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Assessing olfaction in children of elementary and middle school age

Tatyana Yu. Vladimirova ✉, Alexander V. Kurenkov, Anastasia B. Martynova
✉ t.yu.vladimirova@samsmu.ru

Samara State Medical University, Samara, Russia

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Abstract:
Objective: comparative analysis of the olfactory testing results in elementary and middle school children.
Materials and Methods. The study included 245 students from Samara. Group 1 included elementary school children (7-11 years old, n=149), while Group 2 comprised middle school children (12-15 years old, n=96). Olfactory assessment was carried out using Sniffin' Sticks Screening Test 12 (SST-12) and the ReviSmell computer appliance.
Results. The offered SST-12 odorants were recognized by children in 100% of cases, while the ReviSmell computer appliance yielded 95.9-98.4% recognition rate. For children in Group 1, the cumulative mean SST-12 score was 8.2±1.8 pts, while in Group 2, it was 8.9±1.4 pts ($p<0.001$). The best result in Group 1 was noted for the smells of coffee (92.6%), mint (81.2%), banana (79.2%), pharmaceutical mixture (85.2%). The best recognition rate in Group 2 was observed for the smells of banana (88.5%), pineapple (83.3%), pharmaceutical mixture (80.2%) and orange (79.2%). The assessment of olfactory function on the ReviSmell device yielded the best result for the children of Group 1 ($p<0.001$). Identification rates for all five odorants (lavender, peony, spruce, eucalyptus, cloves) ranged 61.1-65.1% in Group 1 and in 34.4-58.3% in Group 2. The greatest difference was detected for the recognition of the smells of cloves (27.7%) and peony (30.1%); less pronounced difference was found for the smells of spruce (17.2%) and eucalyptus (11.1%).
Conclusion. Similar results were obtained for the odor recognition by SST-12 and the novel method for assessing olfaction via virtual reality technology on the ReviSmell computer appliance. For both methods of olfactory assessment, lower values were observed in the group of elementary school children.

Keywords: olfactory testing, identification tests, odorants, children, virtual reality

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Introduction

Olfactory testing is an extremely relevant issue for doctors of various specialties, especially pediatricians. According to available publications, the actual frequency and prevalence of olfactory dysfunction in children is quite difficult to determine due to the limited number of studies [1]. For instance, according to E.L. Cameron, 2-4% of patients report a loss of olfaction during their childhood [2]. According to the latest data, the incidence of olfactory disorders in children increased to 16.6-25.8% (including those associated with SARS-CoV-2 infection) [3]. In addition to upper respiratory tract infection, the causes of olfactory dysfunction include allergic diseases, injuries, as well as endocrine, neurological and mental disorders [4-6].

Difficulty of testing olfactory function in children may be due to a lower level of their olfactory experience, difficulty concentrating, and the characteristics of the child's individual development. Diagnosis of olfactory disorders by questionnaires in children is complex and often does not reflect their actual prevalence. The most frequently employed olfactory screening tests in clinical practice are odor recognition tests aimed at selecting an odorant from the presented options. An important point in the qualitative assessment of olfaction in children is visualization. E.g., in foreign publications, the most popular for assessing olfactory function in children are the Sniffin' Sticks Screening Test 12 (SST-12), the University of Pennsylvania Smell Identification Test (UPSIT), the Lyon Clinical Olfactory Test (LCOT), the NIH Toolbox Odor Identification Test (OIT), the Pediatric Barcelona Olfactory Test-6 (pBOT-6), the U-Sniff international odor identification test for children, and the Brief Smell Identification Test (BSIT) [7-11]. However, the use of these tests in Russian clinical practice is limited, which justifies the relevance of search for the most informative methods of assessing olfactory function in children.

Objective: comparative analysis of the olfactory testing results in children of elementary and middle school age.

Materials and Methods

Our study involved 245 students from School No. 124, School No. 37, and Sputnik Lyceum No. 1 of the Samara urban district. The age of the study subjects ranged 7-15 years; their mean age was 9.9±3.0 years.

Before the study, written voluntary informed consent was obtained from the legal representatives of the children. Our study included only healthy children with no complaints of olfactory impairment. The exclusion criteria were allergic rhinitis or polyposis, symptoms of a recent (within the

previous 4 weeks) respiratory tract infection; sleep apnea, upper respiratory tract surgery within the previous year (including tonsillectomy and/or adenoidectomy), concomitant somatic diseases (cardiovascular, endocrine, autoimmune, or pulmonary diseases) and history of head injuries.

The conditions of our study complied with the ethical standards of the World Medical Association Declaration of Helsinki, Ethical Principles for Medical Research Involving Human Subjects (2000), and the Rules of Clinical Practice in the Russian Federation, approved by the Order No. 266 of the Russian Federation Ministry of Healthcare (2003).

