

Preschool Children's Taste Acceptance of Highly Concentrated Fluoride Compounds: Effects on Nonverbal Behavior

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Objective: The aim of this video-based study was to examine the taste acceptance of children between the ages of 2 and 5 years regarding highly concentrated fluoride preparations in kindergarten-based preventive programs. **Study design:** The fluoride preparation Duraphat was applied to 16 children, Elmex fluid to 15 children, and Fluoridin N5 to 14 children. The procedure was conducted according to a standardized protocol and videotaped. Three raters evaluated the children's nonverbal behavior as a measure of taste acceptance on the Frankl Behavior Rating Scale. The interrater reliability (intraclass correlation coefficient; ICC) was .86. In an interview, children indicated the taste of the fluoride preparations on a three-point "smiley" rating scale. The interviewer used a hand puppet during the survey to establish confidence between the children and examiners. **Results:** Children's nonverbal behavior was significantly more positive after Fluoridin N5 and Duraphat were applied compared to the application of Elmex fluid. The same trend was found during the smiley assessment. The response of children who displayed cooperative positive behavior before the application of fluoride preparations was significantly more positive than those who displayed uncooperative negative behavior. **Conclusion:** To achieve a high acceptance of the application of fluoride preparations among preschool children, flavorful preparations should be used.

Keywords: Fluorides; Taste; Nonverbal behavior; Behavior management; Early childhood caries; Taste acceptance

INTRODUCTION

Caries is the most common childhood disease. Early childhood caries (ECC) is a serious type of caries up to the age of six years.¹ ECC prevalence varies according to age groups, socio-demographic background and preventive programs. In the Western world, the incidence of ECC ranges from 43 percent to 66 percent^{2,3,4,5}

Current evidence-based recommendations for preventing ECC include: i) a dental visit at the age of 1, a consultation about oral care at home, daily tooth brushing with fluoride toothpaste (even in the case of a single tooth), and the education of parents and caregivers about the transmission of *Streptococcus mutans* from caregivers to children and ii) the application of highly concentrated fluoride

compounds twice a year in cases of higher caries risk.⁶ The application of fluoride varnishes has become a highly effective means to prevent caries in primary teeth.^{7,8}

While testing the caries protective effect of highly concentrated fluoride compounds in preschool children has been a priority objective in clinical trials,^{9,10} there are no studies to date about the taste acceptance of different flavored fluoride compounds. In this context, considerations about the sensation of the taste qualities sweet, sour, bitter, salty, and umami are of interest.¹¹ Taste preference for sweet, salty, and umami is genetically determined¹² and an inherent rejection of bitter and sour tastes was found.^{13,14} From an evolutionary point of view, the preference for sweet taste represents a survival benefit because sweet tasting food is associated with high energy, non-toxic food.¹⁵ In contrast, a bitter taste signals the presence of natural toxins like cyanides. In addition to the evolutionary safety principle of not eating anything toxic, there is an inherent aversion to an unfamiliar taste.^{16,17} Such neophobia is especially pronounced in infants.

Changes in taste preferences may occur prenatally or may be based on early experiences during infancy.^{18,19} The influence of the mother's diet during pregnancy and breastfeeding on the child's taste preference was observed.²⁰ Taste preferences, after the first months of life, are also affected by socio-cultural learning processes and the social environment.²¹ The behavior of children's parents and peers can influence this conditioning process.²² For instance, the taste acceptance of unknown foods can be increased by the social influence of peers.²³

A survey of taste preference or acceptance in preschool children represents a special challenge due to developmental psychological aspects. Preschool children's linguistic competence strongly varies according to their age. Two-year-old children's word pool is still very restricted and increases with age.²⁴ The ability to form correct

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Table 1. Fluoride content, taste, consistency and ingredients of the applied fluoride compounds

