

# Influence of Adapted Environment on the Anxiety of Medically Treated Children with Developmental Disability

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**Objectives** To examine the influence of a sensory adapted environment (SAE) on the behavior and arousal levels of children with developmental disability in comparison with typical children, during a stress-provoking medical situation.

**Study design** Sixteen children (6-11 years old) with developmental disability and 19 age-matched typical children participated in a cross-over trial measuring behavioral and psychophysiological variables, performed during a dental intervention.

**Results** Both groups performed better in the SAE compared with the regular environment (RE), by comparing: the mean duration of anxious behaviors in the SAE and RE (5.26 and 13.56 minutes;  $P \leq .001$ ); the mean electrodermal activity for arousal levels, before commencement of treatment in the SAE and RE (784 and 349 Kohms;  $P = .002$ ); and the mean electrodermal activity during treatment in the SAE and RE (830 and 588 Kohms;  $P = .001$ ). A significant group by environment interaction was revealed, indicating that the difference in the 2 environments was greater in children with developmental disability than typical children in all 3 measures.

**Conclusions** These findings indicate the importance of environment in determining the comfort level of all children. The greater difference in the 2 environments observed in children with developmental disability suggests that this group benefits more from sensory adapted environments. (*J Pediatr* 2008;xx:xxx)

Many children are subjected to unnecessary pain and suffering and often fail to cooperate and overcome fear during health care treatment.<sup>1-6</sup> Potential anxiety-provoking medical events include local and general anesthetics, preoperative surgical preparation (induction of anesthesia), radiological procedures, suturing of wounds, oncology therapy, neurological examination, and many others.<sup>1-6</sup> Modes of management that have been described include: conscious sedation, stress-reducing medical devices, behavioral relaxation, pharmacologic analgesic and sedative interventions, hypnosis, and others.<sup>1-6</sup> This study addresses the option that modes of treatment in these situations could also include the sensory adaptation of clinical environments.

Participation is defined as involvement in life situations, and represents the highest level of functional hierarchy.<sup>7</sup> The International Classification of Functioning and Health stresses the importance of identifying risk factors that may affect a child's participation in life activity.<sup>7</sup> It may be influenced by personal (predisposition of the individual) or environmental (the physical setting) factors.<sup>8</sup> People with developmental disabilities have substantial functional limitations that significantly impede their participation in daily activities.<sup>9-11</sup> However, although the functional limitations of subjects with developmental disability frequently captures the most attention, the enhanced intolerance of environmental stimuli not normally or unusually disturbing to others should also receive attention.

A study of typical children demonstrated that behavioral correlates and psychophysiological measures of the autonomic sympathetic nervous system improved significantly in a sensory adapted environment (SAE).<sup>12</sup> The latter consists of a designated room partially lit, with controlled multi-sensory stimuli. SAE has been proposed to improve the quality of life of varied populations sustaining anxiety, pain, and unrest, including individuals with developmental disability, Alzheimer's disease, or traumatic brain injury.<sup>13-16</sup> The physical environment includes special lighting effects, relaxing music, vibration, and aromas. Research documenting the outcome of the multi-sensory environ-

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EDA	Electrodermal activity	RE	Regular environment
NDBC	Negative dental behavior checklist	SAE	Sensory adapted environment

ment reports reduction of pain, behavior facilitation, and balance of heart rate (reduction of heart rate in hyperactive children and increase of heart rate in passive children).<sup>13-16</sup> Evaluation of autonomic sympathetic activity by assessing an individual's palmar electrodermal activity (EDA) is recognized as an objective measure of arousal.<sup>17</sup>

This study examines the influence of SAE, during a stressful situation, on children with developmental disability and compares their responses with those of typical children. Dental clinics are usually characterized by noises, odors, bright lights, intrusive contact, and anticipation of pain. The altered neurophysiological predisposition of individuals with developmental disability with the common dental clinic environment makes a dental visit a particularly uncomfortable experience. Therefore this setting served as a suitable model in that the essential elements aforementioned may be easily controlled. We hypothesized that children with developmental disability would find dental treatment a more stressful situation than typical children and that the children with developmental disability would be more positively influenced by SAE. This would be observed by duration of negative behaviors and electrodermal activity before and during professional dental treatment.

