ORIGINAL ARTICLE

The 8-Odorant Barcelona Olfactory Test (BOT-8): Validation of a New Test in the Spanish Population During the COVID-19 Pandemic

Rojas-Lechuga MJ[1,2,3], Ceballos JC[1,2], Valls-Mateus M[4], Mackers P[5], Izquierdo-Domínguez A[2,6,7], López-Chacón M[1,2,3], Langdon C[1,2,3], Mariño-Sánchez F[8], Valero J[9], Mullol J*[1,2,3], Alobid I*[1,2,3,7]

[1]Rhinology Unit and Smell Clinic, Department of Otorhinolaryngology, Hospital Clinic, Universitat de Barcelona, Spain
[2]Clinical and Experimental Respiratory Immunoallergy, IDIBAPS, Barcelona, Spain
[3]CIBER Respiratory Diseases (CIBERES), Spain
[4]Department of Otorhinolaryngology, Hospital Universitari Son Espases, Mallorca, Spain
[5]Department of Otorhinolaryngology, Hospital del Mar, Barcelona, Spain
[6]Department of Allergology, Consorci Sanitari de Terrassa, Barcelona, Spain
[7]Unidad Alergo Rino, Centro Médico Teknon, Barcelona, Spain
[8]Rhinology and Skull Base Surgery Unit, Otorhinolaryngology Department, Hospital Ramón y Cajal, Madrid, Spain
[9]Departament de Fisicoquímica, Facultat de Farmàcia, Universitat de Barcelona, Spain
*These authors contributed equally as senior and corresponding authors

J Investig Allergol Clin Immunol 2022; Vol. 32(4): 291-298
doi: 10.18176/jiaci.0824

Abstract

Background: Most smell tests are difficult to implement in daily clinical practice owing to their long duration. The aim of the present study was to develop and validate a short, easy-to-perform, and reusable smell test to be implemented during the COVID-19 pandemic.
Methods: The study population comprised 120 healthy adults and 195 patients with self-reported olfactory dysfunction (OD). The 8-Odorant Barcelona Olfactory Test (BOT-8) was used for detection, memory/recognition, and forced-choice identification. In addition, a rose threshold test was performed, and a visual analog scale was applied. The Smell Diskettes Olfaction Test (SDOT) was used for correlation in healthy volunteers, and the University of Pennsylvania Smell Identification Test (UPSIT) was used for patients with OD to establish cut-offs for anosmia and hyposmia. In order to take account of the COVID-19 pandemic, disposable cotton swabs with odorants were compared with the original test.
Results: In healthy persons, the mean (SD) BOT-8 score was 100% for detection, 94.5% (1.07) for memory/recognition, and 89.6% (0.86) for identification. In patients with OD, the equivalent values were 86% (32.8), 73.2% (37.9), and 77.1% (34.2), respectively. BOT-8 demonstrated good test-retest reliability, with agreement of 96.7% and a quadratic κ of 0.84 (P<.001). A strong correlation was observed between BOT-8 and SDOT (r=0.67, P<.001) and UPSIT (r=0.86, P<.001). Agreement was excellent for disposable cotton swabs, with a κ of 0.79 compared with the original test. The cut-off point for anosmia was ≤3 (area under the curve, 0.83; sensitivity, 0.673; specificity, 0.993).
Conclusions: BOT-8 offers an efficient and fast method for assessment of smell threshold, detection, memory, and identification in daily clinical practice. Disposable cotton swabs with odorants proved to be useful and safe during the COVID-19 pandemic.

Key words: Olfaction. Smell test. Loss of smell. Anosmia. COVID-19.

