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Brief communication (Original)

Smell discrimination and identification scores in Thai adults with normosmia

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Background: Olfactory function can be assessed using quantitative or qualitative tests. The phenyl ethyl alcohol (PEA) olfactory threshold test is a useful quantitative test by which to detect olfactory thresholds and to classify them into normosmia, hyposmia, and anosmia. Qualitative tests of olfaction include the smell discrimination and identification tests, which are helpful in diagnosing several neurological diseases.
Objectives: To identify normal values of smell discrimination and identification scores as references for Thai adults.
Methods: We prospectively recruited 128 healthy participants with normosmia as measured by the PEA olfactory threshold test and tested them for smell discrimination and identification scores.
Results: The participants included 64 men and 64 women with age ranging from 18 to 60 years and a mean age of 35.9 years. Median score (interquartile range) of smell discrimination was 16 (13.5-16.0) and mean score (± standard deviation) of smell identification was 8 ± 1.5. The ability of women to discriminate and identify smells was significantly better than that of men as shown by a lower olfactory threshold and higher discrimination and identification scores.
Conclusions: Our study provides normal values for smell discrimination and identification scores in Thai adults, which may be used as references in clinical practice and research. The ability to identify smells may be influenced by individual experience and cultural backgrounds.

Keywords: Normosmia, PEA test, phenyl ethyl alcohol olfactory threshold, smell discrimination test, smell identification test

Olfactory sensation plays an important role in eating. The perceived taste of food is strongly influenced by olfactory experiences and the absence of the sense of smell or anosmia therefore decreases food appreciation and appetite. Furthermore, a healthy olfactory system enables humans to be aware of risks from consuming contaminated or spoiled foods, and injury or death from fire, hazardous environmental chemicals, or toxic vapors [1-3]. Moreover, the sense of smell is also involved in interpersonal relations and may even contribute to the selection of a spouse [4-6].

Olfactory disorders are not uncommon in the general population and their prevalence is about 5% for functional anosmia and 13%–16% for hyposmia [7, 8]. Like other sensory functions, olfactory functions decline with age [9-10]. Because the sense of olfaction can differentiate thousands of different odorants, it is impossible to study the entire sensory system with a few simple tests. Because the identification of different smelling substances, even in a normal population, is strongly affected by various social and cultural backgrounds and experiences, tests should be modified culturally to prevent any biases [11]. In routine clinical practice, the most used smell test should not require complex equipment or devices. There are 3 types of tests commonly used to determine olfactory function, including the smell threshold test, smell discrimination test (SDT), and smell identification test (SIT). Because normal smell detection threshold in Thai population has been reported [12], the objective of this study was to provide normal values for SDT and SIT in Thai adults.

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Materials and methods

Ethical approval of the study protocol

The study protocol and consent procedure received ethical approval from the Siriraj Institutional

Review Board (approval No. Si250/2013). All participants provided documented informed consent before participating in the study.

Participants

We prospectively recruited 128 healthy participants with no evidence of chronic sinonasal diseases or olfactory impairment from April 2013 to June 2014. The participants were 64 men and 64 women with age ranging from 18 to 60 years with a mean age of 35.9 years. Exclusion criteria were a history of olfactory impairment, traumatic brain injury, or any other neurological or psychiatric disease known to cause olfactory dysfunction. A phenyl ethyl alcohol (PEA) olfactory threshold test was conducted by well-trained scientists to evaluate olfactory function in each participant. Only participants with normosmia, as evidenced by olfactory detection threshold more than –6.5 [13], were included in this study. SDT and SIT were then conducted.

Smell discrimination test

The SDT was conducted separately for each nostril by means of triplets of two odorous substances (coffee) and one odorless substance (water). The participant's task was to identify the bottles that contained odorous or odorless substances. Criteria for selection of odorous substances were that (i) participants should generally be familiar with all odorous substance used in the test; and that (ii) odorous substances used in the test should be similar in both intensity and hedonic tone [14, 15]. The nostril that was not tested was closed with 3M Micropore Rayon Synthetic Surgical Tape (Selles Medical, Hull, North Humberside, UK). Participants were blindfolded with a hygienic face mask to prevent visual detection of the substances. Participants were allowed to sniff each bottle only once to save time. Three bottles were then presented to each nostril in a fixed randomized order with a total of 16 trials. If participants answered correctly, bottles containing odorous or odorless substances in triplicate for each trial were used and one score was given. Smell discrimination scores of each nostril ranged from 0 to 16.