## METHODS

### Patients

Estimation of sample size was based on published data that used a design similar to ours.<sup>18-20</sup> Accordingly, a required sample size of 32 was calculated, including 16 children with developmental disability and 16 typical children. To ensure that this study was adequately powered and to reduce the risk of type II error, the number of children was increased beyond the suggested number to 40 (20 children for each group). However, only 19 children with developmental disability could be recruited from the Beit Issie Shapiro Center, Israel, which offers educational and therapeutic services for children with developmental disability and is also the location of a special-needs dental clinic. Each child who is accepted into the Issie Shapiro Center has received a diagnosis. Similar numbers of typical children (matched for age and sex) were recruited (children of employees at the same center). Of the 19 children with developmental disability, 3 were disqualified because they were found to have a developmental disability and autism. Thus, 16 children with developmental disability and 19 typical children (with no known disabilities) were included.

The 16 participants (11 male and 5 female) with developmental disability were aged from 6 to 11 years (mean, 8.3 years; SD, 1.3) and had moderate to severe disability.<sup>21</sup> Nineteen children were developmentally typical (13 male and 6 female) and aged from 6 to 11 years (mean, 8 years; SD, 1.74). The study was approved by the Ethics Committee on Human Experimentation of the Tel Aviv University. Parental informed consent was granted in writing. The procedure used was a routine dental prophylactic cleaning performed by a

dental hygienist, including manual dental calculus removal and tooth cleaning with a low-speed dental hand-piece and a rotary bristle brush. No local anesthesia or sedation was used. The dental hygienist was instructed to provide regular uniform treatment to all children, regardless of the environment.

### Environments

**SENSORY ADAPTED ENVIRONMENT.** The SAE included visual sensation: 1) No overhead fluorescent lighting (50 Hz) or dental overhead lamp; 2) Adapted lighting consisted of dimmed upward fluorescent lighting (30-40 000 Hz), slow moving, repetitive visual color effects ("Solar Projector", Rompa Co., Chesterfield, UK); and 3) The dental hygienist wore a head mounted LED lamp (Black Diamond Zenix IQ, Salt Lake City, Utah) directed into the patient's mouth.

Auditory and somato-sensory stimuli were also included in SAE. Rhythmic music via loudspeakers (Dan Gibson's *Solitudes: Exploring Nature with Music*) at 75 db level with bass vibrator for soma-sensory stimulation (Aura, Bass Shaker, model AST-1B, 4 OHMS; Unical Enterprises, City of Industry, California), connected to the dental chair producing soma-sensory stimulation.

Tactile stimulus was also included in SAE. For children with developmental disability (and not for typical children), a "friendly butterfly" papoose "hugged" the child tightly. For typical children, a dental radiography vest was placed on the child (providing a deep "hugging" effect). The Helsinki permission was granted for use of the "friendly butterfly" only for children with special needs because this has a restrictive function and should not be used for typical children. This was supported by parent approval. The rationale for use of the physical restraint on patients with developmental disability is to reduce preemptively possible disruptive movements rather than rely on deeper sedation or general anesthetic to contain the problem.<sup>22</sup>

**REGULAR ENVIRONMENT.** Fluorescent lighting (50 Hz) and overhead dental lamp were used in the RE. The papoose "hugged" the developmental disability child less tightly, only to ensure safety. The radiography vest was not supplied for typical children.