All subjects were divided into two groups based on the main periods of childhood and adolescence. The groups were similar in gender and age. Group 1 included 149 children of elementary school age (7-11 years of age, mean age: 8.1±1.3 years). Group 2 encompassed 96 youths of middle school age (12-15 years, mean age: 14.3±1.0 years). The physical examination included endoscopic screening of the ENT organs. Olfactory testing was performed using the SST-12 and the ReviSmell computer appliance developed at Samara State Medical University [12]. The SST-12 included the following odorants: orange, leather, cinnamon, mint, banana, grapefruit, pharmaceutical mixture, coffee, cloves, pineapple, rose, and fish. The odorants were presented sequentially with an interval of at least 20 s. The reaction was scored in points: 1 pt (in case of correct identification) or 0 pts (in case of incorrect identification). Visual support was provided on a computer with the presentation of an image of four possible odorants, one of which was correct. The order of presenting odorants was randomized to control for fatigue of attention or olfaction, using a computerized random number generator, so that half of the children from each age group first completed the SST-12, then the olfactory study using the ReviSmell computer appliance, while the other half was tested in the reverse order.

Olfactory assessment by the ReviSmell computer appliance was carried out using five complex odorants (essential oils approved for use in medical purposes and meeting the requirements of the State Pharmacopoeia of the Russian Federation): lavender, peony, spruce, eucalyptus and cloves (*Figure 1*).

The air-ether mixture was supplied to both nostrils simultaneously through a nasal mask with controlled ventilation valves; the supply time was 2 s and the interval between supplies was at least 30 s. During the examination, the child was immersed in a virtual scenario in which he or she answered the questions (Does he or she smell the odor? Is the smell pleasant?) and chose a visual match from the proposed options. The assessment result was automatically recorded in a CSV (XLS) file.

For statistical data processing, SPSS 25.0 software (IBM Corporation, Armonk, New York, USA, license No. 5725-A54) was employed. The distribution law was tested using the Shapiro-Wilk test. The data were consistent with the normal distribution according to this test; hence, parametric statistical methods were chosen, and the means of the variables and their standard deviations were calculated (M±SD). To assess the significance of differences, Student's t-test was performed. The critical level of statistical significance (p) when testing statistical hypotheses was assumed at 0.05 or 0.01.

Figure 1. Assessing olfaction by the ReviSmell computer appliance

Results

According to the SST-12, the cumulative mean score for all subjects regardless of age and gender (n=245) was 8.5±1.7 pts. For children of elementary school age, the cumulative mean score on SST-12 was slightly lower (8.2±1.8 pts) than in children of middle school age (8.9±1.4 pts), p<0.001. The mean score for girls and boys was virtually identical (8.5±1.8 pts vs. 8.4±1.6 pts, respectively; p=0.484).

All offered odorants were recognized by children in 100% of cases. However, the results of odorant identification varied. The most frequently recognized odors by the subjects were banana (203 or 82.9%), coffee (202 or 82.4%), pineapple (189 or 77.1%), orange (181 or 73.9%), and fish (221 or 90.2%). In a smaller fraction of cases, children were able to identify the following odors: cinnamon (119 or 48.6%), leather (129 or 52.7%), and cloves (144 or 58.8%).

A comparative assessment of olfaction in elementary vs. middle school age children showed a difference in odorant identification according to SST-12, with lower values observed in the elementary school age group (*Figure 2*). The lowest values in the elementary school age group were revealed for the odor of leather and cloves (38.9% and 47% of cases, respectively). In the group of middle school age children, the worst result was discovered for the odors of

cinnamon (47.9%) and mint (56.3%). The best result in elementary school age children was exhibited for the odors of coffee (138 or 92.6%), mint (121 or 81.2%), banana (118 or 79.2%) and pharmaceutical mixture (127 or 85.2%); while in the middle school age group, it was shown for the odors of banana (85 or 88.5%), pineapple (80 or 83.3%), pharmaceutical mixture (77 or 80.2%) and orange (76 or 79.2%). The groups differed the most in terms of identification of the smells of coffee (the difference was 25.9%), mint (24.9%), pineapple (10.1%) and orange (8.7%).

The percentage of odorant recognition using the ReviSmell computer appliance varied from 95.9% to 98.4%. The best identification in the total sample of study subjects (n=245) was noted for the smells of eucalyptus (139 or 56.7%), spruce (143 or 58.4%) and lavender (147 or 60.0%). Smaller shares of children identified the smells of cloves (128 or 52.2%) and peony (129 or 52.7%). In children of elementary school age, the identification of all five odorants varied from 61.1% to 65.1%, in contrast to the group of children of middle school age (34.4-58.3%) (*Figure 3*).