Smell identification test

The smell identification or odorant naming test (SIT) was conducted separately for each nostril by using common odorous substances. As for the SDT, only 10 common odorous substances were chosen to save time. Criteria for selection of these odorous substances were similar to those of SDT [14, 15]. In our study, chocolate, coffee, tobacco, pepper, garlic, orange, banana, ammonia, kaffir (makrut) lime, and baby soap were selected. Pepper and ammonia were used to detect malingering. Because smell identification is usually affected by cultural and eating behavior, the tested odorous substances should be selected to fit the culture. Before testing, the participants were asked to check their familiarity with 50 common odorous substances (10 odorous substances tested in SIT were included in this check list). The nostril that was not tested was closed with 3M Micropore Rayon Synthetic Surgical Tape (Selles Medical). Participants were blindfolded with a hygienic face mask to prevent visual detection of the substances. Because smell identification took more time for recognition, the participants were allowed more time and to sniff the container twice. If participants answered correctly, one score was given. The smell identification scores for each nostril ranged from 0 to 10 for each trial.

Statistical analyses

Statistics were analyzed using PASW Statistics for Windows (version 18.0, SPSS Inc, Chicago, IL, USA). A normality test was applied to all data. A nonparametric test was used to analyze nonnormally distributed data including PEA olfactory threshold and smell discrimination scores. A Mann–Whitney *U* test was used to compare data between sexes and each nostril. A Kruskal–Wallis test was used to compare data between age ranges. The nonnormally distributed data are presented as median and interquartile (IQR) values. A parametric test was used to analyze normally distributed data including smell identification score. An unpaired *t* test was used to compare data between the sexes and between each nostril. A one-way analysis of variance was used to compare data between age ranges. The normal distributed data are presented as mean ± standard deviation (SD). All tests were considered significant at $P < 0.05$ (two-tailed).

Results

Participants

Because olfactory function declines with age [9-10], participants were classified into four age groups, namely: 18-25, 26-35, 36-45, and 46-60 years, and 16 men and 16 women were recruited in each group. The overall results of the study are shown in **Table 1**.

Table 1. Olfactory threshold detection test, and smell discrimination and identification scores of Thai healthy participants (n = 128).

	Age[a,b] (years) (mean ± SD)	Phenyl ethyl alcohol test[c,d] (log scale number) median (IQR)	Smell discrimination test[c,d] (Total score = 16) median (IQR)	Smell identification test[a,b] (Total score = 10) (mean ± SD)
Sex				
Male (n = 64)	36.1 ± 11.73	–10.00 (–10.00 to –8.75)	16.0 (13.5 to 16.0)	7.77 ± 1.57
Female (n = 64)	35.7 ± 11.36	–10.00 (–10.00 to –9.75)	16.0 (14.5 to 16.0)	8.28 ± 1.34
P	0.83	0.001*	0.03*	0.051
Age				
18-25 years (n = 32)	22.19 ± 2.35	–10.00 (–10.00 to –9.75)	16.0 (15.0 to 16.0)	7.66 ± 1.24
26-35 years (n = 32)	30.06 ± 2.69	–10.00 (–10.00 to –9.75)	16.0 (14.5 to 16.0)	8.45 ± 1.52
36-45 years (n = 32)	39.63 ± 2.55	–10.00 (–10.00 to –9.75)	16.0 (15.0 to 16.0)	8.25 ± 1.44
46-60 years (n = 32)	51.78 ± 4.36	–10.00 (–10.00 to –8.75)	16.0 (13.5 to 16.0)	7.75 ± 1.59
P	< 0.0001*	0.012*	0.48	0.09
Lateralization				
Right side (n = 128)	35.91 ± 11.50	–10.00 (–10.00 to –8.25)	16.0 (13.0 to 16.0)	7.92 ± 1.59
Left side (n = 128)	35.91 ± 11.50	–10.00 (–10.00 to –8.25)	16.0 (13.0 to 16.0)	8.13 ± 1.50
P	1.00	0.82	0.26	0.46
All participants (n = 128)	35.91 ± 11.50	–10.00 (–10.00 to –8.75)	16.0 (13.5 to 16.0)	7.95 ± 1.53

*Significant differences at the level of $P < 0.05$, [a]unpaired *t* test between sex and lateralization, [b]analysis of variance between age ranges, [c]Mann–Whitney *U* test between sex and lateralization, [d]Kruskal–Wallis test between age ranges. SD = standard deviation. IRQ = interquartile range. Olfactory threshold detection by phenyl ethyl alcohol test.

Phenyl ethyl alcohol olfactory threshold test

Olfactory function was assessed using the PEA olfactory threshold test and the median (IQR) score was –10.00 (–10.00 to –8.75), which was within normal range. Olfactory function of women (–10.00 to –8.75) was significantly better than that of men (–10.00 to –9.75) as shown by a lower PEA olfactory detection threshold ($P < 0.001$). The olfactory function in the age group 46–60 years was significantly decreased when compared with other age groups. However, there were no significant differences in PEA olfactory threshold between left and right nostrils.