## MEASURES

The Negative Dental Behaviors Checklist (NDBC) was developed by the research team. Content inter-rater reliability was determined after training 2 independent coders (not researchers participating in this study) and yielded a standardized alpha value of 0.93. The NDBC contains 7 behavioral descriptors: movements of head, forehead, eyes, and mouth, coughing/gagging, crying/screaming, and other. All behaviors were recorded with videotape. Duration of negative behaviors in minutes was measured by the coder with a stopwatch. The NDBC is newly developed and was used in earlier research.<sup>12</sup>

EDA was monitored by changes in palmar skin conductance by means of electrodes (Mindlife Co, Jerusalem,

**Table. The effect of sensory adapted environment compared with the regular environment on typical children and children with developmental disability, according to behavioral (negative dental behavior checklist) and physiological (electrodermal activity) measures**

Variable	Child Population Group	N	Environment				P* value
			Regular		SAE		
			Mean	(SD)	Mean	(SD)	
Duration of accumulative anxious behaviors by NDBC (in minutes)	Typical	19	3.69	(3.70)	1.48	(1.76)	<.01
Duration of accumulative anxious behaviors by NDBC (in minutes)	Developmental disability	16	23.44	(16.67)	9.04	(11.58)	<.001
Tonic EDA before commencement of dental treatment	Typical	19	270.00	(140.08)	400.95	(236.99)	<.05
Tonic EDA before commencement of dental treatment	Developmental disability	16	428.88	(444.54)	1167.88	(1038.16)	<.05
Phasic EDA during dental treatment	Typical	19	273.68	(144.48)	403.37	(312.05)	<.01
	Developmental disability	16	446.06	(455.90)	1230.81	(800.22)	<.01

\*P levels according to analysis of variance.

Israel). The EDA was determined with an increase in Kohms reflecting raised skin resistance (the higher the score, the more relaxed) and decreased Kohms caused by enhanced perspiration (the lower the score, the less relaxed).

### Study Design

The study used a random cross-over design. During phase 1, the children with developmental disability were assessed. Eight patients with developmental disability were initially treated with SAE (time 1) and received RE on the second encounter (time 2; group A, n = 8). For the second group of 8 children with developmental disability (group B, N = 8), the procedure was reversed. The children received dental treatment approximately 20 to 25 minutes per session, in each dental environment, with a period of 4 months between the 2 sessions. After the study of the children with developmental disability, the typical children underwent a similar cross-over study in 2 groups.

EDA was measured before (tonic) and during (phasic) the dental procedure. During the treatments, each child was filmed, and 1 of the coders coded all behaviors and measured the duration of anxious behaviors with the NDBC.

### Data Analysis

SAS computer software (SAS Institution, Cary, North Carolina) was used to analyze the scores in the study. Analysis of variance was applied to compare SAE and RE for behaviors and EDA, with repeated measures for environments and treatment sequence (time 1 versus time 2). In addition, to relate to potential heterogeneity of variance, non-parametric analysis (Mann-Whitney and Wilcoxon for repeated measures) were additionally applied.

Interactions among the developmental disability group and typical group, the 2 environments (SAE and RE), and the treatment sequence in the effect on behavior and EDA was tested with a simple effect analysis. This analysis explores the nature of the interaction by examining the difference in groups within 1 level of 1 of the independent variables.<sup>23</sup> In

this study, we adopted a cross-over design that enabled control of each subject and thereby controlled for any potential heterogeneity of the samples.<sup>24</sup> All tests applied were 2-tailed, and a P value <.05 was considered to be statistically significant.

## RESULTS

In all analyses, the treatment sequence effect (time 1 versus time 2) was found not to be significant. Therefore we deduced that there was no cross-over effect and the independent treatment environment effect could be independently examined.

### The Duration of Anxious Behaviors by NDBC

Significant main effects of environment and of group were revealed on duration of anxious behaviors (analysis [2X2],  $F[1,33] = 29.09$ ,  $P < .001$ ,  $\text{Eta}^2 = 0.46$ ;  $F[1,33] = 20.82$ ,  $P < .001$ ,  $\text{Eta}^2 = 0.38$ ). In addition, a significant group by environment interaction was found ( $F[1,33] = 15.63$ ,  $P < .001$ ,  $\text{Eta}^2 = 0.32$ ). The Table presents the means of the 2 groups in both environments.

