Evaluation of Culturally-Familiar Odorants for a Persian Smell Identification Test

Seyed Kamran Kamrava¹, Maryam Jalesi¹, Shaghayegh Ebrahimnejad¹, Sahand Ghalehbaghi¹, "Elahe Amini², Alimohamad Asghari¹, Farhad Rafiei¹, Mohammad Farhadi¹

Abstract

Introduction: Processing odor information by the olfactory system depends greatly on the odor concentration. In order to use an odorant in a smell identification test (SIT), the minimum identification concentration (MIC) needs to be determined.

Materials and Methods: This study was conducted in 60 healthy native individuals aged 20 to 60 years, selected from patients’ companions in a tertiary hospital. In the first step, 25 odorants were presented to evaluate familiarity among the subjects. Then, the MICs for the eligible odorants were measured using the ascending method of limits.

Results: Out of 25 odorants, only one (cacao) was distinguished by less than 70% of the subjects, and was therefore removed from the list. The MICs of the remaining 24 odorants ranged from 6.87±2.74% for menthol to 27.62±18.98% for cantaloupe. There was significant correlation between age and the MIC only for coffee (P=0.02, r=−0.300). There was a significant difference in MIC between men and women only for hazelnut (P=0.03).

Conclusion: We present the MICs of 24 culturally-familiar odorants in a sample of the Persian population in a SIT.

Keywords: Culture, Identification, Smell, Odorants.

Received date: 13 Jun 2017
Accepted date: 4 Nov 2017

¹ENT and Head and Neck Research Center and Department, Hazrat Raoul Akram Hospital, Iran University of Medical Sciences, Tehran, Iran.
²Skull Base Research Center, ENT and Head and Neck Research Center, Hazrat Rasoul Akram Hospital, Iran University of Medical Sciences, Tehran, Iran.
*Corresponding Author:
Skull Base Research Center, ENT and Head and Neck Research Center, Hazrat Rasoul Akram Hospital, Niayesh St., Sattarkhan Ave., Tehran, Iran.
Tel: +982166552828, E-mail: elaheaminimd@gmail.com
Introduction

The sense of smell strongly affects human quality of life and health (1). Evaluation of a patient’s olfactory function is an important step in diagnosing and treating the olfactory dysfunctions, and also in the early detection of some neurological diseases (2,3). Newly developed olfactory tests are mainly subjective psychophysical tests that rely on subject detection, identification or discrimination. These tests are easy to use and are more cost-beneficial compared with electrophysiological tests (4).

Smell identification tests (SIT) were the first olfactory tests to gain popularity. Among them, the University of Pennsylvania Smell Identification Test (UPSIT) and its modifications are most commonly, and have been evaluated for applicability in several countries. Another widely available SIT is the Sniffin' Sticks test, which consists of felt-tip pens filled with odorants. Removal of the cap will release the odor. This test originally developed and validated in Germany, and is now also validated in several countries (5–10).

For an odorant to be used in a SIT, the prior condition is to be recognizable by more than 70–75% of the subjects tested (11,12). Many investigations have shown that the identification of an odorant closely depends on social and cultural factors (13,14). In a study by Kamrava et al. (15), more than 50% of the odorants used in the UPSIT were not familiar to the Iranian population, and thus needed to be replaced by more familiar ones.

Furthermore, processing odor information by the olfactory system depends largely on the odor concentration (16). The ability to recall an odorant or define the intensity is directly linked to the minimum identification concentration (MIC) of that odorant in each population (17). MIC is a characteristic of a chemical agent, and the response would be consistent at all higher concentrations (18). However, establishing a MIC for an odorant is not a straightforward task, and no clear consensus is available on how to quantify an odorant (19,20). Different populations may have particular cultural odorant materials, and the recognizable concentration of these materials may differ between communities.

In the present study, we attempted to find culturally-familiar odorants and the MICs of each one in order to be able to use them in a new SIT.

Materials and Methods

This study was conducted in a group of healthy Iranian volunteers, aged 20 to 60 years, selected from patients’ companions in a tertiary hospital. The subjects had no complaint of nasal obstruction, recent upper respiratory tract infection or allergy attack, nasal and sinus surgeries, head trauma or any systemic chronic diseases such as liver or renal dysfunction or history of neurological or psychological problems (except for mild depression or anxiety). Any history of use of medications affecting olfaction was considered an exclusion criterion. This study was performed in accordance with the Declaration of Helsinki, and approved by the ethics committee of the Ear, Nose and Throat (ENT) and Head and Neck Research Center. Informed consent was obtained from all participants.

