

"Sniffin' Sticks": Screening of olfactory performance*

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SUMMARY

"Sniffin' Sticks" is a new test of nasal chemosensory performance based on pen-like odour-dispensing devices. This portable test is suited for repetitive, inexpensive screening of odour identification. The test includes a forced odour-identification task for seven odours performed by means of a list of four items (multiple-choice). In 146 subjects the basic screening test was compared to a down-scaled version of the UPSIT (CC-SIT). Sniffin' Sticks exhibited a relatively higher coefficient of correlation with the subjects' age; they also demonstrated the women's superior olfactory sensitivity more pronounced when compared to men. In addition, the coefficient of correlation between age and olfactory performance was slightly higher when the sticks were used. Preliminary investigations in nine patients with impaired olfactory function (i.e., anosmic or hyposmic patients) revealed significantly lower scores in patients compared to healthy controls matched for age and sex ($p < 0.001$). It is concluded that Sniffin' Sticks may be useful in the routine clinical assessment of olfactory performance where both time and costs matter.

Key words: olfaction, identification, age, screening

INTRODUCTION

In the clinical practice of otorhinolaryngology and neurology standardized tests for the assessment of olfactory performance are rarely applied, although they might be appropriate in a surprisingly large number of diseases (Doty et al., 1991). This lack may be based on the poor reliability of particular tests, the lack of normative data, the time needed for administration, the limited availability, or the costs of tests (for a review, see Doty and Kobal, 1995). This situation certainly limits the quality of medical diagnosis; it also prevents quality control in the treatment of disorders associated with an impaired sense of smell. Based on the acknowledgement of this lack (cf., Arbeitsgemeinschaft Olfaktologie und Gustologie, 1994) the idea of the present study was to create a re-usable test of the olfactory nerve, which should include a verbal odour identification task. The test should utilize the subjects' sniffing behaviour (Laing, 1983) rather than the administration of squeeze bottles. Last but not least, it should utilize cost-effective materials such that the pricing of a final version would lie within reasonable dimensions. Thus, for stimulation pen-like odour-dispensing devices should be used, analogous to the smelling felt-tip pens that had reached some attention at grammar-schools in the seventies. When closed they represent an effective means to seal odorants by means of which both olfactory contamination of the environment and desiccation of the pen is effectively prevented. When

opened the felt tip ensures that odorants are presented in a constant concentration similar to the delivery of dye when writing. The test is referred to as "Sniffin' Sticks".

In parallel to the olfactory test presented in this paper, the "Arbeitsgemeinschaft Olfaktologie und Gustologie" of the German Society for Otorhinolaryngology (1994) also encouraged the development of a more elaborate test of olfactory function suited for a sophisticated, though lengthy evaluation of olfaction which is described elsewhere (Hummel et al., 1996c).

MATERIAL AND METHODS

All experimental procedures were explained and demonstrated in full detail to the subjects, who provided written informed consent. The study was performed in accordance to the Declaration of Helsinki/Hong Kong.

Sniffin' Sticks

Odorants were presented in felt-tip pens (Figure 1) where they were injected into the pen's tampon. Pens had a length of approximately 14 cm, the inner diameter of the cylindrical pens was 1.3 cm. Instead of liquid dye the tampon was filled with 4 ml of liquid odorants or odorants dissolved in propylene glycol, respectively. As with commercially available pens, the use of this highly practical and inexpensive system guaranteed that the odorants were sealed, thus preventing both desiccation and con-

tamination of the environment. Possible bacterial contamination of the sticks was checked regularly over a period of 4 months. None of these tests revealed growth of pathogenic micro-organisms. All microbiological tests were performed in kits that had been regularly used in clinical testing.

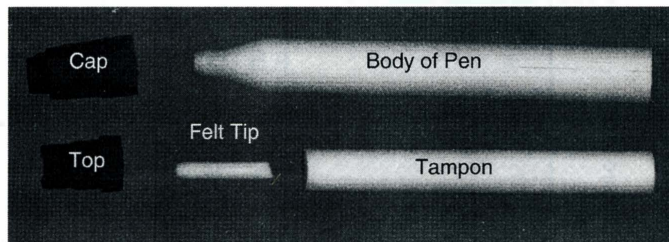


Figure 1. Individual parts of the felt-tip pens used for odour presentation. The tampon was filled with 4 ml of odorant instead of liquid dye. For odour presentation the cap was removed for approximately 3 s and the pen's tip was placed approximately 2 cm under the left or right nostril.