Name	Fluoride content (ppm)	Taste and Consistency	Ingredients
Duraphat	22.600	Sweetish taste Yellowish or neutral light suspension	Sodium fluoride, Ethanol, Bleached wax, Colophonium, Shellac, Mastic, Saccharin, Raspberry aroma
Elmex fluid	12.500	Peppermint taste Slightly yellowish fluid	Olafur, Dectaflur, Propylene glycol, Hydroxyethyl cellulose, Additives, Aqua, Aroma, Saccharin
Fluoridin N5	22.600	Sweetish taste Greenish suspension	Sodium fluoride, Colophonium glycerol ester, Hydrogenated colophonium, Ethanol, Highly dispersed silicon dioxide, Ethyl cellulose, Sodium cyclamate, Saccharin, Iron oxide, Iron hydroxides (E 172), Raspberry aroma

sentences is developed at the age of about 5 years.²⁵ Owing to this variance in preschool children's verbal skills, verbal utterances are difficult to interpret and compare. Additionally, inhibition due to a fear of strangers may be problematic when interviewing preschool children and can result in socially undesirable response behavior.²⁶

In order to compensate for preschool children's lack of verbal competencies, smiley analog scales, which were specially developed for preschool children, can be used.²⁷ The smiley scales are suitable for detecting emotionally connoted judgments, such as emotional state, agreement, and satisfaction.²⁸ As graphically designed ordinal scales, the symbolic faces exhibit high practicability and validity.²⁹ The ability to transfer the perception of taste to a symbolic facial expression may vary according to age. Since a certain amount of abstract thinking is required, this transfer should be easier for older than for younger preschool children. Accordingly, if preschool children at different age levels are addressed, the analysis of their nonverbal behavior should lead to more objective and valid data. Children display distinctive facial expressions in response to different tastes. This nonverbal reaction to gustatory stimuli is innate and exists independently of children's age.³⁰ Hence, deducing taste acceptance from preschool children's nonverbal behavior delivers more objective and contrastable information.^{31,32}

Positive nonverbal behavior is characterized by interest, joy and cooperation, while negative nonverbal behavior is characterized by anxiety, crying and rejection.³³ Against this background, preschool children's nonverbal behavior before the application may also act

as a crucial determinant of the application's success in preventive programs using fluoride compounds. Children with negative and noncompliant nonverbal behavior prior to the application should more likely reject the application.

In addition, a study involving preschool children requires a design suitable for this age group. A puppet can be used during interviews to increase children's attention and to decrease a hierarchical relationship (peer-like exchange) between children and adults.³⁴ Preschool children feel distinctive empathy toward animals.³⁵ A hand puppet with an animal character is thus expected to promote the formation of trust between the children and the interviewer.

This study aimed to examine 2 to 5-year-old children's taste acceptance of highly concentrated fluoride compounds using a design that is appropriate for children. In order to reduce systematic measurement errors and to yield more valid results, the present research combined and compared different methods to assess preschool children's taste acceptance. It considered both other-rated, objective data (i.e. preschool children's nonverbal behavior) and self-reported, subjective data (i.e. smiley ratings) on preschool children's taste acceptance of highly concentrated fluoride compounds.

MATERIALS AND METHOD

The taste acceptance of the fluoride compounds Duraphat (Colgate-Palmolive GmbH, Hamburg, Germany), Elmex fluid (GABA International AG, Therwil, Switzerland), and Fluoridin N5 (VOCO GmbH, Cuxhaven, Germany) was investigated. The fluoride content, taste, consistency, and composition of the preparations are presented in Table 1.

Study population

Forty-five children between the ages of 2 and 5 were randomly selected from three kindergartens in the city of Jena, Germany, to take part in this study. Kindergartens did not significantly differ in terms of children's age and gender distribution. Since all of them were located in comparable districts of the same city, it can be assumed that the children in the sample had a similar socio-demographic background. Following the Thuringian state working group for youth dental care (Landesarbeitsgemeinschaft Jugendzahnpflege Thüringen), children attending these kindergartens fulfilled the criteria of high caries risk (based on children's caries experience (dmft) and social criteria). Only children who had not yet received any applications of highly concentrated fluoride preparations in a dental practice or in kindergarten-based programs were selected to take part in this study. One randomly selected fluoride compound was assessed by the children in each kindergarten. Duraphat was administered to 16 children (11 boys, 5 girls), Elmex fluid to 15 children (10 boys, 5 girls), and Fluoridin N5 to 14 children (5 boys, 9 girls). The fluoride preparations were applied with microbrushes (Hager & Werken GmbH & Co, Duisburg, Germany) in age-appropriate dosages.

