Children's Responses to Sensory Stimuli and their Behavior in the Dental Office

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Objectives: *To evaluate children's behavior during dental examinations, their reactions to various selected sensory stimuli and the association between them.* ***Study design****: Sixty-three children (28 boys and 35 girls) aged 5–12 years (mean age 7.9 ± 1.6 years) participated in the study. Their parents were asked to complete a questionnaire while in the dentist's waiting room. The dentists evaluated the children's behavior in the dental office using Frankl's behavioral scale and noted the children's reactions to the sensory stimuli of touch, noise, smell and backward tilting of the examination chair.* ***Results:*** *Most of the children cooperated during the dental examination. Lack of cooperation was associated with adverse reactions to all selected sensory stimuli. There was also an association between resistance to brushing teeth and adverse reaction to touch. Children who reacted negatively to sensory stimuli during dental examinations were more likely to have needed advanced management techniques during past dental treatment.* ***Conclusions:*** *Children's behavior during dental examinations is known to be affected by many factors, including age, previous experiences, anxiety and fear and others. This investigation demonstrates that it is also associated with their reactions to various sensory stimuli.*

Key words: Children, sensory stimuly, behavior, dentistry

INTRODUCTION

The response of a pediatric patient to the demands of dental treatment is complex and is determined by many factors. The child's age, cognitive level,[1-5] temperament, personality characteristics,[6-10] anxiety and fear,[1,7,11] reaction to strangers,[12] previous dental experiences,[1,3,13] and maternal dental anxiety[13-15] are among the factors which influence a child's reaction to the dental setting. One potential factor, which could significantly influence a child's reaction to dental care and which has received remarkably limited attention, is the way a child processes incoming sensory information. Individuals differ in their response to sensation with respect to the type, intensity and affective tone displayed.[16] Thus, for example, some people like to touch and be touched, while others prefer that people keep their distance; some are picky eaters and others are not; some need high volume music in order to remain calm, whereas others feel overwhelmed by the very same sensory experiences.[17] Individual differences such as these are normal and do not necessarily have a significant influence on overall daily life. However, between 5-16% of preschool and school-aged children suffer from a condition termed "sensory modulation disorder" (SMD).[16,18,19] These children have difficulty regulating and organizing the degree, intensity, and nature of responses to sensory input in a graded and adaptive manner to an extent that interferes with their participation in daily activities.[20]

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Three subtypes of SMD have been reported: sensory over-responsivity (SOR), sensory under-responsivity (SUR), and sensory seeking/craving (SS/C). Children with SOR experience sensations more intensely and for longer durations than other children. The affected children experience otherwise benign sensations as unpleasant, distracting or even painful, and respond with exaggerated avoidant and defensive behaviors that are inappropriate to the environmental demands. [20] Children with SOR may demonstrate over-responsivity to one or multiple sensory systems (e.g., tactile, vestibular, proprioceptive, visual, auditory, olfactory, and/or gustatory).[21,22] Behavioral responses may commonly include aversive responses to touch or tasks of daily living (e.g., to brushing teeth, showering, fingernail cutting or face washing, as well as to different food textures), avoidance of everyday activities (e.g., use of playground equipment and participation in sports), over-responsivity to everyday smells (e.g., cleaning materials, shampoo, soap), or over-responsivity to routine sounds (e.g., home appliances, people talking, doorbell ringing). Thus, children with SMD have been reported to have problems with functional performance in all areas of daily living.[23]

One of the daily functions in which difficulties might be observed among children with SOR is maintaining proper oral hygiene and coping with dental treatment due to the multiple sensory inputs inherent in these situations. For example, oversensitivity to touch may be the response to an unexpected touch to the facial region and even produce a gag reflex during examination of the mouth or the taking of radiographs. There may be visual oversensitivity to the light of the dental unit or auditory oversensitivity to the noise of the dental turbine. Oversensitivity related to vestibular stimuli may be expressed during the backward tilting of the examination chair, and oversensitivity to smell may be observed in reaction to olfactory stimuli such as to the smell of latex gloves, nitrous oxide or other materials.

Although SOR may negatively impact a child's ability to participate cooperatively at the dental clinic, the literature on this issue is limited. Some dental applications were described on a theoretical basis in relation to oral SOR.[24,25] A few other studies have considered the influence of an adapted sensory dental environment as well as psychophysiological measures of relaxation on children's behavior.[26-29] Those latter studies found that an environment adapted to reduce SOR, such as a partially dimmed room and vibroacoustic stimuli during the examination, had a positive effect on children's behavior and level of relaxation. Those studies were done on typically developing children, children with developmental disability and children with autism spectrum disorders (ASD). To the best of our knowledge, the association between a child's behavior in a dental clinic and his/her reaction to sensory stimuli has not been investigated before. We hypothesized that children with adverse reactions to sensory stimuli in the dental office will demonstrate more behavioral problems during the examination. To test this hypothesis, we evaluated the children's behavior during the dental examination, their reaction to selected sensory stimuli, and the association between them.