For odour presentation the cap was removed for approximately 3 s and the pen's tip was placed approximately 2 cm under both nostrils. Subjects were free to sample the odours as often as necessary. They had to identify seven odours which were chosen on the basis of recommendations made at the 1994 Meeting of the "Arbeitsgemeinschaft Olfaktologie und Gustologie" of the German Society for Otorhinolaryngology, held in Aachen, Germany. These recommendations required the testing of: (A) three odorants producing little or no trigeminal excitation; (B) three odorants producing a mixed, but balanced stimulation of both the trigeminal and the olfactory nerve; and (C) one stimulant which would produce a strong trigeminal excitation. Thus, phenylethyl alcohol, limonene, and α -ionone were chosen as odorants for group A; iso-amylacetate, eucalyptol, and eugenol were chosen for group B; and mustard oil was used as a trigeminal stimulant (odorants by Fluka, Ulm, Germany). This selection of odorants was based both on previous research [*phenylethyl alcohol*: Doty et al. (1978); Kobal et al. (1989); *limonene* and *α -ionone*: Ito (1962); *iso-amylacetate*: Kobal (1985); *eucalyptol*: Kobal and Plattig (1978); *eugenol*: Hummel and Kobal (1994); and *mustard oil*: Henning (1916)] and on judgements of six highly-trained observers recruited from the laboratory staff.

The experimenter presented each one of them separated by an interval of at least 30 s to prevent olfactory desensitization (Hummel et al., 1996a). Thus, this task took the subjects approximately 4 min to complete. Identification of odorants was performed as a forced multiple choice from a list of four descriptors. During preliminary experiments it had already been ascertained that all items used in that list, both targets and distracters, were familiar to a large group of subjects. This was done by means of questionnaires during which subjects were confronted with a list containing 92 pre-selected items. The subject's familiarity with the odour of each of these items was rated on a 6-point numerical scale (1: highly familiar; 6: unknown). Only those items were included into the multiple choice that had ratings of "1" or "2" in more than 90% of the 63 subjects investigated (32 males and 31 females; mean age 29.3 years; see Table 1).

Table 1: Familiarity with target and non-target odours. Investigation in 32 male and 31 female subjects (mean age 29 years). Numbers in brackets represent percentage of items rated very familiar on a 6-point scale (1: highly familiar; 2: very familiar, *et cetera*; 6: unknown). In the forced multiple choice three distracters were combined with the target in a list of four items.

	target	distractor 1	distractor 2	distractor 3
phenyl ethylalcohol	rose [98]	bread [97]	gas [97]	smoke [100]
limonene	citrus-fruit [100]	salami [98]	banana [100]	grass [97]
α -ionone	flower [100]	ham [98]	cheese [100]	fish [100]
isoamyl acetate	solvent [92]	mint [97]	peach [94]	wood [97]
eucalyptol	eucalyptus [94]	lilac [95]	coconut [95]	chives [95]
eugenol	cloves [94]	leather [97]	pineapple [97]	turpentine [92]
mustard oil	mustard [91]	rum [91]	chewing-gum [92]	strawberry [97]

CC-SIT

The Cross-Cultural Smell Identification Test (CC-SIT; Sensonics Inc., Haddon Heights, NJ, USA; Doty et al., 1996) is a subtest of the University of Pennsylvania Smell Identification Test (UPSIT; Doty et al., 1989), which has become a North-American standard for the clinical assessment of olfactory perception. The "scratch-and-sniff" technique employed is based on the mechanical release of micro-encapsulated odorants. The CC-SIT comes with 12 odours. Like the UPSIT odour identification, it is based on a forced multiple choice from a list of four items. Since there is no German translation of the items used in the test, they were carefully translated by three of the investigators. In order to avoid olfactory adaptation or habituation when administering the CC-SIT, an interstimulus interval of approximately 30 s was observed. Thus, it took the subjects approximately 6 min to complete the test.

All odorants were handled most carefully; the experimenters always wore deodorized disposable cotton gloves. Measurements were performed in quiet, well-ventilated rooms allowing for a relaxed atmosphere.

Statistical analysis

Results were analyzed by means of the SPSS/PC⁺ programme package as follows: Results were submitted to paired t-tests. In addition, correlations were computed between all experimental variables.