Before starting the study, parents and the staff of the kindergartens were informed about the goal and procedure of the study in written form. In each kindergarten, all inquired parents of the selected children (N=45) gave informed consent to their children's participation in the study in written form. The study was approved and registered by the ethics committee of the University Hospital of Jena (Nr. 3064-02/11).

The study was conducted by a dentist who applied the fluoride preparation on the children's teeth, and an interviewer who carried

Study phases	Content	Chosen spectrum of methods
Puppetry	Communication of the procedure and demonstrations of the fluoride application and the taste evaluation with smileys in the context of the situational story of the hand puppet raccoon, Willi	Puppet interview ³⁸
Phase 1	Evaluation of the nonverbal behavior of children before the fluoride application Standardized application of fluoride by the dentist	Frankl Behavior Rating Scale ³³
Phase 2	Rating of the nonverbal behavior of children after fluoride application	Frankl Behavior Rating Scale ³³
Phase 3	Interview with the children about the taste of the fluoride preparations and about the acceptance of a repeated application by the dentist in the presence of the hand puppet	Rating scale with smileys ²⁷ , puppet interview ³⁸

Figure 1.

out the interviews using the hand puppet. The hand puppet was the mascot of the Thuringian state working group for youth dental care, an approximately 60 cm tall raccoon called Willi, which was used in the kindergarten-based preventive program all over the state. To enhance the children's cooperation, the examiner used the "Tell-Show-Do" technique for behavior management.^{36,37}

The examination procedure consisted of four phases and was documented on video (Figure 1). To establish confidence between the children and the examiners, the procedure of fluoride application was explained and demonstrated playfully in groups in a standardized dialogue between the hand puppet and the interviewer. During this introductory phase, labeled "puppetry" (Figure 1), the children were guided on and practiced how to indicate the taste of the fluoride preparation on the basis of a three-point smiley rating scale. After this group instruction, children were allowed to paint pictures of Willi the raccoon in another room. For the application of the fluoride preparations, children were requested to enter the examination room one by one. Child and dentist sat opposite to each other on children's chairs. The phase before fluoride application, termed Phase 1 (Figure 1), consisted of the time period from a child's entry into the room up to the application of the fluoride compound. Phase 2 comprised the period of time after fluoride application (Figure 1). Both Phase 1 and Phase 2 were analyzed in terms of preschool children's nonverbal behavior. In Phase 3, the child was asked to rate the taste of the fluoride preparation based on a three-point smiley rating scale; the child was also asked whether he or she would be willing to receive repeated fluoride application by the dentist (Figure 1).

Video analysis of the children's nonverbal behavior

To compensate for limitations associated with interviewing preschool children, such as linguistic restrictions, both the intervention and interview were recorded with a video camera in order to analyze the children's nonverbal behavior. Video records ensure objective data collection with the dimension of time being implied.³⁹ Children's facial expressions and gestures were evaluated after editing the recordings into video sequences of approximately 5 minutes each. Video analyses by three independent raters focused on the children's behavior in Phase 1 (before fluoride application) and Phase 2 (immediately

after fluoride application, Figure 1). All raters were blinded to the fluoride preparations children had received. Using a 12-point version of the Frankl Behavior Rating Scale³³ (Figure 2), the raters assessed the behavior of each child. The scale ranged from "clearly negative" to "clearly positive" behavior. Characteristics of clearly negative behavior were, for example, crying and a distinct rejection of the treatment. A clearly positive behavior was characterized by showing pleasure during and interest in the situation as well as cooperation. For every child, a mean score from all three raters was used. Since the Frankl Behavior Rating Scale is considered an interval scale, the intraclass correlation coefficient (ICC) was preferred to Cohen's Kappa to measure interrater reliability. The ICC was .86.