A comparative assessment of olfaction in groups of children elucidated the best result for elementary school age children. The greatest difference was detected for the identification of the odors of cloves (27.7%) and peony (30.1%), less pronounced difference was revealed for spruce (17.2%) and eucalyptus (11.1%).

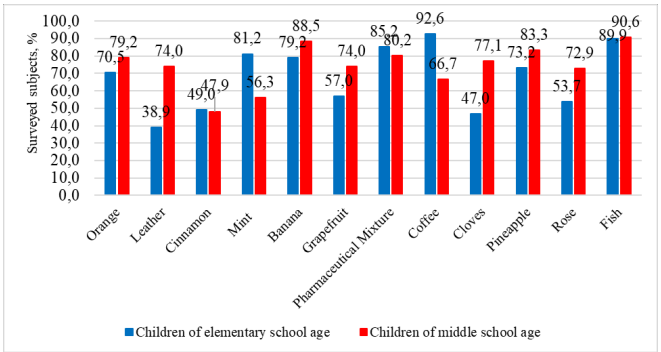

Figure 2. Results of the identification of odorants based on the Sniffin' Sticks Screening Test 12 for groups of elementary school age and secondary school age children

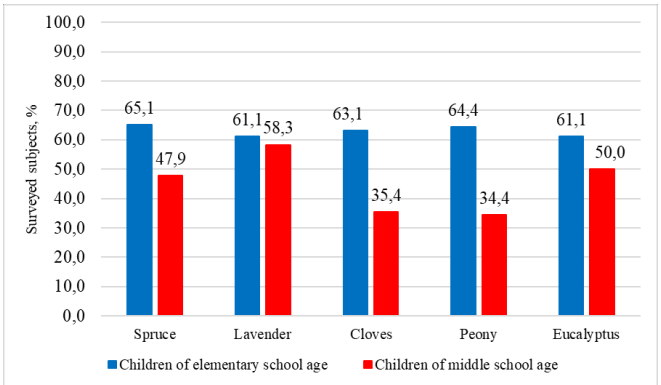

Figure 3. Results of odorant identification using the ReviSmell computer appliance in the groups of elementary and middle school age children

Discussion

In our study, all children (n=245) aged 7 to 15 years were able to pass the SST-12 olfactory screening and the ReviSmell olfactory assessment. Age-related differences were detected the study groups ($p<0.001$) with an increase in the cumulative mean SST-12 score, which is consistent with a previous study [13].

According to various studies, the effect of gender on the olfactory screening test performance is controversial, especially regarding odor identification capabilities. Most studies did not detect differences of the kind between girls and boys [8, 14]. The results of our study are consistent with previously obtained data.

Given that the order of odor presentation was randomized to control for attention-related or olfaction-related fatigue, we concluded that the differences in performance were due to the intrinsic features of the testing, rather than to the features of the experiment per se.

The use of the SST-12 allowed us detecting the best identification rate in elementary school age children for such odors as coffee (92.6%), mint (81.2%), banana (79.2%) and pharmaceutical mixture (85.2%). In the group of middle school age children, the best identification rates were characteristic for the odors of banana (88.5%), pineapple (83.3%), pharmaceutical mixture (80.2%) and orange (79.2%). Identification of odorants on the ReviSmell device in elementary school age children ranged from 61.1% to 65.1%; while in the group of middle school age children, the identification rate ranged 34.4-58.3%.

Conclusion

The results of our study showed similar results between using the SST-12 and a novel method for assessing olfactory function via virtual reality technology on the ReviSmell computer appliance: the offered SST-12 odorants were recognized by children in 100% of cases, while when using the ReviSmell device, the recognition rate varied 95.9-98.4%.

A comparative assessment of olfaction demonstrated a difference between the groups of children in odorant recognition rate both by the SST-12 and by the ReviSmell technology. Lower values were observed in the elementary school age group. The revealed differences in odorant recognition are important for the subsequent selection of optimal odorants for the screening of the olfactory function in children.

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Conflict of interest. None declared by the authors. The study was carried out within the framework of the research program at Samara State Medical University, New Technology for Diagnostics, Treatment and Prevention of Diseases of The Ear and Upper Respiratory Tract (state registration number 121111600149-3).

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Authors:
Tatyana Yu. Vladimirova – DSc, Associate Professor, Chair of the Department of Otorhinolaryngology, Samara State Medical University, Samara, Russia, https://orcid.org/0000-0003-1221-5589;
Alexander V. Kurenkov – Instructor, Department of Otorhinolaryngology, Samara State Medical University, Samara, Russia, https://orcid.org/0000-0002-8385-6407;
Anastasia B. Martynova – PhD, Instructor, Department of Otorhinolaryngology, Samara State Medical University, Samara, Russia, https://orcid.org/0000-0001-5851-5670.