Smell discrimination test

Median of SDT score (IQR) was 16.0 (13.5 to 16.0) in men and 16.0 (14.50 to 16.0) in women. Women had significantly better smell discrimination than men ($P = 0.028$). However, there were no significant differences in SDT scores between age groups and between each nostril. Like PEA olfactory threshold, SDT scores in the age group 46–60 years tended to decrease when compared with other age groups. However, the decrease was not significant.

Smell identification test

Mean of SIT scores (± SD) was 7.77 ± 1.57 in men and 8.28 ± 1.34 in women. There were no significant differences in SIT scores between age groups and between each nostril ($P = 0.46$). However, women had higher SIT scores compared with men and this difference was almost significant ($P = 0.051$). In SIT, more than 70% of our participants could correctly identify all odorous substances except chocolate and tobacco, which <70% of participants could identify correctly, and yet these were considered familiar odorous substances. The most commonly recognized odorant was coffee (97.7%) followed by ammonia (90.6%), and baby soap (82%). The most common misinterpreted odorant was chocolate (65.6%) followed by tobacco (53.9%). There was an increased smell identification score in the second trial (**Table 2**).

Discussion

Olfactory dysfunction can occur in various sinonasal diseases and some neurological diseases. Olfactory function can be assessed by either

Table 2. Correct smell identification for each nostril in the 1st and 2nd trial and familiar odorant identified in 1st and 2nd rank

Odorant	Correct smell identification (%)			Familiar odorant identified (%)	
	Side	1st trial	2nd trial	1st rank	2nd rank
Chocolate	Rt	54.0	65.6	Vanilla (19.5)	Cocoa (14.1)
	Lt	65.6	65.6	Cocoa (18.0)	Vanilla (8.6)
Coffee	Rt	92.2	98.4	Smoke (1.6)	Tobacco smoke (1.6)
	Lt	96.9	97.7	Tobacco smoke (0.8)	Tea leaf (0.8)
Tobacco	Rt	45.3	47.7	Herbal medicine (18.0)	Tea leaf (15.6)
	Lt	50.0	53.9	Tea leaf (14.8)	Herbal medicine (14.8)
Pepper	Rt	64.1	71.9	Spices (10.2)	Herbal medicine (9.4)
	Lt	75.0	81.3	Herbal medicine (7.0)	Spices (5.5)
Garlic	Rt	62.5	77.3	Spices (8.6)	Sour pork (3.9)
	Lt	75.8	80.5	Spices (9.4)	Sour pork (4.7)
Orange	Rt	72.7	78.1	Pomelo (15.6)	Lime (7.8)
	Lt	77.3	80.0	Pomelo (14.8)	Lime (3.1)
Banana	Rt	75.8	77.3	Vanilla (2.3)	Bread (1.6)
	Lt	81.3	81.3	Vanilla (1.6)	Cake (1.6)
Ammonia	Rt	80.5	84.4	Ethyl alcohol (3.9)	Herb inhaler (3.9)
	Lt	87.5	90.6	Ethyl alcohol (2.3)	Herb inhaler (2.3)
Kaffir (makrut) lime	Rt	61.7	75.0	Orange (9.4)	Lime (5.5)
	Lt	67.2	71.1	Lemongrass (10.9)	Pomelo (10.2)
Baby soap	Rt	78.1	80.5	Perfume (12.5)	Flower (6.3)
	Lt	81.3	82.0	Perfume (11.0)	Flower (3.9)

Rt = right side nostril. Lt = left side nostril.

quantitative or qualitative tests. The PEA test is useful to detect olfactory thresholds quantitatively and to classify them into normosmia, hyposmia, and anosmia [16]. The SDT and SIT are qualitative and are helpful in diagnosing several neurological diseases, such as an early stage of Alzheimer's disease, idiopathic Parkinson's disease, amyotrophic lateral sclerosis, essential tremor, multiple sclerosis, multiple system atrophy, parkinsonism, dementia of Guam, progressive supranuclear palsy, and schizophrenia [12, 16-18]. Olfactory tests are useful to determine whether patients have a unilateral or bilateral problem because each nostril can be tested separately. They are then helpful to localize the site(s) of lesions.