Interview with the children

As preschool children's verbal skills are limited, we used a three-point smiley scale as another measure of their taste acceptance of fluoride preparations. The scale used cardboard faces with a laughing, crying or neutral facial expression.⁴⁰ The interview with the children, which was developed with a child psychologist, was embedded in puppetry (puppet interview).⁴¹ The procedure was tested in a pilot study with three children. After fluoride application, the hand puppet asked every child to evaluate the taste of the fluoride preparation by choosing the appropriate smiley face (Phase 3). The smileys were arranged on a table, always in the same order and distance from the child. Similarly, the children were asked to indicate their acceptance to receive a second fluoride application by picking up the appropriate smiley face.

Statistical analysis was performed using the SPSS program (Version 18). First, children's taste acceptance of fluoride varnishes and the acceptance of fluoride application were investigated. As a measure of children's taste acceptance, their nonverbal behavior immediately after the application was examined. For these purposes, differences between the three fluoride preparations were tested using a univariate analysis of variance (ANOVA) and post-hoc tests following Gabriel's test for statistical significance. Differences in the acceptance of taste and fluoride application between the preparations based on the smiley ratings were tested using the Kruskal-Wallis test in Phase 3.

Table 2. Nonverbal behavior of children before the application of a highly concentrated fluoride compound in terms of acceptance of the fluoride application

Nonverbal behavior before fluoride application	Fluoride application	
	Yes	No
Positive	73 % (n=33)	0 % (n=0)
Negative	18 % (n=8)	9 % (n=4)
Total	91 % (n=41)	9 % (n=4)

(χ^2 Test: $\chi^2=12.07, p=.001, n=45$)

Second, the effect of children's nonverbal behavior prior to the application on application success was analyzed. For these purposes, scale values ranging from 1 to 6 were coded as negative and values from 7 to 12 were labeled as positive. A χ^2 (chi-squared) test was used to evaluate the success of the application (fluoride application yes/no) between both groups (positive vs. negative nonverbal behavior prior to application). An independent samples t-test was used to analyze differences in behavior after fluoride application (Phase 2) between both groups.

RESULTS

Fluoride compounds were applied to 41 out of 45 children; four children refused fluoride application despite child behavior management.

Taste acceptance of fluoride preparations and acceptance of another fluoride application

As a measure of children's taste acceptance, their nonverbal behavior after the application of the different fluoride compounds (Phase 2) was analyzed. For this analysis, one child was excluded from the survey as his behavior deviated very strongly from the mean score of the group (>3 deviations from the mean score). Statistical analysis revealed a significant main effect of fluoride varnishes on children's nonverbal behavior (univariate ANOVA; $F=4.33, p=.02, n=40$). Post-hoc tests showed that those who received Elmex fluid behaved significantly more negatively than those who received

Duraphat ($p=.042$) and Fluoridin N5 ($p=.045$, Figure 3). There was no significant difference between the children's taste acceptance of Duraphat and Fluoridin N5 ($p>.99$).

The smiley ratings revealed no significant effect of the fluoride preparations on children's taste acceptance (Kruskal-Wallis test; $\chi^2=2.69, p=.26, n=40$); however, the same tendencies that were reflected in the children's nonverbal behavior were also evident here. Thus, Fluoridin N5 scored slightly higher in the taste acceptance evaluation than Duraphat and higher than Elmex fluid ($M_{Fluoridin\ N5} = 2.75; M_{Duraphat} = 2.40; M_{Elmex\ Fluid} = 2.23$).

The acceptance of a repeated fluoride application was compared on the basis of children's smiley evaluation of the applied compound. Although no significant differences were detected (Kruskal-Wallis test; $\chi^2=1.89, p=.39, n=40$), the children who received Fluoridin N5 showed the strongest willingness to receive another fluoride application ($M_{Fluoridin\ N5} = 2.75; M_{Duraphat} = 2.40; M_{Elmex\ Fluid} = 2.38$).

The nonverbal behavior of the children entering the room was scored on the basis of the Frankl Behavior Rating Scale as being either negative or positive. Thirteen children showed a negative behavior prior to fluoride application. Fluoride compounds could be applied more frequently to children who exhibited positive nonverbal behavior than to those who displayed negative nonverbal behavior (χ^2 test; $\chi^2=12.07, p=.001, n=45$). All children who refused fluoride application ($n=4$) had already displayed negative nonverbal behavior before fluoride application (Phase 1, Table 2). Significantly more positive responses after fluoride application were seen in children who had entered the room with positive behavior (independent samples t-test; $t=-2.37, p=.02, n=41$, Figure 4).