Resumen

Introducción: Las olfatometrías son difíciles de implementar en la práctica clínica diaria por su larga duración. El objetivo del presente estudio fue desarrollar y validar una prueba simple, fácil y reutilizable para ser utilizada durante la pandemia de COVID-19.
Métodos: Se incluyeron 120 voluntarios sanos ≥18 años y 195 pacientes con disfunción olfatoria (DO) autoreportada. Se utilizó el *Barcelona Olfactory Test* (BOT-8) con 8 odorantes para la detección, memoria/reconocimiento e identificación. Además, se hizo una prueba de umbral de rosa (alcohol feniletílico) de 6 diluciones, escala visual analógica (EVA). Se compararon los resultados con una prueba validada *Smell Diskettes Olfaction Test* (SDOT), para definir puntos de corte de hiposmia y anosmia se comparó en pacientes con DO con UPSIT™. Considerando la pandemia de COVID-19, se compararon hisopos de algodón desechables con los odorantes respecto a la prueba original.
Resultados: BOT-8 se tarda entre 3 y 7 minutos en realizar. En población sana, la media de detección fue del 100%, memoria 94,5% (DE=1,07) e identificación 89,6% (DE=0,86). En pacientes con DO fue de 86% (DE=32,8), 73,2% (DE=37,9) y 77,1% (DE=34,2), respectivamente. BOT-8 demostró buena fiabilidad test-retest con 96,7% de concordancia observada y una kappa cuadrática de 0,84 (p<0,001). Presentó una fuerte correlación con SDOT (r=0,673, p <0,001) en población sana y con UPSITTM en pacientes con DO (r=0,86, p<0,001). Los hisopos de algodón desechables mostraron una excelente concordancia (kappa de 0,79) en comparación con la prueba original. El punto de corte para anosmia fue ≤ 3 (AUC=0,83, Se= 0,673, Sp=0,993) y de hiposmia ≤ 6 (AUC=0,451, Se= 0,088, Sp= 0,814).

Conclusiones: BOT-8 ofrece un método eficiente y rápido para ser utilizado en la práctica clínica diaria para evaluar el sentido del olfato mediante la detección, memoria, identificación y umbral. Los hisopos de algodón desechables con odorantes son un método útil y seguro de aplicación durante la pandemia de COVID-19.

Palabras clave: Olfato. Olfatometría. Pérdida de olfato. Anosmia. COVID-19.

Introduction

Olfaction is the earliest and most primal sense [1,2]. The ability to identify and discriminate between smells reflects the health of the sinonasal cavity, cognitive state, and higher cortical centers [3].

Olfactory dysfunction (OD) is common in many conditions, including sinonasal diseases [4], postinfectious disorders [2], traumatic brain injuries [5,6], and neurodegenerative disorders [7], among others [8,9]. Olfactory function also plays an important role in daily living, eg, enjoyment of food, ability to detect spoilage, detection of safety hazards, socialization, and overall quality of life [10].

Methods for subjective measurement of OD are an important component of diagnosis and monitoring of treatment. Nowadays, one of the most common problems in olfactory tests is the time they take to perform and their difficult applicability in daily practice [11].

The scientific literature shows how the COVID-19 pandemic has raised awareness of OD in patients with SARS-CoV-2 infection [12]. Consequently, there is a clear need to adapt current olfactory tests to ensure that they can be applied safely by medical personnel and patients through single-use and/or self-administered tests [13]. This approach raises considerably the cost of examinations, creating the need for more cost-effective alternatives, such as disposable cotton swabs.

Aims and Objectives

The aim of the present study was to develop and validate a simple, easy-to-perform, and reusable smell test to be implemented over a short period (5 to 10 minutes). In addition, the test had to be adaptable and viable and comply with the necessary safety measures during the COVID-19 pandemic.

Patients and Methods

Participants

Two groups were recruited at Hospital Clínic, Barcelona, Spain. The first included healthy adult volunteers aged ≥18 years with no subjective loss of smell who were equally distributed by sex and in age groups of 10-year intervals. We excluded patients with upper respiratory tract infection in the previous 2 weeks, known psychiatric or neurocognitive impairment, head trauma, or sinonasal OD. We also excluded pregnant women and patients who had undergone nasal surgery.

We assessed a second group of participants with self-reported OD (age, ≥18 years). The inclusion criterion was loss of smell (visual analog scale [VAS], ≥30 mm).

All patients provided their signed informed consent to permit use of their data for scientific purposes. The study was approved by the Ethics Committee of our institution (HCB-2015-0076).