The principles for selection of the odorants were familiarity with all odorants-describing items, similarity in intensity and hedonic tone, and corrected identification rate more than 70% in healthy subjects (5,11,12). Odor familiarity rate was evaluated through a list of multiple choices. In order to select the appropriate odorants, nine odorants that were shown to have more than 70% identification rate in a previous study on Iranian population were adopted (15). Six odorants that are known to be stimulators of trigeminal nerve were also added to the list.

Then, 60 healthy subjects were asked to rate 40 odorants using a questionnaire adopting a Likert-type scale ranging from 0 to 5 (0=unfamiliar, 5=very familiar). The results of each odorant were converted to a percentage, and odorants with a familiarity rate of greater than 70%, were selected.

In the second phase, 25 eligible odorants (by Magnolia Co., Iran) were presented to 10 subjects to confirm their familiarity in a pilot study. Then, all subjects were presented with the odorants. The subjects were asked to not eat, drink or smoke 15 min prior to the test. The odorants were presented in uniform pens with tampons filled with odorants that had been labeled with different codes at the bottom. The cap was then removed for 3 s, and the patient was asked to sniff. Each marker was placed 1 to 2 cm away from the nostrils. The subjects were asked to choose the correct
answer from the list of multiple choices. The time interval between presenting the various odorants was 30 s. Those odorants that were identified correctly in more than 70% of the subjects were selected for the second phase of the study. In the third phase, the odorants were presented to the subjects in five different concentrations (6.25%, 12.5%, 25%, 50%, and 75%) with the same disciplines adopted in the first phase. The concentrations were presented to the subjects from the lowest to the highest for each odorant (ascending method of limits). The subjects were asked to identify the odorant in a questionnaire. If the answer was incorrect, a higher concentration was presented until the correct answer was reached. This concentration was assumed to be the MIC for that odorant, and was measured in each person for all of the odorants. All procedures were followed by one expert in a specified quiet room (smell laboratory) using standard methods (21–24).

The results were presented as mean ± standard deviation (SD) for quantitative variables, and frequency (percentage) for categorical variables. Continuous variables were compared using t-test, analysis of variance (ANOVA) test or non-parametric Mann-Whitney U test or Kruskal-Wallis test whenever the data did not appear to have normal distribution. Categorical variables were compared using the chi-square test. For the statistical analysis, the statistical software SPSS version 22.0 for windows (SPSS Inc., Chicago, IL) was used. P-values of 0.05 or less were considered statistically significant.

**Results**

Sixty healthy individuals (28 men and 32 women) with a mean age of 37.5±9.7 years, ranging from 20 to 58 years were included (men: 38.61±9.86 years [23 to 57 years], women: 36.53±9.60 years [20 to 58 years]). A final list of odorants consisting of 25 descriptors and 31 distractors was developed. Out of 25 odorants that were evaluated, one odorant (cacao) did not reach the correct identification rate of 70% (61.6%), and was thus removed from the list. The percentages and numbers of corrected detections of each odorant are presented in Table 1.

**Table 1:** Numbers and percent of corrected detection of the 25 odorants

| Odorant   | Number and percent | Odorant   | Number and percent |
|-----------|--------------------|-----------|--------------------|
| Coffee    | 60 (100%)          | Orange    | 60 (100%)          |
| Vinegar   | 59 (98.3%)         | Saffron   | 59 (98.3%)         |
| Banana    | 60 (100%)          | Cantaloupe| 58 (96.6%)         |
| Mint      | 55 (91.6%)         | Smoke     | 59 (98.3%)         |
| Coconut   | 59 (98.3%)         | Rosewater | 60 (100%)          |
| Cucumbers | 53 (88.3%)         | Cardamom  | 56 (93.3%)         |
| Onion     | 53 (88.3%)         | Honey     | 44 (73.3%)         |
| Cinnamon  | 57 (95 %)          | Crud      | 53 (88.3%)         |
| Cacao     | 37 (61.6%)         | Hazelnut  | 51 (85%)           |
| Apple     | 56 (93.3%)         | Garlic    | 59 (98.3%)         |
| Menthol   | 58 (96.6%)         | Butter    | 60 (100%)          |
| Pineapple | 60 (100%)          | Lemon     | 60 (100%)          |
| Vanilla   | 53 (88.3%)         |           |                    |