In the present study, we found that women had significantly better olfactory function than men as shown by a lower PEA olfactory threshold, and higher smell discrimination and identification test scores. This is in agreement with the report of Landis et al. [7]. Moreover, Katotomichelakis et al. [19] found that healthy Greek women had higher smell discrimination scores than healthy Greek men, and several other studies also have shown that women have a better sense of smell than men [10, 12, 22]. There are some articles that attempt to explain how sex differences could influence human olfactory perception [10, 22]. Doty and Cameron [22] concluded that the relationship between reproductive hormones and human olfactory function is complex. One known influence may be that sex-related alterations in human olfactory function, e.g. menstrual cycle, pregnancy, gonadectomy and hormone replacement therapy affect

a range of olfactory functions. Moreover, the biological roles of motherhood, including the connection of pregnant mother's circulatory system to the fetus, nursing procedure, sense and awareness of food, and environmental factors potentially dangerous for the baby, are passed to women. However, Chaiyasate et al. [20] found that there were no significant differences in smell identification scores and threshold between Thai women and men. This may be the result of the limited number of participants and the recruitment process in their study.

There were significant differences in smell detection threshold in the older age group in the present study, which is in agreement with other reports [10, 17]. The decline in olfactory function with age is similar to that of other sensory functions [9, 10]. However, age did not affect smell discrimination or identification scores in the present study. This was probably because of the suprathreshold levels of odorous substances used in our tests. Olfactory function in older individuals is related to aging processes or to other factors associated with aging, such as the culmination of repeated insults from viral infection, the onset of age-related diseases, poor hygiene, use of medication, and changes in life style [9, 10].

Functional asymmetry of the nervous system, especially auditory and visual senses, have received much attention. Olfactory testing of each nostril separately is necessary because this helps to detect unilateral olfactory loss. We investigated the olfactory function of each nostril and found no significant differences in olfactory detection threshold, smell discrimination, and smell identification scores between nostrils of normosmic individuals. Similarly, Frasnelli et al. [23] reported no significant differences in olfactory threshold between nostrils. By contrast, Katotomichelakis et al. [19] reported significant differences in odor detection thresholds, odor discrimination and identification between nostrils with the right nostril being more sensitive compared with the left. Zatorre and Jones-Gotman [24] found that smell discrimination of the right nostril was significantly better than that of the left, but that no significant differences in smell detection threshold were found between the nostrils. Differences in odor detection thresholds between nostrils have been found to correlate with the handedness of the participants, i.e. left-handed participants had more sensitive left nostrils, whereas right-handed participants tended to have more sensitive right nostrils [25]. In the present study, we noticed that the nostril that was tested first tended to be less sensitive than the second nostril. We attributed this to a learning process. Unfortunately, we did not record the handedness of participants. Therefore, we cannot conclude whether or not handedness affected the olfactory function of each nostril.

For SIT, we found that only 8 of 10 odorants were correctly identified by >70% of the participants. These odorants included coffee (97.7%), ammonia (90.6%), baby soap (82%), banana (81.3%), pepper (81.3%), garlic (80.5%), orange (80%), and kaffir (makrut) lime (71.1%). Only two odorants (chocolate (65.6%) and tobacco (53.9%)) were correctly identified by <70% of the participants in the present study. This is probably because of different experiences and eating behavior, and may have a cultural base. We found that, the majority of participants were nonsmokers. Teenagers could more often identify chocolate correctly than older participants. By contrast, older participants could identify tobacco more correctly than younger participants. In addition, there were increased smell identification scores in the second trial compared with the first trial. In the first trial, participants could smell the odorant, but they could not remember the name of odorant, and in the second trial correct smell identification increased. Chaiyasate et al. [20] studied normal smell identification scores in Thais who lived in the northern region of Thailand, and these Thais were proven to have normal olfaction using an *n*-butanol detection threshold. Chaiyasate et al. used 14 common odorants for their SIT i.e. fish sauce, patchouli water, coconut, lemongrass, orange, ammonia, vinegar, oil, tea leaf, Thai perfume, jasmine, rose, and lemon. Four odorants were similar to ours, namely coffee, banana, orange, and ammonia. The rates of correct smell identification for these 4 odorants by their participants were 80%, 80%, 79%, and 78% respectively. Ours were 97.7%, 81.3%, 80.0%, and 90.6%, respectively. Individual experiences, social differences, and culture might play important roles in identifying odorous substances correctly and explain the differences in correct smell identification. Therefore, appropriate selection of odorous substances for SIT is essential and the odorants should be as familiar as possible to the participants [26].

Conclusion

Our data demonstrated that smell discrimination (median (IQR)) and identification (mean ± SD) scores in Thai healthy adults were 16 (13.5-16.0) and 8 ± 1.5, respectively. Women have better olfactory function than men as indicated by higher mean SDT and SIT scores and a lower PEA olfactory threshold. These values can be used as references in clinical practice and research involving Thais. Because SDT and SIT are simple qualitative tests of the olfactory function, they should be included in routine clinical assessment of patients with olfactory disorders. However, in selection of odorous substances it is necessary to be aware of social and cultural differences that may affect the results of the SIT.

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Conflict of interest statement

The authors have no conflicts of interest to declare.

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