DISCUSSION

Up to now, there have been no reports in the literature about preschool children's taste acceptance of highly concentrated fluoride preparations. To fill this gap, the present study evaluated the taste acceptance of recommended fluoride compounds for kindergarten-based preventive programs in Germany (Duraphat, Fluoridin N5 and Elmex fluid) in a standardized way. As a measure of taste acceptance, we considered both other-rated (i.e. preschool children's nonverbal behavior after the application) and self-report data (i.e. smiley ratings).

The children's taste acceptance of the three tested fluoride preparations differed. To explain these findings, it may be helpful to consider the taste of each fluoride compound. The greater

Characterization of nonverbal behavior	Clearly negative			Negative			Positive			Clearly positive		
	Rejection of treatment, strong crying, anxiety or any other obvious evidence of extreme rejection	Reluctance to accept treatment, uncooperativeness, indication of negative attitude (not pronounced, e.g., sullen, uncommunicative)			Acceptance of treatment, sometimes with restraint, willingness to comply, occasional resistance, but cooperative following of constructions			Positive behavior, interested in happenings, laughter and enjoyment of the situation				
Scale value	1	2	3	4	5	6	7	8	9	10	11	12

Figure 2.

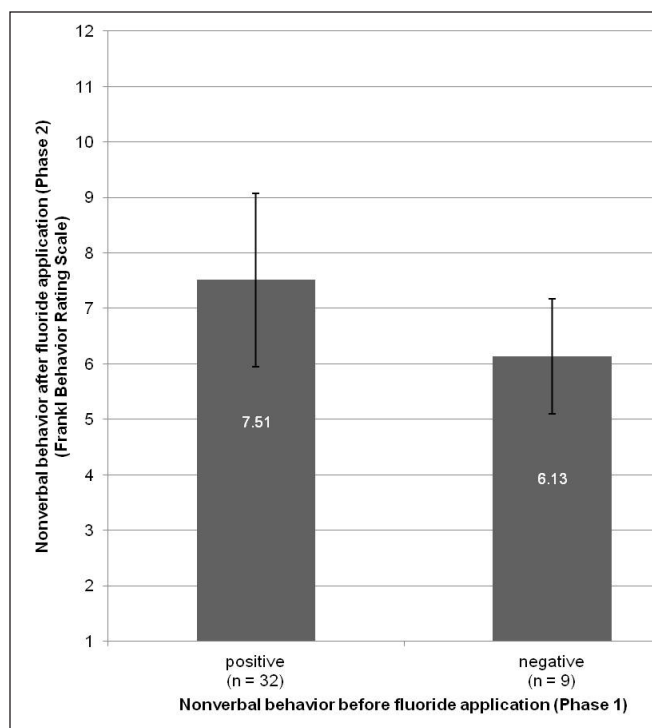


Figure 3.

acceptance of the fluoride preparations Duraphat and Fluoridin N5 may be due to their sweet, fruity flavor and the neutral pH of these compounds. In contrast, Elmex fluid has a peppermint-like flavor and a sour taste due to its pH of 3.9. This is also supported by other studies suggesting an inherent preference for a sweet taste and a rejection of a sour taste.^{42,43}

In general, a pleasant taste is important for the acceptance of products used for caries prevention, such as xylitol chewing gums,⁴⁴ or products in dental medicine, like topical anesthetics.^{45,46} Since our study revealed that children's taste acceptance of the preparations differed, it is also essential for highly concentrated fluoride compounds to have a pleasant taste. To enhance children's acceptance of kindergarten-based preventive programs, fluoride compounds with a pleasant taste should be applied.

As expected, in addition to the significant effects of fluoride compounds on nonverbal behavior, preschool children's nonverbal behavior before the application influenced application success. Fluoride compounds were applied more frequently to children who exhibited a positive nonverbal behavior prior to the application (compared to children who displayed a negative nonverbal behavior). Furthermore, they reacted significantly more positive than those who exhibited negative nonverbal behavior before the application. In conclusion, it is recommended to get children in the right mood for the fluoride application.