As shown in the Table, the main effect was a shorter duration of anxious behaviors in the adapted environment (mean, 5.26; SD, 7.9) as compared with the regular environment (mean, 13.56; SD, 11.6). Regardless of environment, the 16 children with developmental disability had an overall longer duration of anxious behaviors (mean, 16.24; SD, 8.8) than the 19 typical children (mean, 2.59; SD, 8.8). As indicated by the interaction effect, the difference in the 2 environments in the children with developmental disability is greater than in the typical children. According to simple effect analysis that was applied to assess the source of the interaction, a significant difference was found in the 2 environments for the typical group ( $F[1,18] = 9.13$ ,  $P < .01$ ,  $\text{Eta}^2 = 0.34$ ) and for the developmental disability group ( $F[1,15] = 19.62$ ,  $P < .001$ ,  $\text{Eta}^2 = 0.57$ ).

## Electrodermal Activity

**TONIC EDA (BASELINE) BEFORE COMMENCEMENT OF DENTAL TREATMENT.** Data revealed significant main effects of environment and group on baseline tonic EDA (analysis of variance [2X2],  $F[1,33] = 11.61, P = .002, \text{Eta}^2 = 0.26$ ;  $F[1,33] = 11.00, P = .002, \text{Eta}^2 = .25$ ). In addition a significant group by environment interaction was found ( $F[1,33] = 5.67, P < .023, \text{Eta}^2 = 0.15$ ). The Table presents the means of the 2 groups in both environments.

As shown in the Table, the main effect on tonic EDA before treatment in the adapted environment (mean, 784.41; SD, 724.1) was higher (more relaxed) as compared with the regular environment (mean, 349.43; SD, 318.3). Regardless of environment, the 16 children with developmental disability had an overall higher (more relaxed) tonic EDA before commencement of treatment (mean, 798.37; SD, 411.2) than the 19 typical children (mean, 335.47; SD, 411). As indicated by the interaction effect, the difference in the 2 environments in the children with developmental disability is greater than in the typical children. According to simple effect analysis that was applied to assess the source of the interaction, a significant difference was found in reactions to the different environments for the typical group ( $F[1,18] = 4.97, P < .05, \text{Eta}^2 = 0.22$ ) and for the developmental disability group ( $F[1,15] = 7.49, P < .05, \text{Eta}^2 = 0.33$ ).

**PHASIC EDA DURING TREATMENT.** Data revealed significant main effects of environment and group during treatment (analysis of variance [2X2],  $F[1,33] = 23.96, P = .001, \text{Eta}^2 = 0.42$ ;  $F[1,33] = 14.20, P = .001, \text{Eta}^2 = 0.30$ ) on phasic EDA. In addition, a significant group-by-environment interaction was found ( $F[1,33] = 10.66, P < .003, \text{Eta}^2 = 0.24$ ). The Table presents the means of the 2 groups in both environments.

The main effect on phasic EDA during treatment in the adapted environment (mean, 830.59; SD, 588.6) was higher (more relaxed) as compared with the regular environment (mean, 359.87; SD, 326.6). Regardless of dental environment, the 16 children with developmental disability had an overall higher (more relaxed) phasic EDA during treatment (mean, 838.43; SD, 380.4) than the 19 typical children (mean, 352.02; SD, 380.4). As indicated by the interaction effect, the difference in the 2 environments in the children with developmental disability is greater than in the typical children. According to simple effect analysis that was applied to assess the source of the interaction, a significant difference was found in the 2 environments for the typical group ( $F[1,18] = 8.68, P < .01, \text{Eta}^2 = 0.33$ ) and for the developmental disability group ( $F[1,15] = 15.34, P < .01, \text{Eta}^2 = 0.51$ ).

Because of the wide heterogeneity of variance as seen in the Table, non-parametric analysis, Mann-Whitney, and also Wilcoxon for repeated measures were carried out between the groups for all the analysis of variance analyses. Levels of significance remained the same as those for the analyses, and

therefore only data related to analysis of variance were presented.