MATERIALS AND METHOD

Sixty-seven consecutive children aged 5-12 years who were referred between January 2015 to July 2015 for routine dental examination to the Department of Pediatric Dentistry at the Tel Aviv University School of Dental Medicine and to private clinics of senior members of the department were eligible for study enrollment. The inclusion criteria were the American Society of Anesthesiology scale 1 or 2[30] (i.e., healthy or mild systemic disease with no functional limitations or a well-controlled disease of one body system) and no developmental disabilities (such as ASD, attention deficit hyperactivity disorder, cerebral palsy). Four children failed to meet the entry criteria, leaving a final total of 63 children who comprised the study group.

Following approval of the ethics committee of Tel Aviv University, parents of children who were referred for dental examination were given a detailed explanation about the research. Parents who agreed to participate in the study signed a consent form. While in the waiting room, they were asked to complete a parent's questionnaire, which included the following:

1. Background information relevant to the inclusion criteria: medical history and developmental disabilities (e.g., health problems, previous hospitalization, previous or current developmental therapies [occupational, speech, physical, or psychological]).
2. Information regarding the child's oral sensory responsivity in the home environment: (e.g., resistance to brushing teeth, picky eater [yes/no]).
3. Information regarding the child's behavior in dental situations: parents were asked to predict their children's level of cooperation during the current dental visit (yes/no).
4. Information regarding previous dental treatment (yes/no).
5. For children who previously underwent dental treatment: parents were asked to record which management techniques were used (e.g., behavior management, nitrous oxide and oxygen sedation, pharmacological sedation or general anesthesia).

In addition, the pediatric dentists evaluated the following:

1. The children's behavior in the dental office when entering the treatment room, during the dental examination and during taking bitewing radiographs. The evaluation was performed using Frankl's behavioral scale[31] which is comprised of 4 responses: *1 -definitely negative* (refusal of treatment, crying forcefully, fearful or any other overt evidence of extreme negativism), *2- negative* (reluctant to accept treatment, uncooperative, some evidence of negative attitude but not pronounced, i.e., sullen, withdrawn), *3 – positive* (acceptance of treatment, sometimes cautious, willingness to comply with the dentist, sometimes with reservation but following the dentist's directions cooperatively), and *4 –definitely positive* (good rapport with the dentist, interested in the dental procedures, laughing and enjoying the situation). For statistical analysis, the first 2 responses were combined to comprise the

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negative behavior and the last 2 responses were combined to comprise the positive behavior.

2. The children's reaction to sensory stimuli: touch, noise, smell and backward tilting of the examination chair. Children's reactions were scored as accepting the stimuli (neutral or positive responses) or presenting adverse responses to them (physically attempting to remove the stimulus, demonstrating aggression, panic/fear, expressing aversion to the stimulus).

Statistical analyses

Data analyses were performed using the Statistical Package for the Social Sciences 15.0 software (SPSS Inc., Chicago. IL., USA). Fisher's Exact test was used for comparison between the children's behavior (Frankl scale) and their responses to various sensory stimuli in the dental clinic. The Fisher's Exact test was also used to compare between items of the parents' questionnaire and the children's behavior and responses to the various sensory stimuli. The Pearson chi-square test was used for comparison between behavior management techniques which had been applied in previous dental treatments and the children's behavior (Frankl scale) and the responses to sensory stimuli in the present treatment session.

RESULTS

Sixty-three children (28 boys and 35 girls) aged 5–12 years (mean ± standard deviation age 7.9 ± 1.6) who met the inclusion criteria participated in the study. There were no significant age- or gender-based differences between the groups. Results from the parents' questionnaire (Table 1) showed that the vast majority of the parents predicted that their children would cooperate in the dental office. Food selectiveness of the child was reported by 38.7% of the parents, while resistance to brushing teeth was reported by 13.3%.

The children's responses to the various sensory stimuli during the dental examination are shown in Table 2. Most of the children accepted the sensory stimuli without protest. Among the children who demonstrated adverse reactions, noise was not accepted by 33.3%, touch by 31.7%, smell by 23.8% and examination chair tilting by 20.6%.

