# Odor Familiarity and Improvement of Olfactory Identification Tests in Chinese Population

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**Abstract**

Aims: This study aimed to design the Chinese Modified Olfactory Identification (CMOI) test based on the Sniffin' Sticks Olfactory Identification (SSOI) test and to present participants' sensitivity to unpleasant odors. Materials and methods: We recruited 200 healthy volunteers from 2021 to 2022; in a survey, 100 volunteers rated their familiarity with 121 odors, including all the SSOI test odor descriptors and common odors in Chinese daily life. The SSOI test was modified according to the survey results. The other 100 were tested three times: the standard SSOI test, the Modified Distractors Olfactory Identification(MDOI) test established by modified distractors in the SSOI test, and the CMOI test developed by using familiar unpleasant odors to replace the MDOI test odors with low correct recognition rates. Results: Volunteers were unfamiliar with 31 odor descriptors in the SSOI test; 23 distractors with low familiarity were replaced with more familiar distractors. The three odors with the lowest correct recognition rate in the MDOI test were replaced with familiar unpleasant odors . The familiarity score was significantly higher in the CMOI test than in others (P = 8.6864e-13 < 0.0001); the correct recognition rate in the CMOI test was significantly higher than in the SSOI test (P = 0.007 < 0.05). Conclusion: The familiarity scores in the CMOI test were significantly improved; it prevented choosing wrongly due to unfamiliarity with an odor and its distractors, highlighting the importance of unpleasant smell with a warning function. The CMOI test effectively evaluated olfactory function in Chinese people. Key-words: odor familiarity;olfactory test; modification; distractor; unpleasant odor;correct recognition rates

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**Results:** Volunteers were unfamiliar with 31 odor descriptors in the SSOI test; 23 distractors with low familiarity were replaced with more familiar distractors. The three odors with the lowest correct recognition rate in the MDOI test were replaced with familiar unpleasant odors . The familiarity score was significantly higher in the CMOI test than in others ($P = 8.6864e^{-13} < 0.0001$); the correct recognition rate in the CMOI test was significantly higher than in the SSOI test ($P = 0.007 < 0.05$).

**Conclusion:** The familiarity scores in the CMOI test were significantly improved; it prevented choosing wrongly due to unfamiliarity with an odor and its distractors, highlighting the importance of unpleasant smell with a warning function. The CMOI test effectively evaluated olfactory function in Chinese people.

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**Key points**

The aim of the study was to design a test that can detect the olfactory function of Chinese people more comprehensively.

We collected odor familiarity questionnaires to screen familiar odors of Chinese people.

Three odors (tetrahydrothiophene, 2-methylpyrazine, and trimethylindole) can simulate natural gas, burnt smell, and fecal odor, respectively.

In this study,the Sniffin' Sticks Olfactory Identification test was modified from the distractors and odors.

Through the modification, the scores of olfactory identification test were significantly improved.

## 1 INTRODUCTION

Olfaction is an important sense of organisms that can regulate emotions, affect cog-nition and behaviour[1,2], and also remind us of dangers in the environment[3]. It can be imp-aired by chronic rhinosinusitis, head trauma, infections, ageing, long-term smoking, alco-holism, metabolic diseases, and autoimmune diseases[4]. Olfactory dysfunction can signifi-cantly affect patients' quality of life[5], and it is an early marker of neurodegenerative dise-ases such as Alzheimer's disease and Parkinson's disease[6,7].

The diagnosis and classification of olfactory dysfunction mainly depend on olfacto-ry psychophysical tests such as the Sniffin' Sticks test[8], the Connecticut Chemosensory Clinical Research Center test[9], the University of Pennsylvania Smell Identification Test[10], T&T test[11], and so on. Among them, the Sniffin' Sticks test has been the most widely us-ed. The test comprises an olfactory threshold test, olfactory discrimination test, and olfa-ctory identification test (SSOI test).

According to the research of Chrea et al.[12], differences in culture, customs, and other factors in different countries and regions can lead to different people's familiarity with th-e same smell. When subjects receive olfactory identification tests that are not suitable for their region, they may be unfamiliar with the odor itself or its distractors, which may aff-ect the results of olfactory tests. Therefore, many researchers designed olfactory test met-hods suitable for local people by changing odors and distractors. Among them, the modified scheme for the Sniffin' Sticks test is the most common. Dozens of countries and reg-ions, including Spain, Malaysia, Congo, and Turkey, have put forward the modified sche-me for the Sniffin' Sticks test suitable for local people[13-16].