## DISCUSSION

This study confirms that the SAE creates a significant calming effect for both children with developmental disability and typical children undergoing a high anxiety procedure. In interviews with parents, it was clear that 63% of children with developmental disability exhibit more than average general anxiety, as compared with 38% of the typical children. Although both groups of children were significantly more relaxed during dental care in the SAE, the results of this research indicate that children with developmental disability relaxed to a greater extent than did the children with typical development. This was objectively demonstrated by both behavioral and physiological measures. Our data support the findings of Hall and Case-Smith,<sup>25</sup> that the use of various sensory strategies may be effective in reducing many behaviors associated with sensory processing disorders.

The study is consistent with earlier observations of participation and environment. According to Grandin,<sup>26</sup> people with developmental disability, similarly to people with autism, are strongly influenced by the physical environment. This is because sensory processing disorders are pervasive in the developmental disability group, expressing themselves as an inability to filter out distracting stimuli in the environment. It is this sensory flooding that leads to emotional discomfort manifesting as high anxiety levels and difficulty in participation.<sup>27</sup> For this reason, when offering children with developmental disability an environment in which aversive stimuli were substituted by gentler stimuli, like soft moving light effects, calming music, and deep pressure, the children became more focused on the pleasant stimuli and their anxiety was reduced. The modified sensory environment results in the participants' attention being intently focused on the moving visual and auditory stimuli or the deep pressure, bringing about an "altered state," with the inevitable concomitant reduced awareness of discomforting or noxious stimuli, much as an altered state may reduce the intensity of pain in chronic pain sufferers.<sup>28</sup>

Children with developmental disability, in both environments, familiar with the location, may have started their treatment in a more relaxed manner. Typical children, unfamiliar with this center for the developmentally disabled, may have been more influenced by preconceived associations and earlier experiences. Typical children may be buffered from sensory stimuli in some way and accordingly independent of environmental factors,<sup>29</sup> and therefore may not have been influenced by the regular or adapted stimuli to the same extent. Elucidation of the neural mechanisms mediating these differences, including cortisol measures, presents a worthwhile investigative challenge for future studies.

In subjects with developmental disability and typical subjects, to modulate conditions of the physical environment to optimize participation, it may be necessary to find some means of individualizing sensory inputs. This may be achieved

by analyzing in greater depth the responses of subjects with developmental disability, in particular, to the components of the SAE (namely, its visual, auditory and tactile elements). It is possible that a fine tuning of 1 or a combination of these stimuli to individualize the effects may help to considerably enhance the positive effects, especially in more vulnerable subjects. Dunn et al<sup>30</sup> suggest that people might exhibit poor sensory processing because they have not been able to engage in the environment to gather appropriate experiences, or, that they may not be able to engage because they have poor sensory processing and the environment has not been modified to suit their needs. Our data would seem strongly to support the latter supposition.

The cross-over design of this study enabled providing different treatments to the same subjects. The sequence effect, which in this design is the only potential confounder, was found not to be significant, eliminating any possible "carry-over" effect.<sup>24</sup>

This study design could not accommodate observer blindness because of the visible physical environment. This fallibility should be recognized; however, the EDA physiological data enhance the results' validity. It should be noted that the SD levels in the results of the 2 groups were large and not similar (possibly because of the relatively small study samples).

Children commonly but unnecessarily experience adverse psychological reactions to a wide spectrum of stress-invoking medical settings, and pediatricians have explored a wide range of plausible solutions.<sup>1-6</sup> The findings of this research should encourage the adaptation of the physical environment to minimize negative experiences of children with and without developmental disabilities and enhancing their positive participation. Improvement of behavior is of value not only for the wellbeing of the child, but also for the confidence of the physician in the validity and reliability of his/her examination diagnosis and subsequent treatment.<sup>2</sup> This study demonstrates that in the context of delivering medical and dental care to both typical and the very challenging group of children with developmental disability, a sensory controlled environment may represent an important substitute for the commonly used alternatives of pharmacological sedation or even general anesthesia.

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