Development of an International Odor Identification Test for Children: The Universal Sniff Test

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Objective To assess olfactory function in children and to create and validate an odor identification test to diagnose olfactory dysfunction in children, which we called the Universal Sniff (U-Sniff) test.

Study design This is a multicenter study involving 19 countries. The U-Sniff test was developed in 3 phases including 1760 children age 5-7 years. Phase 1: identification of potentially recognizable odors; phase 2: selection of odorants for the odor identification test; and phase 3: evaluation of the test and acquisition of normative data. Test—retest reliability was evaluated in a subgroup of children (n = 27), and the test was validated using children with congenital anosmia (n = 14).

Results Twelve odors were familiar to children and, therefore, included in the U-Sniff test. Children scored a mean ± SD of 9.88 ± 1.80 points out of 12. Normative data was obtained and reported for each country. The U-Sniff test demonstrated a high test—retest reliability ($r_{27} = 0.83$, $P < .001$) and enabled discrimination between normosmia and children with congenital anosmia with a sensitivity of 100% and specificity of 86%.

Conclusions The U-Sniff is a valid and reliable method of testing olfaction in children and can be used internationally. *(J Pediatr 2018;■■:■■-■■).*

Approximately 20% of people have a reduced sense of smell and 5% have functional anosmia.[1-3] The incidence of olfactory dysfunction is assumed to be lower in children and adolescents than in adults,[4] but reliable data to support this hypothesis are lacking. This may be due in part to difficulties performing olfactory testing in children. Anosmia in children may be congenital (among others: isolated disorder or Kallmann syndrome[5]) or acquired secondarily, such as from head trauma, adenoid hypertrophy, or cystic fibrosis.[6-9]

Many tests for evaluating olfactory function have been developed over the past few decades[10-13] because of an increasing appreciation of the importance of olfaction in everyday life. People with olfactory dysfunction experience an increased frequency of hazardous events, such as food poisoning or failure to detect smoke,[14] and have an overall decreased quality of life.[15] Olfactory function is most commonly evaluated orthonasally both clinically and for research purposes using the University of Pennsylvania Smell Identification Test (UPSIT)[11] and the Sniffin' Sticks battery—especially the odor identification subtest of the Sniffin' Sticks.[10] In addition to orthonasal olfactory assessment, measurements for retronasal olfactory testing such as using the "candy smell test" and the "taste powders" are available.[16,17] The range of stimuli for retronasal olfactory testing is limited due to simultaneous gustatory stimulation in a sweet (sorbitol) candy, and odors such as fish or cut grass cannot be used.[16] Even though the Sniffin' Sticks and the UPSIT test have been used in children as young as 5 years of age, they are suboptimal for evaluating olfaction in young children. In both odor identification tests, increases in test performance are observed from childhood through adolescence into adulthood.[18,19] However, the increment of performance is not due to actual increase in olfactory function. Children and adults perform equally well on olfactory threshold testing, but children's performance is lower than adults on odor identification tasks,[20,21] which may be attributed to "odor learning."[20,22-24]

AFC	Alternative forced choice
ICA	Isolated congenital anosmia
NIH	National Institutes of Health
ROC	Receiver operator characteristics
SCHOT	Sydney Children's Hospital Odor Identification Test
UPSIT	University of Pennsylvania Smell Identification Test
U-Sniff	Universal Sniff

Detailed affiliations available at www.jpeds.com
Funding information available at www.jpeds.com

https://doi.org10.1016/j.jpeds.2018.03.011

Odorants used in identification tests might not be familiar to children. In addition, the complexity of an olfactory test is considerable. For example, odor identification tests are commonly administered using a 4-alternative forced-choice (AFC) paradigm (ie, the presented odor has to be identified with the help of 4 descriptors).[11,25] These descriptors usually are presented in writing, which may not be optimal for children. To overcome these shortcomings, odor identification tests were developed for children.[21,26-31] However, only 2 tests have gained use, namely the Smell Wheel and the Sydney Children's Hospital Odor Identification Test (SCHOT).[27,28] The Smell Wheel has been used to evaluate olfactory function in children with a tracheostomy, and the SCHOT has been used to study children with cystic fibrosis, otitis media, renal disease, and following bone marrow transplantation.[32-36] These tests have not been used commonly likely because they were developed for children from a single country and are not translatable across cultures,[27,28] and most tests are not commercially available.