RESULTS

Three experiments were performed. The first experiment investigated the test-retest reliability of the sticks in a group of 24 healthy volunteers on two different days. The second experiment compared results obtained by means of both the CC-SIT

and the sticks in 143 healthy volunteers. In this study also comparisons were made regarding gender-related differences in olfactory performance. Based on the data obtained in experiment 2 the third experiment focussed on the question whether the sticks discriminate between healthy subjects and patients with hyposmia or anosmia. Here a preliminary study was performed in a total of nine olfaction-impaired patients (anosmia/hyposmia). Their results were compared to results of healthy subjects matched for age and sex.

Experiment 1: test-retest reliability

A total of 24 healthy subjects participated in this experiment (14 males and 10 females; mean age: 32 years, ranging from 24 to 59 years). None of the subjects reported any olfactory disturbances. Measurements were performed on different days. The coefficient of correlation between test and retest was $r_{24}=0.73$. When re-tested only 7 out of 24 subjects had a score different from the first testing (Figure 2).

Experiment 2: comparison of sticks and CC-SIT

This experiment was performed in out-patients of the ENT Clinic of the University of Erlangen-Nurnberg. None of the 143 subjects tested reported to have a major olfactory dysfunction (72 males and 76 females; mean age: 42 years, ranging from 12 to 81 years). The sequence of testing sticks and CC-SIT was randomized across all subjects; sessions had a duration of approximately 10 min.

Scores obtained with the two tests exhibited a positive correlation of $r_{148}=0.34$ ($p<0.001$; Figure 3). This indicated that both tests were measuring similar characteristics of the patients' olfactory performance. Since there was a large ceiling effect for both tests the coefficient of correlation was small.

When computing coefficients of correlations between the subjects' age and their score in either one of the two tests, there was no significant correlation; however, the sticks reached a slightly higher coefficient of correlation (sticks: $r_{148}=0.16$; CC SIT: $r_{148}=0.13$; Figure 4). Regarding gender-related differences in olfactory performance both tests indicated that females scored higher in identifying odorants (Figure 5). For the sticks ($t=2.62$, $p<0.01$) this difference was clearer, as compared to the difference obtained with the CC-SIT ($t=2.08$, $p<0.05$).

Experiment 3: preliminary testing in patients

Experiments were performed in nine in-patients of the ENT Clinic of the University of Erlangen-Nurnberg; three of them claimed to be totally anosmic, and six stated that they had a strongly decreased olfactory sensitivity mostly due to sinusitis. Patients had a mean score of 2.4 items ($SD=1.2$; minimum 1, maximum 5), while healthy subjects scored with 6.2 items ($SD=1.0$; minimum 4, maximum 7). These differences were significant ($t=7.38$, $p<0.001$).

Correlation between results obtained for test and re-test of the Sticks (n=24)

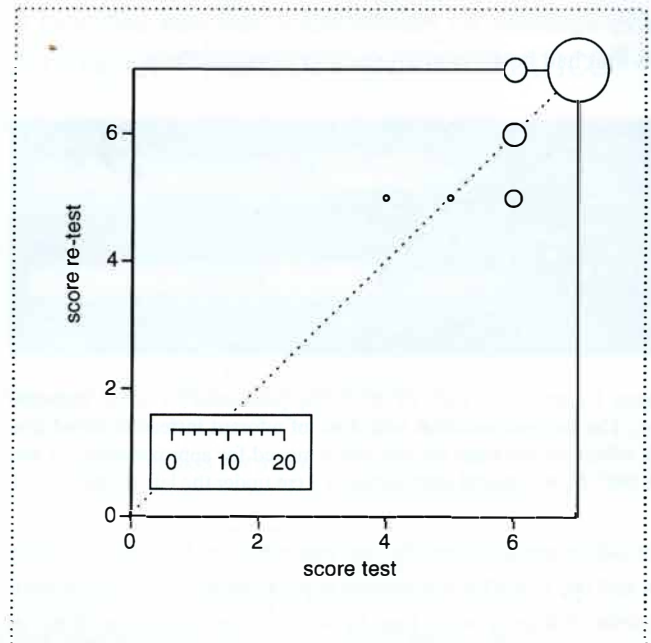


Figure 2. Correlation between scores when testing and re-testing 24 healthy subjects by means of the sticks. The larger the circles, the more data points converge on that coordinate. The number of conversions per data point (as they are represented by the size of the circles) is indicated by the inserted scale. The coefficient of correlation was $r_{24}=0.73$ ($p<0.001$).