The children's behavior (Frankl scale) and their responses to the sensory stimuli are shown in Table 3. Behavior was found to be significantly associated with the reactions to all sensory stimuli (touch, noise, smell and chair tilting) during all 3 stages of the dental examination, i.e., entering the treatment room, during the dental examination and during the taking of bitewing radiographs. Full cooperation was recorded among 87.3%, 85.7% and 80% of the children, respectively.

Parents' questionnaire and children's behavior

There was no significant association between the items on the parent's questionnaire (food selectiveness, resistance to brushing teeth, parental prediction of the child's cooperation, previous dental treatment and previous management techniques) and the children's behavior when entering the room, during the dental examination and during the taking of bitewing radiographs (Frankl scale).

Parents' questionnaire and children's responses to sensory stimuli

There was no significant association between the items on the parent's questionnaire on food selectiveness, parental prediction of the children's cooperation, and previous dental treatment and the children's response to the 4 studied sensory stimuli. Only the association between resistance to brushing of teeth and adverse response to touch during examination of the mouth reached a level of significance (P=0.049).

Table 1. The distribution of the parents' responses*

	Yes			No			Total		
Variable	*n*	Percent	Valid Percent	*n*	Percent	Valid Percent	*n*	Percent	Valid Percent
Food selectiveness	24	38.1	38.7	38	60.3	61.3	62	98.4	100
Resistance to brushing teeth	8	12.7	13.3	52	82.5	86.7	60	95.2	100
Prediction of child's cooperation	55	87.3	88.7	7	11.1	11.3	62	98.4	100
Previous dental treatment	52	82.5	82.5	11	17.5	17.5	63	100	100

*The valid percent was calculated because not all parents answered all questions.

Table 2. Children's responses to different sensory stimuli during dental examinations

Response	Touch		Noise		Smell		Backward tilting of chair	
	n	%	*n*	%	*n*	%	*n*	%
Accept stimulus	43	68.3	42	66.7	48	76.2	50	79.4
Adverse reaction	20	31.7	21	33.3	15	23.8	13	20.6
Total	63	100.0	63	100.0	63	100.0	63	100.0

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Table 3. Children's behavior (by Frankl's categories) and their responses to the sensory stimuli*

Child Behavior (Frankl)			Touch		Total	Noise		Total	Smell		Total	Backward tilting of chair		Total
			Accept	Adverse		Accept	Adverse		Accept	Adverse		Accept	Adverse	
When entering the room	Negative	*n*	0	8	8	0	8	8	3	5	8	3	5	8
		% of all child behavior (Frankl)	.0	100.0	100.0	.0	100.0	100.0	37.5	62.5	100.0	37.5	62.5	100.0
		% of all reaction to sensory stimuli	.0	40.0	12.7	.0	38.1	12.7	6.3	33.3	12.7	6.0	38.5	12.7
	Positive	*n*	43	12	55	42	13	55	45	10	55	47	8	55
		% of all child behavior (Frankl)	78.2	21.8	100.0	76.4	23.6	100.0	81.8	18.2	100.0	85.5	14.5	100.0
		% of all reaction to sensory stimuli	100.0	60.0	87.3	100.0	61.9	87.3	93.8	66.7	87.3	94.0	61.5	87.3
Total		*n*	43	20	63	42	21	63	48	15	63	50	13	63
		% of all child behavior (Frankl)	68.3	31.7	100.0	66.7	33.3	100.0	76.2	23.8	100.0	79.4	20.6	100.0
		% of all reaction to sensory stimuli	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
P-value				<0.000			<0.000			0.015			0.007	
During examination	Negative	*n*	1	8	9	0	9	9	1	8	9	1	8	9
		% of all child behavior (Frankl)	11.1	88.9	100.0	.0	100.0	100.0	11.1	88.9	100.0	11.1	88.9	100.0
		% of all reaction to sensory stimuli	2.3	40.0	14.3	.0	42.9	14.3	2.1	53.3	14.3	2.0	61.5	14.3
	Positive	*n*	42	12	54	42	12	54	47	7	54	49	5	54
		% of all child behavior (Frankl)	77.8	22.2	100.0	77.8	22.2	100.0	87.0	13.0	100.0	90.7	9.3	100.0
		% of all reaction to sensory stimuli	97.7	60.0	85.7	100.0	57.1	85.7	97.9	46.7	85.7	98.0	38.5	85.7

