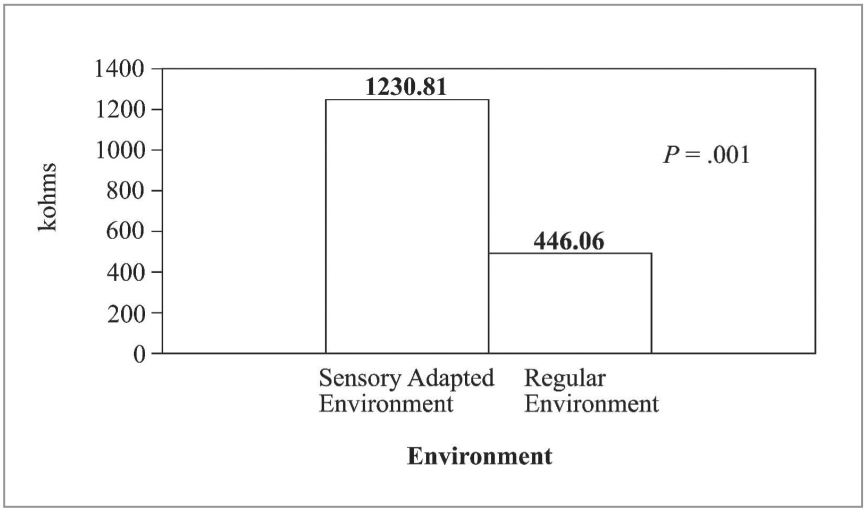

Figure 2. Mean Electrodermal Activity values in the Sensory Adapted Environment versus the Regular Dental Environment (N=16).

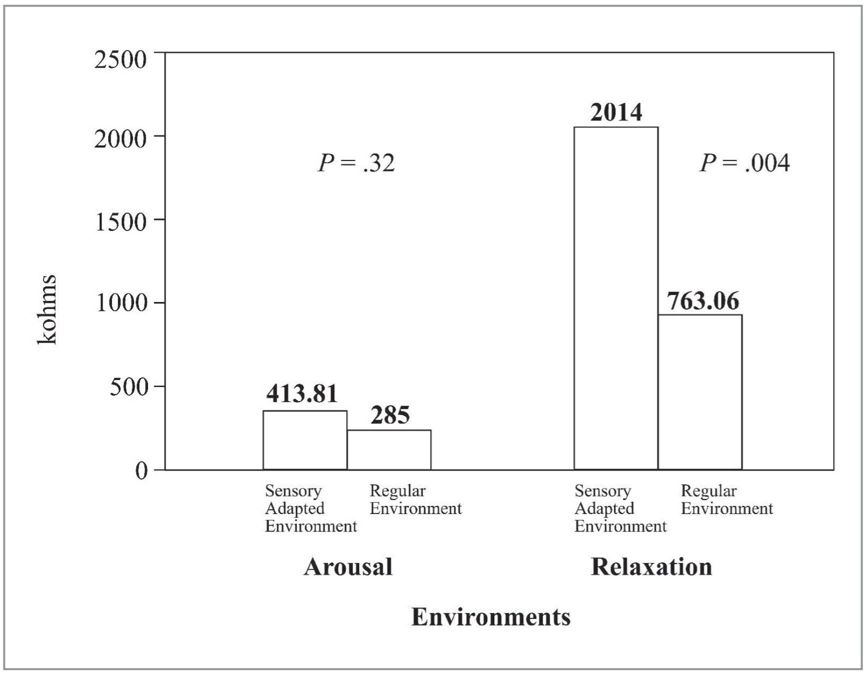

Figure 3. Difference in degree of Arousal and Relaxation in the Sensory Adapted Environment versus the Regular Dental Environment (N=16).

The physiological parameters of arousal were assessed by mean EDA and the degree of arousal/relaxation. For the mean EDA, a value of 1,230 kohms was found for SADE vs 446 kohms for RDE. ANOVA for repeated measures found a significant treatment effect: F=15.34, *P*=.001, indicating that the mean EDA was significantly reduced. Thus, the children were in a state of lower arousal (improved relaxation) in the SADE compared to the RDE (Figure 2).

For the degree of arousal, a mean value of 413 kohms was found for the SADE, compared to 285 for the RDE. The paired *t* test was applied, and no significant difference was revealed (*P*=.32). For the degree of relaxation, a mean value of 2,014 kohms was found for the SADE and 763 for the RDE. According to the *t* test, this difference was significant (*P*=.004). These results indicate that CDDs were more relaxed in the SADE environment vs the RDE, but no significant difference was found in degree of arousal between the 2 dental set-tings (Figure 3).

Discussion

For the first time, this study shows the potential role of the sensory-adapted environment modification in creating a calming effect among CDDs undergoing a potentially high-anxiety procedure. This was demonstrated according to the evaluation of both behavioral and physiological parameters. A previous study has demonstrated a similar effect on typical children.[13]

Most CDDs normally exhibit extreme general anxiety. This clarifies why this population finds dental intervention aversive. A major assumption underlying this study is that sensory modification of a potentially threatening environment, with a concomitant change in sensory stimuli, leads to more comfort and enables reduction of anxiety. Varied anxious behaviors were seen in the regular dental environment, including extreme screaming and head banging. These were significantly reduced, however, in the sensory-adapted dental environment.