Correlation between results obtained for Sticks or CC-SIT (n=146)

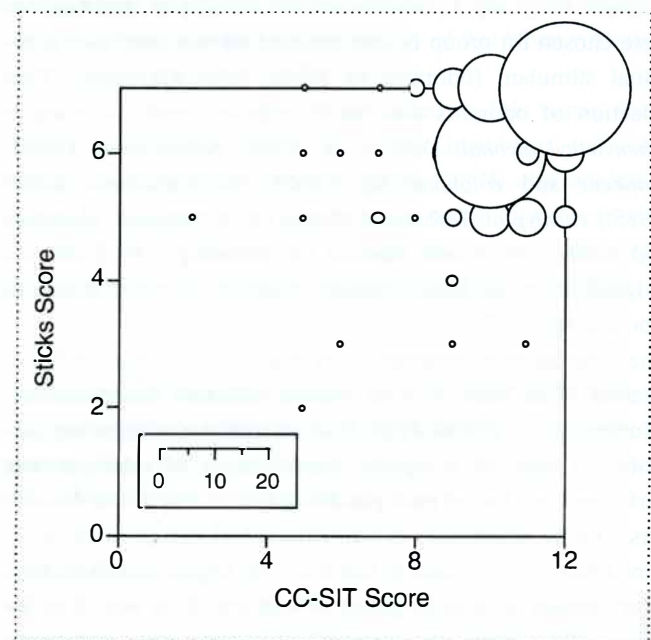


Figure 3. Correlation between scores obtained with the CC-SIT and the sticks. The larger the circles, the more data points converge on that coordinate. The number of conversions per data point (as they are represented by the size of the circles) is indicated by the inserted scale. Since there was a large ceiling effect for both tests the coefficient of correlation was small ($r_{148}=0.34$; $p<0.001$).

Correlation between age and odor identification scores (n=146)

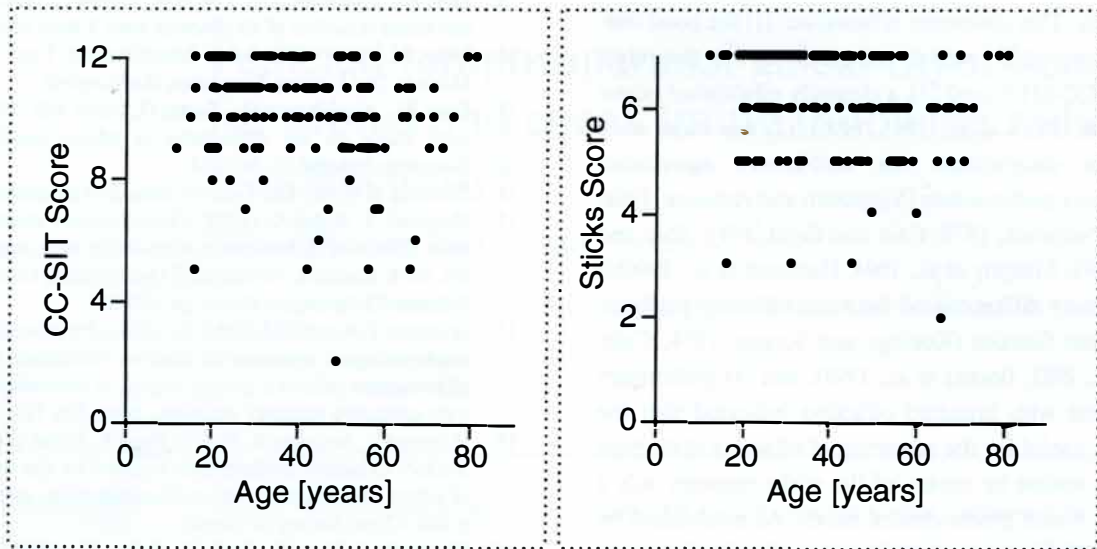


Figure 4. Relation between the subjects' age and their olfactory performance obtained with either the CC-SIT (left) or the sticks (right). The coefficient of correlation was slightly higher when the sticks were used.