The MIC for the remaining 24 odorants evaluated ranged from 6.87±2.74% for menthol to 27.62±18.98% for cantaloupe. The MIC of the odorants are shown in Table 2. Out of all odorants, only the MIC of hazelnut was significantly different in men and women (6.25±0.01 vs. 7.81±3.88, respectively, P=0.03). Comparing the MICs of the odorants across age groups, a significant difference was found for lemon (P=0.01). The mean MIC for each odorant in each age group is shown in Table 3. There were significant correlations between age and mean MIC for coffee (P=0.02, r =−0.30) and lemon (P=0.05, r =−0.26). These MICs were then rounded up to the next higher concentration. The percentage of correct identification at these concentrations was 71–98.3%, and thus considered as the MIC for each odorant.
Table 2: Mean±standard deviation (SD) of minimum identification concentration of each odorants

| Odorant     | Total Mean±SD | Men Mean±SD | Women Mean±SD |
|-------------|---------------|-------------|---------------|
| Coffee      | 17.60±12.15   | 19.64±13.03 | 15.82±11.22   |
| Vinegar     | 10.52±6.35    | 10.49±5.90  | 10.54±6.81    |
| Banana      | 7.60±6.20     | 8.03±8.30   | 7.22±3.58     |
| Mint        | 7.81±3.92     | 8.48±5.16   | 7.22±2.30     |
| Coconut     | 12.50±9.34    | 12.94±6.34  | 12.10±11.44   |
| Garlic      | 8.64±3.65     | 8.48±3.04   | 8.78±4.15     |
| Curd        | 19.80±15.57   | 20.98±15.61 | 18.75±15.72   |
| Apple       | 10.52±9.16    | 9.82±6.68   | 11.13±10.96   |
| Cinnamon    | 11.86±10.42   | 12.26±11.69 | 11.52±9.40    |
| Menthol     | 6.87±2.74     | 7.14±3.69   | 6.64±1.53     |
| Cucumbers   | 7.18±3.00     | 6.91±1.96   | 7.42±3.70     |
| Pineapple   | 12.91±9.61    | 12.05±9.46  | 13.67±9.84    |
| Lemon       | 22.52±17.90   | 23.43±17.31 | 21.66±18.69   |
| Orange      | 7.39±3.72     | 7.81±4.03   | 7.03±3.45     |
| Saffron     | 9.06±7.03     | 8.70±4.28   | 9.37±8.83     |
| Smoke       | 10.52±6.03    | 12.05±6.78  | 9.17±5.01     |
| Rosewater   | 23.95±19.90   | 24.55±17.83 | 23.43±21.82   |
| Cardamom    | 7.29±3.66     | 6.69±1.63   | 7.81±4.76     |
| Honey       | 14.11±13.32   | 12.96±9.79  | 15.12±15.87   |
| Vanilla     | 14.16±11.72   | 15.62±11.96 | 12.89±11.55   |
| Hazelnut    | 7.08±2.92     | 6.25±0.1    | 7.81±3.88     |
| Cantaloupe  | 27.62±18.98   | 27.60±20.76 | 27.64±17.60   |
| Butter      | 7.70±3.87     | 8.03±4.11   | 7.42±3.70     |
| Onion       | 8.16±7.23     | 8.37±6.83   | 7.97±3.28     |

Table 3: Mean±standard deviation (SD) of each odorant’s minimum identification concentration in age groups