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Child Behavior (Frankl)			Touch		Total	Noise		Total	Smell		Total	Backward tilting of chair		Total
			Accept	Adverse		Accept	Adverse		Accept	Adverse		Accept	Adverse	
Total		*n*	43	20	63	42	21	63	48	15	63	50	13	63
		% of all child behavior (Frankl)	68.3	31.7	100.0	66.7	33.3	100.0	76.2	23.8	100.0	79.4	20.6	100.0
		% of all reaction to sensory stimuli	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
P-value				.000			.000			.000			.000	
During bitewing	Negative	*n*	2	10	12	1	11	12	3	9	12	4	8	12
		% of all child behavior (Frankl)	16.7	83.3	100.0	8.3	91.7	100.0	25.0	75.0	100.0	33.3	66.7	100.0
		% of all reaction to sensory stimuli	4.8	55.6	20.0	2.4	57.9	20.0	6.5	64.3	20.0	8.5	61.5	20.0
	Positive	*n*	40	8	48	40	8	48	43	5	48	43	5	48
		% of all child behavior (Frankl)	83.3	16.7	100.0	83.3	16.7	100.0	89.6	10.4	100.0	89.6	10.4	100.0
		% of all reaction to sensory stimuli	95.2	44.4	80.0	97.6	42.1	80.0	93.5	35.7	80.0	91.5	38.5	80.0
Total		*n*	42	18	60	41	19	60	46	14	60	47	13	60
		% of all child behavior (Frankl)	70.0	30.0	100.0	68.3	31.7	100.0	76.7	23.3	100.0	78.3	21.7	100.0
		% of all reaction to sensory stimuli	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
P-value				.000			.000			.000			.000	

*Fisher's Exact test.

Previous management technique and children's response to sensory stimuli

Fifty-six out of the 63 study participants had previously undergone dental treatment. The management technique which had been used in the past correlated significantly with adverse responses to touch and noise during the current examination. The percent of children who demonstrated adverse responses to touch was highest when sedation or general anesthesia had been used in their previous dental treatment (55.6%), followed by nitrous oxide and oxygen (47.6%), and behavior management (11.5%). The percent of children who demonstrated adverse response to smell was highest when sedation or general anesthesia had been used in their previous treatment. Table 4 shows the association between the current acceptance of touch, noise, smell and examination chair tilting and the previous management techniques (behavior management, nitrous oxide and oxygen, and pharmacological sedation or general anesthesia).

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Table 4. Responses to touch, noise, smell and backward tilting of the examination chair and previous management techniques *

Previous management technique		Touch		Noise		Smell		Backward tilting of chair		Total
		Accept	Adverse	Accept	Adverse	Accept	Adverse	Accept	Adverse	
Behavior management	*n*	23	3	24	2	23	3	23	3	26
	% of all behavior management alone	88.5	11.5	92.3	7.7	88.5	11.5	88.5	11.5	100.0
	% of all sensory stimulus	60.5	16.7	63.2	11.1	53.5	23.1	51.1	27.3	46.4
Nitrous oxide	*n*	11	10	11	10	14	7	15	6	21
	% of all nitrous oxide	52.4	47.6	52.4	47.6	66.7	33.3	71.4	28.6	100.0
	% of all sensory stimulus	28.9	55.6	28.9	55.6	32.6	53.8	33.3	54.5	37.5
Sedation / General Anesthesia	n	4	5	3	6	6	3	7	2	9
	% of all sedation / general anesthesia	44.4	55.6	33.3	66.7	66.7	33.3	77.8	22.2	100.0
	% of all sensory stimulus	10.5	27.8	7.9	33.3	14.0	23.1	15.6	18.2	16.1
Total	*n*	38	18	38	18	43	13	45	11	56
	% of all past behavior management	67.9	32.1	67.9	32.1	76.8	23.2	80.4	19.6	100.0
	% of all sensory stimulus	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
P-value		0.008		0.001		0.156		0.336		

*Chi-square

DISCUSSION

It is in everybody's interest to ensure that the child's experience during a dental appointment be as free of negativity as possible. Awareness of the elements that can potentially sabotage the treating team's best efforts to achieve the child's cooperation could serve to ameliorate their deleterious effects on what could otherwise be a relatively problem-free visit. An association between a child's reaction to sensory stimuli and his/her behavior in the dental clinic has not been explored in depth, and this was the aim of the current investigation.