Mean differences between male and female subjects

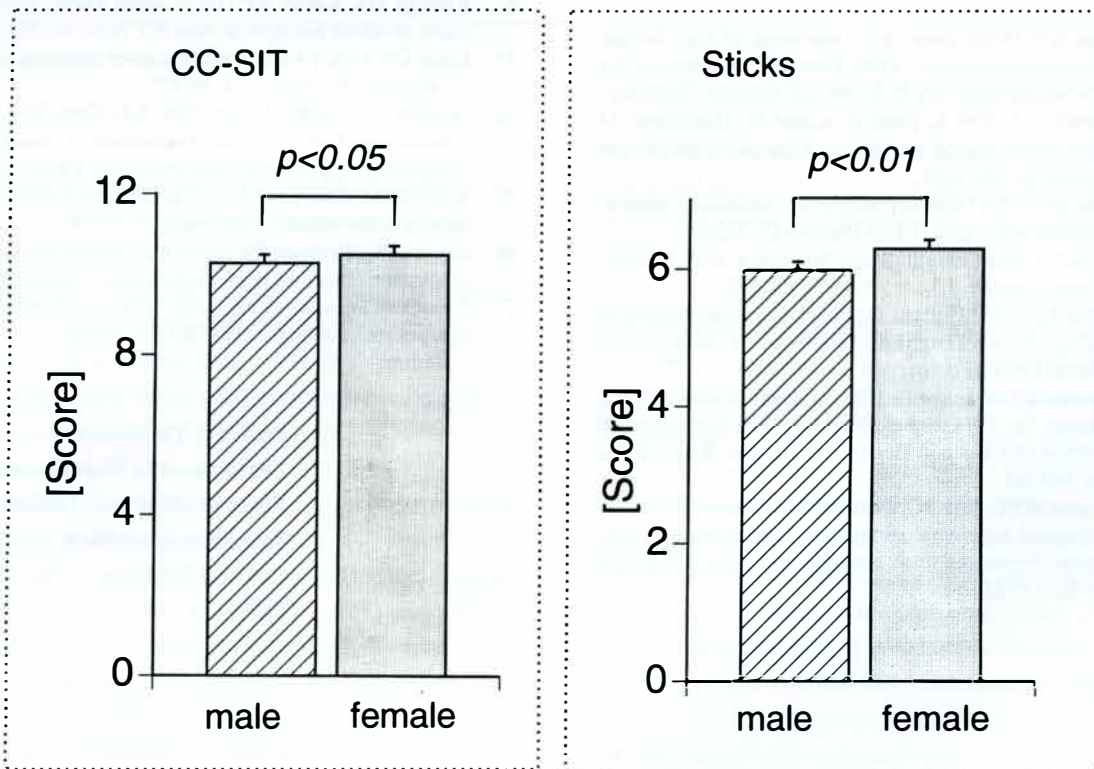


Figure 5. Gender-related differences obtained with the two tests. Both tests indicated differences between male and female subjects in olfactory identification. For the sticks ($p < 0.01$) this difference was more pronounced compared to the difference obtained with the CC-SIT ($p < 0.05$).

DISCUSSION

The present data indicate that the screening version of the "Sniffin' Sticks" is suited for the testing of olfactory performance in a clinical setting. This statement is based on: (1) the good test-retest reliability ($r_{24}=0.73$) which compares to the test-retest reliability of the CC-SIT ($r_{57}=0.71$), a clinically established odour identification task (Doty et al., 1995, 1996); (2) the sticks were demonstrated to discriminate the well-known age-related changes in olfactory performance (Venstrom and Amoore, 1968; Schiffman and Pasternak, 1979; Cain and Gent, 1991; Ship and Weiffenbach, 1993; Murphy et al., 1994; Hummel et al., 1996b); (3) the sticks clearly differentiated between olfactory performance in males and females (Koelega and Koster, 1974; Cain, 1982; Doty et al., 1985; Becker et al., 1993); and (4) preliminary data from patients with impaired olfaction indicated that the sticks may prove useful for the screening of olfactory disturbances. In addition, testing by means of the sticks requires only a total of 3-4 min, which meets clinical needs. As established by Hummel et al. (1996c) the test may be used repetitively over a period of at least 4 months. It is easy to administer, provides a means to safely store odorants, and it appears as if the costs for a commercial version of the test might be kept comparatively low. Within the framework of a multinational collaborative effort the test is currently applied in more than 20 centres in Germany, Switzerland, Austria, and Italy. Since most centres agreed to report results to the authors of this paper, the database of the sticks is expected to expand continuously, which in turn will strengthen the power of the "Sniffin' Sticks" as a diagnostic tool.

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