| Odorants   | 20–30 years Mean±SD | 30–40 years Mean±SD | 40–50 years Mean±SD | 50–60 years Mean±SD | P-value |
|------------|----------------------|----------------------|----------------------|----------------------|---------|
| Coffee     | 23.82±15.00          | 16.87±13.15          | 14.14±7.16           | 13.75±6.84           | 0.09    |
| Vinegar    | 12.10±7.02           | 10.62±6.75           | 9.86±6.00            | 7.50±2.79            | 0.51    |
| Banana     | 7.42±2.51            | 8.43±9.78            | 7.23±4.30            | 6.25±0.00            | 0.88    |
| Mint       | 7.42±4.68            | 6.87±1.92            | 9.21±4.82            | 7.50±2.79            | 0.29    |
| Coconut    | 12.89±11.74          | 10.93±6.68           | 14.80±10.46          | 8.75±3.42            | 0.47    |
| Garlic     | 7.81±2.79            | 8.12±2.93            | 9.53±8.82            | 10.00±3.42           | 0.39    |
| Curd       | 26.95±19.19          | 15.31±11.55          | 20.06±15.53          | 12.50±8.83           | 0.11    |
| Apple      | 9.37±6.45            | 10.62±10.35          | 12.17±10.91          | 7.50±2.79            | 0.71    |
| Cinnamon   | 15.62±14.79          | 11.84±11.00          | 9.86±4.80            | 7.50±2.79            | 0.30    |
| Menthol    | 7.81±4.84            | 6.56±1.39            | 6.57±1.43            | 6.25±0.00            | 0.46    |
| Cucumbers  | 7.81±2.79            | 6.25±0.00            | 7.56±4.45            | 7.50±2.79            | 0.40    |
| Pineapple  | 12.10±8.05           | 13.12±10.31          | 14.14±11.38          | 10.00±3.42           | 0.83    |
| Lemon      | 33.98±19.49          | 16.77±14.13          | 17.70±11.98          | 25.00±28.98          | 0.01    |
| Orange     | 6.64±1.56            | 7.81±4.47            | 6.57±1.43            | 11.25±8.14           | 0.06    |
| Saffron    | 10.93±11.52          | 9.06±5.90            | 7.56±2.61            | 8.75±3.42            | 0.58    |
| Smoke      | 9.37±5.10            | 10.62±5.77           | 10.85±6.85           | 12.50±7.65           | 0.76    |
| Rosewater  | 29.68±26.26          | 19.06±15.23          | 25.32±18.45          | 20.00±18.43          | 0.42    |
| Cardamom   | 6.64±1.56            | 6.56±1.39            | 7.89±4.58            | 10.00±8.38           | 0.21    |
| Honey      | 14.58±17.93          | 14.80±11.06          | 13.48±13.21          | 12.50±7.65           | 0.98    |
| Vanilla    | 10.15±6.40           | 15.62±13.37          | 17.76±13.54          | 7.50±2.79            | 0.13    |
| Hazelnut   | 6.64±1.56            | 7.18±2.28            | 7.56±4.45            | 6.25±0.00            | 0.73    |
| Cantaloupe | 32.14±19.28          | 26.64±19.96          | 26.64±19.96          | 31.25±21.65          | 0.64    |
| Butter     | 6.64±1.56            | 8.12±4.57            | 8.22±4.68            | 7.50±2.79            | 0.62    |
| Onion      | 10.63±9.51           | 8.93±4.99            | 8.53±3.60            | 8.32±4.01            | 0.47    |
**Discussion**

SITs are currently the most popular olfactory tests that are available in various versions in different countries (25–27). In the United States, UPSIT is the SIT that is most commonly used in studies focusing on olfaction. This test is shown to be able to clearly differentiate between persons with normal olfactory ability and those who have well-documented olfactory dysfunction (14).

However, there are some limitations regarding the use of UPSIT in other countries. When the standard UPSIT was used in Japanese normal subjects, the identification rates of some odorants were quite low. For this reason, a cross-culturally modified UPSIT was developed in the Japanese population (28). This also led to a British version and an international version of the UPSIT (27,29). A study in Iran using UPSIT demonstrated most of the odorants of this test were not familiar in this population, with more than 50% of odorants of this test having less than 70% correct identification rate (15). Therefore, it was necessary to develop and adopt a SIT that is adapted to the Iranian culture.

The next step in adopting an odorant in a SIT is to determine the MICs of the odorants that are going to be used. Through standardization of the method of sample presentation and minimizing of the extraneous sensory interference, we tried to achieve a higher accuracy in determining the MIC. Because determining the optimal MICs may directly depend on the sensitivity of human olfaction, we tried to select subjects with the healthiest conditions and tested them in a standard environmental condition (16,30).

Some studies demonstrated that the olfactory ability of a human reaches a plateau between the ages of 20 and 60, with subjects aged less than 20 years or more than 60 years of age having lower scores in olfactory evaluations (5,31,32). The effect of neurodegenerative disease or olfactory epithelium damage are common explanations for olfactory impairments in old age (32,33). However, the reasons in children are not obviously defined, and may be the same as the development in their verbal skills (34,35). In our study we selected people aged 20–60 in order to minimize these interfering factors. Although in our study women had lower MICs in more odorants compared with men, these differences were only significant for hazelnut. Surprisingly, men had a lower MIC compared with women for this odorant. However, some authors considered sex hormones to have the ability to affect the olfactory function. In a systematic review by Doty et al. (36), women were shown to have a higher correct identification rate compared with men for some odorants, especially for body odors. However, for more accurate analysis, situations such as pregnancy, use of oral hormonal contraceptives, or menstrual cycle need to be considered (37–39). The differences in MICs across the age subgroups were also not significant (except for lemon). These data show that these MICs can be used sex- and age-independently in a SIT.