Cultural background also is of importance in odor identification. To counter this, the Cross-Cultural Smell Identification Test was developed for adults, which is based on the UPSIT.[37] Several country-specific, modified versions of the UPSIT and the Sniffin' Sticks odor identification test are used (eg, in Brazil, China, South Korea, Turkey, and Egypt).[38-42] Because of the child's development in odor learning, it is plausible that especially for children, the cultural background has substantial impact on odor identification tasks.

The aim of this multicenter study was to develop and validate an international odor identification test for children, called the Universal Sniff (U-Sniff) test, to enable the discrimination between normosmia and a reduced sense of smell with high sensitivity and specificity. We hypothesize that the study design enables the development of an odor identification test for children, can be used internationally, but that odor identification scores might differ across countries.

Methods

This study was performed in accordance with the Declaration of Helsinki on Biomedical Studies Involving Human Subjects. This study was approved by the local Ethics Committee of the Medical Faculty at the TU Dresden (EK 150042014, EK 383092015) and additionally by individual ethics committees of participating centers. Study details were explained to the children and their parents/legal guardians, and oral and/or written consent was obtained where required. In addition, children provided assent. The study was divided into 3 phases: phase 1—identification of potentially recognizable odor items; phase 2—selection of odorants for the odor identification test; and phase 3—evaluation of the test and acquisition of normative data.

Laboratories and clinics from the following countries participated: Europe: Czech Republic, Finland, Germany, Greece, Italy, Poland, Spain, Sweden, Switzerland, Turkey, and United Kingdom (only phase 3); America: Canada, Chile, Mexico, and the US. In addition Egypt (phases 2 and 3), India, Israel, and Japan contributed to this study.

Prior to phase 1, a pilot study was conducted whereby investigators from each contributing country submitted names of odor items that they believed would be well known to children in their country. A list of 42 odor items was generated. Items (n = 36) that were most common to all countries are listed in **Figure 1** (available at www.jpeds.com) and were subsequently used in phase 1.

Phase 1—Identification of Potentially Recognizable Odor Items

A total of 324 children with age ranging from 5 to 7 years from 17 countries participated. Each country interviewed 20 participants, except Finland (n = 17) and Canada (n = 7). The mean age was 5.9 ± 0.3 (SD) years. Slightly more girls (52.4%) than boys (47.6%) were included, but the difference was not statistically significant ($\chi^2_{[df = 1]} = 0.57$, $P = .45$). There was no difference in sex distribution across countries ($\chi^2_{[df = 13]} = 13.47$, $P = .41$). However, the sex of children from 3 countries (India, Israel, and Japan) was not recorded.

Photographs of each of the 36 odor items generated in the pilot phase of this study were presented to the children (**Figure 1**). For each item, a photograph representing the item was chosen. The majority of photographs were produced in the Smell and Taste Clinic in Dresden, Germany, and a few, copyright-free photographs were acquired from the internet.

Children were tested individually in a quiet room. The task was explained verbally to each child and 1 photograph at a time was shown to each child. Children were asked the following questions: Do you know what this is? (recorded as yes/no) and How does it smell? (responses written by the investigator).

Phase 2—Selection of Odorants for the Odor Identification Test

A total of 495 children aged 6 to 8 years from 18 countries were included; 30 children were tested from each country, except Egypt (n = 28), Turkey (n = 26), Finland (n = 25), US (n = 25), Greece (n = 21), and Czech Republic (n = 9). The mean age was 6.3 ± 0.5 years. There was an equal number of girls (n = 241) and boys (n = 254; $X^2_{[df = 1]} = 0.58$ $P = .45$), and there was no difference in sex distribution across countries ($\chi^2_{[df = 17]} = 14.98$, $P = .60$).

Based on results from phase 1, 17 odor items were used to create an odor identification test (**Figure 1**). Appropriate odorants were selected by a panel of experienced investigators to represent the visual items. Pen-like Sniffin' Sticks were used for odorant presentation. Pens were filled with 4 mL of each odorant and numbered 1-17. Details about the odorants are shown in **Table I** (available at www.jpeds.com). Odor identification was cued using a 4-AFC procedure. Four descriptors (1 target and 3 distractors) were used for each odor. One related and 2 unrelated items were chosen as distractors (eg, target: strawberry, distractors: flower [related], butter, cheese [unrelated] (**Figure 2**; available at www.jpeds.com). Photographs of odor items (from phase 1) with additional words were used as descriptors.

FLA 5.5.0 DTD ■ YMPD9866_proof ■ May 2, 2018