In recent years, some researchers in China also have been committed to putting for-ward modified schemes of olfactory tests suitable for Chinese people. The Institute of Ps-ychology of the Chinese Academy of Sciences and the Beijing Anzhen Hospital, Affiliat-ed with Capital Medical University, have put forward the modified scheme of olfactory t-ests suitable for Chinese people, CSIT and COIT[17,18]. Although these two modified sche-mes used odors familiar to Chinese people to modify the olfactory identification test, the-y ignored two problems. First, both schemes only changed some odors but did not adjust the distractors of other options. Second, researchers mostly choose pleasant or neutral od-ors instead of unpleasant odors in most olfactory test modification schemes, including th-ese two modification schemes. The warning function is an important olfactory function, and most of the odors with warning functions are unpleasant odors, such as burnt smell in case of fire, special smells in case of natural gas leakage, etc.

To detect the olfactory function of subjects more comprehensively, it is necessary to introduce some un-pleasant odors with warning function into olfactory tests. In this study, we modified the distractors in an olfactory identification test appropriately, and some un-pleasant odors with warning functions were introduced to modify the olfactory identifica-tion test. We aimed to design the Chinese Modified Olfactory Identification (CMOI) test based on the SSOI test and to present participants' sensitivity to unpleasant odors.

## 2MATERIALS AND METHODS

For the development of this report, the STROBE guide for observational studies has been followed.

### 2.1 Participants

We recruited 200 volunteers with normal olfaction from 2021 to 2022. The first 100 volunteers (42 males and 58 females, aged 18–65 years, mean age 35.70 years,SD 10.88) participated in the odor familiarity survey. The remaining 100 volunteers (61 males and 39 females, aged 18–60 years, mean age 34.38 years, SD 11.00) participated in the modi-fication of the olfactory identification test. They reported having no obvious olfactory di-sorder and no previous history of nasal craniocerebral surgery. Physical examination sho-wed that both nasal cavities and olfactory clefts were unobstructed. Signed informed con-sent was obtained.All procedures used in this experiment involving human participants were approved by the Ethics Committee and were in accordance with the Declaration of Helsinki.

### 2.2 Odorants preparation

This experiment used three odorants, namely tetrahydrothiophene, 2-methylpyrazine, and trimethylindole, purchased from Aladdin Company (Shanghai, China). Appropriate amounts of the above three odorants were added to a felt-tip pen (Burgart Messtechnik, Wedel, Germany). Regarding the safety of the odorants: first, after adding an appropriate amount of the three odorants, the pen can be used for 6 months without adding odorants again during the period. Also, the amounts of tetrahydrothiophene, trimethylindole, and 2-methylpyrazine used in this experiment were 1 mg, 2 mg, and 300 mg, respectively. A-fter animal experiments and literature review, the damage of these three odorants to the human body can be ignored[19-21].

### 2.3 Test procedure

Sniffin' Sticks Olfactory Identification test: The test comprises 16 felt-tip pen-like d-evices; only one olfactory pen cap can be opened at a time. The pen tip was placed appr-oximately 2 cm under the middle of the subject's double nostrils and did not touch the su-bject's skin. The time for the subject to smell each pen shall not exceed 2–3 seconds, with an interval of about 30 seconds. After presenting a stick, the subject was provided with f-our odor descriptors to select the option that could best describe the presented odor. Even if subjects were uncertain about the odor, they were required to use the exclusion method to make a choice. The test was repeated successively until all 16 odors were presented.

### 2.4 Study Design

*2.4.1 Odor familiarity survey*

The familiarity of 121 odors was investigated in 100 volunteers (aged 18–65 years). Based on Niklassen et al.'s study[22], we developed an odor familiarity questionnaire co-ntaining 121 kinds of odors. The questionnaire included basic information of the volunte-ers: name, gender, age, contact details, and occupation (strict measures were taken to ens-ure that the privacy and personally identifiable information of volunteers were not expos-ed during the research process, and the names of volunteers were hidden and replaced by numbers only). According to the familiarity with the 121 common odors provided in the questionnaire, we used a Likert-type scale for the volunteers to score using an online or paper questionnaire (the content of the online and paper questionnaires were similar). T-he scale ranged from 1 to 5, for which 1 is not familiar, and 5 is highly familiar. If the v-olunteers scored 4 or 5 on an odor, they were considered "familiar" with the odor. The n-umber of "familiar" volunteers with an odor among 100 volunteers was the final familia-rity score of the odor.