**Conclusion**

In the present study, we tried to introduce some culturally-familiar odorants with their MICs for use in the SIT. However, the detection of an odorant may also be influenced by the different genetic and environmental factors. As Iran consists of various ethnic subgroups, this selection of odorants needs to be evaluated in a cross-country study including subjects from various ethnic subgroups.

**References**

1. Hummel T, Landis B N, Hüttenerink K-B. Smell and taste disorders. GMS Curr Top Otorhinolaryngol Head Neck Surg 2011; 10:Doc04.
2. Gros A, Manera V, De March CA, Guevara N, König A, Friedman L, et al. Olfactory disturbances in ageing with and without dementia: towards new diagnostic tools. J Laryngol Otol 2017;131:572–9.
3. Barresi M, Ciurleo R, Giacoppo S, Foti Cuzzola V, Celi D, Bramanti P, et al. Evaluation of olfactory dysfunction in neurodegenerative diseases. J Neurul Sci 2012; 323:16–24.
4. Eibenstein A, Fioretti AB, Lena C, Rosati N, Amabile G, Fusetti M. Modern psychophysical tests to assess olfactory function. Neurul Sci 2005; 26(3):147–55.
5. Hummel T, Sekinger B, Wolf SR, Pauli E, Kobal G. ‘Sniffin’ sticks’: olfactory performance assessed by the combined testing of odor identification, odor discrimination and olfactory threshold. Chem Senses 1997; 22: 39–52.
6. Kobal G, Hummel T, Sekinger B, Barz S, Roscher S, Wolf S. ‘Sniffin’ sticks’: screening of olfactory performance. Rhinology 1996; 34(4):222–6.
7. Mackay-Sim A, Grant L, Owen C, Chant D, Silburn P. Australian norms for a quantitative olfactory function test. J Clin Neurosci 2004;11: 874–9.
8. A Eibenstein, AB Fioretti, C Lena, N Rosati, I Ottaviano, M Fusetti. Olfactory screening test: experience in 102 Italian subjects. Acta Otorhinolaryngol Ital 2005; 25(1): 18–22.
9. Boesveldt S, Verbaan D, Knol DL, van Hilten JJ, Berendse HW. Odour identification and discrimination in Dutch adults over 45 years. Rhinology 2008; 46(2):131-6.
10. Silveira-Moriyama L, Sirisena D, Gamage P, Gamage R, de Silva R, Lees AJ. Adapting the Sniffin’ Sticks to diagnose Parkinson’s disease in Sri Lanka. Mov Disord 2009 15; 24(8):1229-33.
11. Jiang RS, Su MC, Liang KL, Shiao JY, Wu SH, Hsin CH. A pilot study of a traditional Chinese version of the University of Pennsylvania Smell Identification Test for application in Taiwan. Am J Rhinol Allergy 2010; 24:45–50.
12. Silveira-Moriyama L, Azevedo AM, Ranvauard R, Barbosa ER, Doty RL, Lees AJ. Applying a new version of the Brazilian-Portuguese UPSIT smell test in Brazil. Arq Neuropsiquiatr 2010; 68:700–5.
13. Altundag A, Tekeli H, Salihoglu M, Cayonu M, Yasar H, Kendirli MT, et al. Cross-culturally modified University of Pennsylvania Smell Identification Test for a Turkish population. Am J Rhinol Allergy 2015; 29:e138–41.
14. Fornazieri MA, Doty RL, Santos CA, Pinna Fde R, Bezerra TF, Voegels RL. A new cultural adaptation of the University of Pennsylvania Smell Identification Test. Clinics (Sao Paulo) 2013; 68: 65–8.
15. SK Kamrava, M Farhadi, M Jalessi, B Khosravian, B Pousti, E Amir Tehran et al. University of Pennsylvania smell identification on Iranian population. Iran Red Crescent Med J 2014; 16: e7926.
16. Gautam SH, Short SM, Verhagen JV. Retronasal odor concentration coding in glomeruli of the rat olfactory bulb. Front Integr Neurosci 2014;24: 8:81.
17. Hasin-Brunsstein Y, Lancet D, Olender T. Human olfaction: from genomic variation to phenotypic diversity. Trends Genet 2009; 25: 178–84.
18. Walker JC, Hall SB, Walker DB, Kendal-Reed MS, Hood AF, Niu XF. Human odor detectability: new methodology used to determine threshold and variation. Chem Senses 2003; 28:817–26.