The results of the three-point smiley analog scale, as with most rating scales, served as a graded measurement of attitudes and opinions. However, the scale revealed no significant difference in taste acceptance between any of the fluoride compounds. Thus, the use of this rating scale may not be optimal for children between the ages of 2 and 5 years because they may not be able to cope with transferring a perception of taste to a symbolic facial expression. This speculation was confirmed by observations in three cases where the children did not choose the smiley face that was appropriate for their

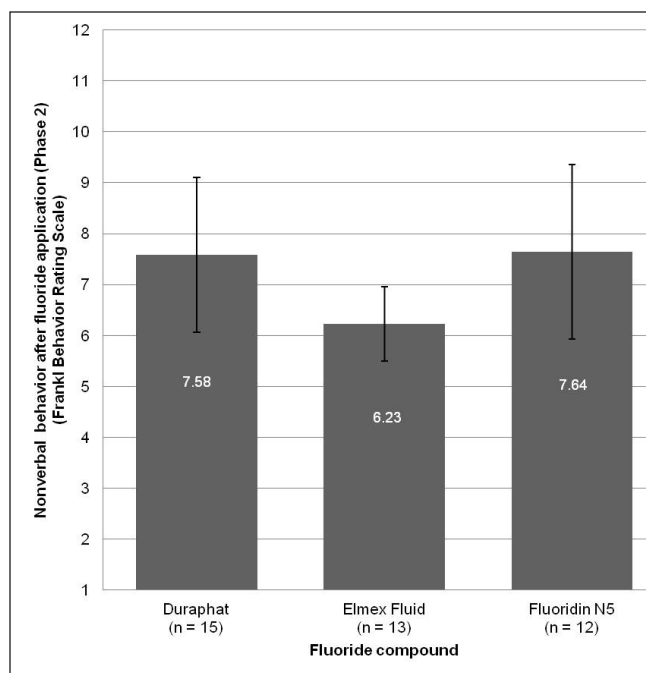


Figure 4.

verbal utterances. In addition, a three-point scale may not be sensitive enough to reveal slight differences in children's taste acceptance.

As expected, the analysis of children's nonverbal behavior delivered more appropriate results to evaluate their taste acceptance than the smiley analogue scale. Children displayed distinctive nonverbal reactions as a function of the applied fluoride compounds. Since children react nonverbally to gustatory stimuli, children's nonverbal behavior emerged as a good means to assess taste acceptance. The high interrater reliability indicated that a clear assessment of children's nonverbal behavior was possible. In general, the analysis of video recordings by three raters allowed for the necessary estimation of reliability and internal validity.⁴⁷ Any possible influence of the video camera's presence on the children's verbal and nonverbal behavior can be excluded.⁴⁸

To ensure that the study design is appropriate for children, a familiar place should be selected, and the interview should be conducted promptly to take advantage of children's immediate memory.⁴⁹ Therefore, our study was embedded in a kindergarten-based preventive program, and children were interviewed in their kindergarten directly after the fluoride application. In addition, hand puppets can be used to reduce age and rank-related differences. The puppet interview is an established and common method used in the social sciences.⁵⁰ Therefore, in the present study, the hand puppet raccoon, Willi, was used during the interviews with the children. As nearly all the children (41 out of 45) willingly received a fluoride application, the behavior guidance can be considered successful.

Limitations of the current study include the lack of a crossover design for the examination. As every child was administered only one fluoride preparation, no conclusion could be drawn concerning the child's taste acceptance of the other fluoride preparations. The primary reason for the abandonment of a crossover design was the large amount of temporal effort required for the qualitative video analysis. Standardized behavior analyses of the 45 children took approximately 5 minutes of video per child; repeated analyses of behavior were implemented in certain cases.

CONCLUSIONS

1. Fluoride compounds with a sweet and fruity taste are most accepted by preschool children.
2. Since they are preferred by small children, we recommend applying flavorful fluoride preparations to preschool children.
3. Analyzing children's nonverbal behavior is a suitable means for investigating children's taste preferences.
4. Behavior management among preschool children encourages the acceptance of fluoridation measures.
5. To achieve a high acceptance of preventive measures among preschool children, it is important to make every dental contact as positive as possible.

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