Modifying the sensory environment is believed to “cushion” and thus “protect” the subject from harsh stimuli, reducing visual, auditory, and tactile intensity. In addition, the modified sensory environment results in the participants’ attention focused intently on the moving visual and auditory stimuli and the deep pressure, bringing about an “altered state”with the inevitable concomitant reduced awareness of discomforting or nocuous stimuli.[14]

Ideas as to how to adapt the physical environment were drawn to a large extent from the literature of authors Grandin and Williams, who are autistic.[15,16] Firstly, the room was partially dimmed, diminishing any disturbing visual stimuli. This is supported by Williams, who speculated that people who are oversensitive to visual stimuli have a problem filtering different wavelengths of light. The result is an overload of visual perception and a difficulty making sense of visual stimuli.[16] Direct fluorescent lighting (50 Hz) has been documented as flickering and excessively disturbing.[6,16,17] This lighting was removed both from the ceiling and the dental chair in the SADE and was substituted with reflective, upward-facing fluorescent lighting (30-40,000 Hz) and soft-colored, slowly repetitive moving lighting.

Noise is another important factor. The SADE employed soft music (75 dB) to distract from the regular loud sounds of the dental equipment (suction=90 dB) and the power-driven dental handpiece brush (suction=100 dB). A considerable body of knowledge has documented the negative effects of noise on infants in neonatal intensive care units, finding that higher noise levels may decrease oxygen saturation, elevate blood pressure, and increase heart and respiration rates.[18] One of the observations made during the present research was that more anxious behaviors and lower skin resistance, according to EDA measurements, were noted when noise levels increased due to the dental handpiece brush or the power suction machine. These same stimuli were notably less disturbing during SADE conditions. According to Love, dental clinics' noises, such as drills, are in the range of 100 dB, presenting a significant risk of noise-induced hearing loss.[19]

The third sensation was the deep pressure. Somatic sensation was provided by means of vibroacoustic stimulation on the dental chair and deep pressure via the butterfly. Vibration, proprioception, and deep pressure are forms of sensory stimulation that may produce a calming effect.[20,21] Ayres and King reported wrapping a CDD in a gym mat to produce a calming effect.[22,23] Research by Fertel-Daly et al and Vandenberg support the use of weighted vests (an effect similar to the "butterfly") for reducing maladaptive behaviors and calming and improving attention in special needs children.[24,25] In the present study, a less tightly hugging "butterfly" was employed to ensure safety in the control (RDE) group. This, in itself, may have induced relaxation to a certain extent, but would not have diminished the tested SADE's overall observed effect.

The present study design could not accommodate observer blindness, due to the visible physical environment. This fallibility should be recognized, however, the EDA physiological data enhance the results' validity.

This study's cross-over design enabled different treatments to be provided to the same subjects. This design prevented the potential confounding effect of individual characteristics. The sequence effect was found to be insignificant, eliminating any potential "carry-over" effect.[26]

The study results are not indicative of potential utilization for all anxiety-provoking dental and medical treatments. Only 16 6- to 11-year-old subjects participated in this pilot study (5 males and 11 females)–4 with severe and 12 with moderate mental retardation. These small numbers could not enable analyzing the potential modifying effects of age, gender and mental retardation level. These variables should be addressed in future studies. Further research should also investigate larger and more varied populations in additional dental and medical treatment environments.

The NDBC was constructed for the study. Inter-rater reliability was utilized and yielded good results. Nevertheless it is suggested that further studies use this measure in different environments to further validate the use of this measure.

The SADE modification has multiple components: visual; auditory; somatosensory; and tactile. In future studies, each stimulus should be tested separately to evaluate their individual effect.

Conclusions

Based on this study's results, the following conclusions can be made:

1. This research is an innovative, noninvasive environmental approach to inducing relaxation and reducing anxiety in the dental clinic.
2. The sensory-adapted dental environment approach requires neither psychotherapeutic experience for dental personnel nor pharmacological sedation.
3. The proposed approach is simple to apply and has no negative side effects.
4. This model has the potential to significantly provide oral and general health care for all children—as demonstrated specifically for those with developmental disabilities.

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Abstract of the Scientific Literature

Treating Dental Caries with Ozone?

The purpose of this article was to use Ozone (O3), which has been used in other medical subspecialties such as; vascular pathology, oncology and pulmonary pathology as an anti-bacterial agent in the treatment of dental disease. For the purposes of this in vitro study, mutans streptococci were specifically targeted. A delivery device (HealOzone) was used which releases ozone at 2100 ppm via a handpiece/removable silicone cup. The anti-bacterial effect was time-dependant, there were fewer viable samples with 20 seconds compared to 10 seconds. After 40 seconds of ozone therapy none of the bacterial samples were viable. The lower the initial bacterial concentration, the greater the inhibition.

Comments: *This study addresses a provocative topic in cariology. It should be noted, that as mentioned in this study, there is a narrow difference between therapeutic and toxic ozone. One limitation in the clinical application of this study is that targeted bacteria specifically was mutans streptococci and the under-standing of colonization patterns that lead to dental disease is still in a nascent stage.* ***ST***

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