*2.4.2 Modification of the olfactory identification test*

(1) Preparation of the olfactory test: First, we did not change the odors in the SSOI test but adjusted the distractors according to the odor familiarity results and randomly replaced the unfamiliar distractors with the distractors with a odor familiarity score hi-gher than 75[22], to form the MDOI test. Then, we used tetrahydrothiophene, 2-methylpy-razine, and trimethylindole to simulate natural gas, burnt smell, and fecal odor, respecti-vely, and distractors were randomly assigned to the three odors.

(2) Olfactory identification test modification: First, the SSOI test was conducted on 100 volunteers. Then the volunteers were tested by MDOI test after 30 minutes, with the test process unchanged. Finally, the volunteers were tested with three odors of natural gas, burnt smell, and Fecal odor to complete the olfactory identification test.

### 2.5 Statistical analysis

R version 3.5.3 was used for statistical analysis. $P < 0.05$ indicated statistical signif-icance. Measurement data are expressed as mean ± standard deviation (x ± s) and counti-ng data as rate (%). The correct recognition rate of odors in each test was calculated, and the test scores in the modification process were tested by paired sample Friedman M test. The correct recognition rate of odors in the SSOI and CMOI tests was tested by the paire-d sample Wilcoxon signed rank-sum test. Draw FIGURE 1 and FIGURE 2 with GraphP-ad Prism 8 (GraphPad Software, La Jolla, CA, USA).

## 3 RESULTS

### 3.1 Odor familiarity test

As shown in Table 1, the odor familiarity of 70 kinds of odor descriptors was <75 points. Among the 64 odor descriptors in SSOI, 31 odor descriptors had a familiarity of <75 points; 23 distractors with odor familiarity >75 were selected to randomly replace the distractors with low familiarity in the first modification.

### 3.2 Establishment of the CMOI test

As shown in Figure 1, the correct recognition rates of leather, cinnamon, lemon, tur-pentine, apple, clove, and pineapple in the SSOI test were <75%. After the modification of distractors, the correct recognition rate of orange decreased from 99% to 98%. The co-rrect recognition rates of liquorice and pineapple also decreased, and that of peppermint was still 100%. The correct recognition rates of all other odors were significantly impro-ved, such as cinnamon from 59% to 88% and lemon from 70% to 86%. However, the re-cognition rates of apple, leather, and pineapple were still low, which were 20%, 57%, an-d 60% respectively. We added natural gas, burnt smell, and Fecal odor into the MDOI t-est to replace the three odors of apple, leather, and pineapple and established the CMOI t-est (as shown in Table 2, the bolded words are the correct odors). The correct recognition rate of 16 odors in the CMOI test is shown in Figure 2. Because the odors, distractors, a-nd volunteers participating in the other 13 tests remained unchanged, to reduce the olfact-ory fatigue of volunteers, the results of natural gas, burnt smell, and Fecal odor were co-mbined with the test results of 13 odors other than apple, leather, and pineapple in the M-DOI test to form the final result of the CMOI test.

### 3.3 Statistical analysis

Statistical methods were used to analyse the scores of volunteers in the SSOI, MD-OI, and CMOI tests. After the paired sample Friedman M test, the average values of the three groups were not the same ($P = 2.6757e\text{-}26 < 0.0001$), and the scores of volunteers in the MDOI test were significantly higher than those in the SSOI test ($P = 8.5854e\text{-}12 < 0.001$). The scores of volunteers in the CMOI test were significantly higher than those in the MDOI test ($P = 8.6864e^{-13} < 0.0001$) and SSOI test ($P = 8.6864e^{-13} < 0.0001$). The co-rrect recognition rates of odors in the SSOI and CMOI tests were tested by the Wilcoxon signed-rank sum test of paired samples. The correct recognition rates of test odors in the CMOI test were significantly higher than that in the SSOI test ($P = 0.006 < 0.05$).

## 4 DISCUSSION

Based on the SSOI test, the CMOI test proposed in this study significantly improved the score of the olfactory test and the correct recognition rate of odors by using the distra-ctors and odors more familiar to Chinese people. It is an effective tool for evaluating the olfactory function of Chinese people.