The majority of the children in our study were cooperative during their dental appointments. When entering the treatment room, during the dental examination and during the taking of bitewing radiographs, only 12.7%, 14.3% and 20%, respectively, of the children demonstrated uncooperative behavior. This finding is in accordance with the results of previous works.[1,3,6,8,32] Other studies demonstrated that the younger the child, the higher the chances for negative behavior.[1,3,13,33] In those studies, children under 6 years of age presented more negative behavior than older children. The fact that the children in our study were older (mean age 7.9 years) could explain our finding that their age did not significantly affect their behavior in the dental office. The lack of significant correlations between the children's gender and their behavior during dental examination is in accordance with previous findings.[1]

Neither age nor gender correlated with the children's reaction to various selected sensory stimuli, and most of the children were cooperative throughout the examination. Among the children with adverse responses to sensory stimuli, noise was the most adverse stimulus, followed by touch, smell and backward tilting of the examination chair. Previous reports on noise in the dental office are inconclusive. While one study found that noise from a high-speed drill and the Erbium laser did not cause any irritable behavior among children,[34] Yu *et al* [35] showed that noise from the ultrasonic scaling hand-piece was perceived as an aversive auditory stimulus by the subjects. We demonstrated a significant association between behavior (Frankl scale) and the acceptance of the various sensory stimuli during the dental examination. Negative behavior (during all 3 points of the examination) was associated with adverse reactions to all types of sensory stimuli (noise, touch, smell and backward tilting of the examination chair). As noted earlier, lack of cooperation has been attributed to a number of other factors, among them age, cognitive level,[1-5] temperament, personality characteristics,[6-10] anxiety and fear,[1,7,11] reaction to strangers,[12] previous dental experiences,[1,3,13] and maternal dental anxiety.[13-15] We now propose that an additional factor that should be considered is the intolerance to certain sensory stimuli during the examination. Conditions, such as oral

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defensiveness or a sensory processing disorder which affects the ability to cope with sensory stimuli, may have deleterious effects in the dental situation as well. As such, adaptations of the sensory environment during dental treatment might help to provide some relief for children with adverse responses to sensory stimuli. Previous studies reported that children's behavior and psychophysiological measures of relaxation during scaling and polishing appointments with a dental hygienist improved in a sensory adapted dental environment that consists of a partially dimmed room with lighting effects and vibroacoustic stimuli, compared with a regular dental environment.[26-29] In addition, various practical recommendations to help these children at the dental clinic have been suggested [24,25] such as:

- Use of a firm touch whenever touching the child, first touching the outside of the oral cavity before examination of the mouth
- Avoidance of sudden movements
- Adherence to Tell Show Do principles
- Adherence to the same routines in each appointment
- Allowing choices (e.g., music, color of dental dam)
- Application of positive visual imagery (e.g., kissing the suction tube)
- Clear limits
- Checking if covering the child with the X-ray apron to provide extra weight and deep pressure has a calming effect
- Allowing the child to hold a fidget toy ~~for heavy work.~~
- Before beginning the session, letting the parent apply deep oral pressure or vibration with an electric toothbrush and/or letting the child bite on a chewy tube
- Avoiding background noise
- Allowing the child to listen to calming music over headphones to block background noises
- Letting the child to wear sunglasses that block the bright lights if he/she is light sensitive

An association was found between resistance to brushing teeth at home and an adverse reaction to touch during the dental examination among the children in our study cohort. Food selectiveness with regard to taste, texture and smell have been related to oral oversensitivity,[24] but there was no such association among our study participants, possibly because very few instruments with limited textures were used, unlike the manifold characteristics of food. Others have reported a correlation between parental prediction of their children's cooperation in the dental office and the children's actual behavior.[12,33] This was not our experience, and we have no explanation for this difference.

The data on associations between the children's previous dental experience and their behavior and acceptance of the 4 tested stimuli during the index examination are contradictory. While Klingberg *et al* reported less dental fear among children who had undergone previous dental treatment,[13] Baier *et al* found that children who were previously treated with local anesthesia demonstrated more negative behavior compared to children who were not given local anesthesia.[1] Another study showed that negative reactions to previous dental treatment and current child behavior were highly associated.[33] The correlations between adverse reaction to touch and to noise during dental examinations and the management technique which had been used with these children in previous dental visits also reached a level of significance in the current work. Children who did not accept touch or noise at the present dental visit were more likely to have been treated with sedation or nitrous oxide and oxygen in the past. We assume that the difficulty to tolerate the sensory stimuli in the present dental visit had already been present in the past. It may therefore be that behavior management techniques alone were not sufficient to gain these children's cooperation, and that more advanced management techniques (e.g., as nitrous oxide and oxygen sedation or pharmacological sedation) were needed.

CONCLUSIONS

In conclusion, most of the youngsters were cooperative during their dental examinations. The lack of cooperation during dental examination among the others was associated with negative reactions to noise, touch, smell and backward tilting of the examination chair. Resistance to the brushing of teeth was associated with adverse reactions to touch. Children who reacted negatively to the selected sensory stimuli during dental examinations were probably more likely to have needed advanced management techniques during their past dental treatment.

Future studies on larger samples to compare children with and without diagnosed SMD with regard to their behavior in the dental clinic are warranted.

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