19. Brattoli M, de Gennaro G, de Pinto V, Loiotile AD, Lovascio S, Penza M. Odour detection methods: olfactometry and chemical sensors. Sensors (Basel) 2011; 11:5290–322.
20. Rosenkranz HS, Cunningham AR. Environmental odors and health hazards. Sci Total Environ 2003; 313:15–24.
21. Greenberg MI, Curtis JA, Vearrier D. The perception of odor is not a surrogate marker for chemical exposure: a review of factors influencing human odor perception. Clin Toxicol (Phila) 2013; 51:70-6.
22. Malnic B, Godfrey PA, Buck LB. The human olfactory receptor gene family. Proc Natl Acad Sci USA 2004; 101:2584–9.
23. Cook GR, Krithika S, Edwards M, Kavanagh P, Parra EJ. Quantitative measurement of odor detection thresholds using an air dilution olfactometer, and association with genetic variants in a sample of diverse ancestry. Peer J 2014; 6:2:e643.
24. Takagi SF. A standardized olfactometer in Japan. A review over ten years. Ann N Y Acad Sci 1987; 510:113–8.
25. Doty RL. Olfactory dysfunction and its measurement in the clinic and workplace. Int Arch Occup Environ Health 2006; 79:268–82.
26. Jiang RS, Su MC, Liang KL, Shiao JY, Wu SH, Hsin CH. A pilot study of a traditional Chinese version of the University of Pennsylvania Smell Identification Test for application in Taiwan. Am J Rhinol Allergy 2010; 24:45–50.
27. Velayudhan L, Gasper A, Pritchard M Baillon S, Messer C, Protsi P. Pattern of Smell Identification Impairment in Alzheimer’s Disease. J Alzheimer’s Dis 2015; 46:381–7.
28. Oghihara H, Kobayashi M, Nishida K, Kitano M, Takeuchi K. Applicability of the cross-culturally modified University of Pennsylvania Smell Identification Test in Japanese Population. Am J Rhinol Allergy 2011; 25:404–10.
29. Vengalil S, Agadi JB, Raghavendra K. University of Pennsylvania Smell Identification Test Abnormalities in Parkinson’s Disease. J Assoc Physicians India 2016; 64:32–6.
30. Sela L, Sobel N. Human olfaction: a constant state of change-blindness. Exp Brain Res 2010; 205(1): 13–29.
31. Stevenson RJ, Attuquayefio T. Human olfactory consciousness and cognition: its unusual features may not result from unusual functions but from limited neocortical processing resources. Front Psychol 2013; 4:819.
32. Hummel T, Kobal G, Gudziol H, Mackay-Sim. A Normative data for the “Sniffin’Sticks” including tests of odor identification, odor discrimination, and olfactory thresholds: an upgrade based on a group of more than 3,000 subjects. Eur Arch Otorhinolaryngol 2007; 264:237–43.
33. Doty RL. The olfactory system and its disorders. Semin Neurol 2009; 29:74–81.
34. Oleszkiewicz A, et al. Developmental Changes in Adolescents’ Olfactory Performance and Significance of Olfaction. PLOS ONE 2016; 11:e0157560.
35. Monnery-Patris S, Rouby C, Nicklaus S, Issanchou S. Development of olfactory ability in children: sensitivity and identification. Dev Psychobiol 2009; 51:268–76.
36. Richard L, Doty and E. Leslie Cameron. Sex differences and reproductive hormone influences on human odor perception. Physiol Behav 2009; 97: 213–28.
37. Navarrete-Palacios E, Hudson R, Reyes-Guerrero G, Guevara-Guzmán R. Lower olfactory threshold during the ovulatory phase of the menstrual cycle. Biol Psychol 2003; 63:269–79.
38. Nordin S, Broman DA, Olofsson JK, Wulff M. A longitudinal descriptive study of self-reported abnormal smell and taste perception in pregnant women. Chem Senses 2004; 29:391–402.
39. Doty RL, Hall JW, Flickinger GL, Sondheimer SJ. Cyclic changes in olfactory and auditory sensitivity during the menstrual cycle: No attenuation by oral contraceptive medication. In: Breipohl W, ed. Olfaction and endocrine regulation. London, IRL Press, 1982. 35-42.