From the odor familiarity survey, we found that, out of the 64 odor descriptors in S-SOI test, the familiarity scores of 31 odor descriptors were <75 points; nearly half of the odors in SSOI test were unfamiliar to the volunteers. In the olfactory test, it is likely that although the subjects perceived the odors, they found it difficult to make a correct choice because they were unfamiliar with the odors or distractors.

After adjusting the 23 distractors of the SSOI test according to the odor familiarity survey results, the scores of the olfactory identification test of healthy volunteers were si-gnificantly improved. Taking the odor "cinnamon" as an example, in the SSOI test, only 59% of the volunteers could correctly identify the odor "cinnamon". However, after ch-anging the distractors, the correct recognition rate of the odor "cinnamon" reached 88%. This may be because volunteers were more familiar with the smell of some new distrac-tors and could choose the correct answer through exclusion. However, the correct recog-nition rates of some odors were still low, such as apple, leather, and pineapple, whose c-orrect recognition rates were 20%, 57%, and 60%, respectively; many volunteers could not recognize them correctly. This may be because volunteers were unfamiliar with some odors; even if the distractors were modified, the recognition rate of the odor "leather" w-as only improved from 53% to 57%. It may also be because the odor was familiar, but the name was inaccurate. Take the odor "apple" as an example, there are many varieties of a-pples in the world, and the smell is not exactly the same. The odor "apple" does not spec-ify the specific apple variety, and the apple aroma is relatively light, which can be easily ignored. Therefore, it was difficult for volunteers to make the correct choice in the test. If the names of both odors and distractors are inaccurate, the interference of volunteers may be more serious. The last reason is that the similarity between odors and distractors was high, and the difference was insignificant. Take the odor "apple" as an example again; the distractors of the odor were melon, peach, and orange. In the identification test, most vol-unteers could only smell fruit flavour, and these four options all had fruit flavour, increa-sing the difficulty of accurate identification. To further improve the score of the olfactory identification test and enable it to have the ability to test unpleasant odors, through litera-ture search, tetrahydrothiophene, 2-methylpyrazine, and trimethylindole were selected to simulate natural gas, burnt smell, and Fecal odor respectively, and replace three odors: a-pple, leather, and pineapple. After randomly assigning distractors, the CMOI test was co-mposed of 16 odors: 3 tested for the third time, and the other 13 unchanged odors.

The CMOI test scores of volunteers were significantly higher than that of the MDOI test scores and SSOI test scores, which reduced the occurrence of wrong choices due to t-heir unfamiliarity with some odors to avoid some subjects being misdiagnosed with olfa-ctory disorder due to the error of the olfactory test. Moreover, after adjusting the SSOI te-st, the score of the olfactory identification test was improved so that the degree of olfact-ory dysfunction can be diagnosed more accurately when testing patients with poor olfact-ion. Therefore, the CMOI test focuses on detecting the severity of patients' olfactory dys-function and makes it easier to identify patients who are not sensitive to unpleasant odor-s. It is more suitable for clinical diagnosis of olfactory disorder and evaluation of treatm-ent effect. Also, with the overall improvement of the CMOI test score, the olfactory det-ection ability of people who are too sensitive to smell may decline.

At present, patients with olfactory disorders mostly use pleasant odor reagents in ol-factory training but rarely use unpleasant odor reagents with important warning functions, such as natural gas odorant and simulated burnt odor reagents used in the experiment, w-hich may lead to poor recovery effect of patients' olfactory ability to this kind of odor. In this experiment, the unpleasant smell with a warning function was introduced into the ol-factory test, which could better detect the recovery degree of patients' perception of this kind of smell; this was of great significance to evaluate the effect of olfactory treatment.

It is hoped to screen patients who cannot correctly identify natural gas, burnt smell, and Fecal odor for the next treatment to reduce patients' risk in natural gas leakage, fire, and other dangerous events.

## 5 CONCLUSION

In this experiment, we modified both distractors and odors in the SSOI test to establish t-he CMOI test. The odor identification score of healthy volunteers in the CMOI test was significantly improved, reducing instances where volunteers found it difficult to name an odor because they were unfamiliar with the odor and corresponding distractors despite p-erceiving it. It highlighted the importance of unpleasant smells with warning functions. The CMOI test proposed in this study is an effective tool for evaluating the olfactory fun-ction of Chinese people.

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