Testing Procedure

All the volunteers were tested individually in a well-ventilated room with controlled humidity and temperature (21-23ºC). They were tested simultaneously in both nostrils, first with the 8-Odorant Barcelona Olfactory Test (BOT-8) to assess smell detection, recognition/memory, and forced-choice identification. The smell threshold was assessed using rose (phenylethyl alcohol). The total time taken to perform the test was measured (Figure 1A). To compare the results of our smell test with a previously validated and standardized smell identification test, all healthy volunteers were also tested using

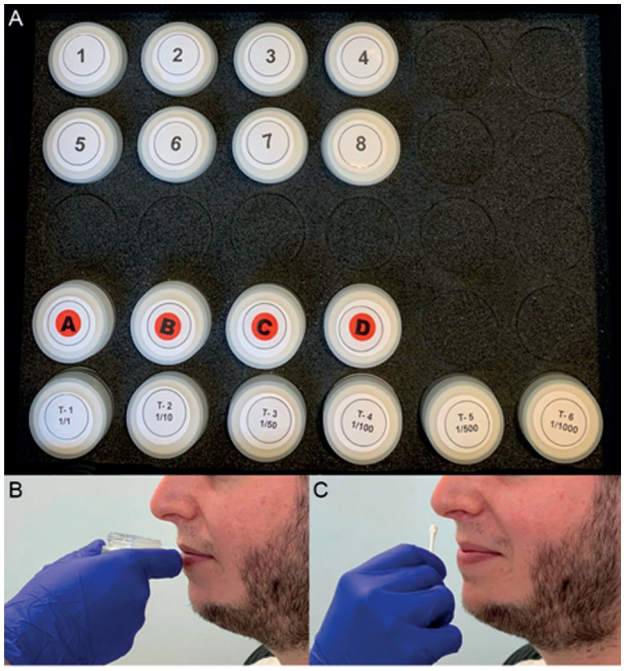

Figure 1. 8-Odorant Barcelona Olfactory Test (BOT-8). A, The kit includes 8 odorants (1, banana; 2, chocolate; 3, lemon; 4, rose; 5, coffee; 6, onion; 7, mint; 8, vinegar) and 6 rose threshold odor concentrations (T1-T6). B and C, Application of the BOT-8 with the original glass jar and with a disposable cotton swab.

the Smell Diskettes Olfaction test (SDOT) [14], and all cases with self-reported OD were compared using the University of Pennsylvania Smell Identification Test (UPSIT) to define cut-off points for hyposmia and anosmia.

A smell VAS (with 0 mm representing no loss and 100 mm maximum loss) was administered and nasal endoscopy performed to evaluate septal deviation and turbinate hypertrophy and rule out the presence of nasal polyps in healthy controls.

A subgroup of 30 healthy adults were tested in 2 separate sessions with a 2-week interval to evaluate the test-retest reliability of BOT-8.

Considering the current situation of the SARS-CoV-2 outbreak and the safety limitations with respect to multiuse smell tests, a subgroup of 20 healthy adults were tested using disposable cotton swabs with odorants to evaluate agreement between the swab and the routine smell test (BOT-8) in order to favor single-use material during the COVID-19 pandemic, as recommended in guidelines [15] (Figure 1, B and C).

Barcelona Olfactory Test (BOT-8)

The BOT-8 is a supraliminal orthonasal subjective olfactometry test. The different odors were presented in random order using semi–solid-state odorants contained in glass jars and placed about 3 cm below the nostrils for 3-5 seconds, with a latency of 30 seconds between each smell. The 8 odorants (banana, chocolate, lemon, rose, coffee, onion, mint, and vinegar [Table 1]) were selected after analysis by an expert consultant based on international guidelines and the previously validated Barcelona Smell Test 24 (BAST-24).

Participants were asked to answer Yes or No to the following questions: (*1*) Can you smell anything? (detection); (*2*) Do you remember having smelt it before? (memory/recognition); and (*3*) Which of these 4 odorants is correct? (forced-choice identification).

Table 1. Odorants Selected for the BOT-8 Identification Test With Their Chemical Compounds and Descriptors Used for the Forced-Choice Task

No.	Odorant	Chemical compound	From pure essence, %	Descriptors
1	Banana	Isoamyl acetate	15	Vanilla, sausage, chicken
2	Chocolate	Pyrazines	5	Tangerine, pineapple, soap
3	Lemon	Citral	15	Cheese, popcorn, fish
4	Rose	Phenethyl alcohol	15	Apple, honey, cookies
5	Coffee	Furans, pyrazines	5	Coconut, mustard, cherry
6	Onion	Dipropyl disulfide	10	Cinnamon, strawberry, ham
7	Mint	Menthol	15	Tomato, peach, gasoline
8	Vinegar	Acetic acid	5	Smoke, ammonia, orange

Abbreviation: BOT-8, 8-Odorant Barcelona Olfactory Test.

The score was calculated independently for detection, memory, and identification as an absolute value and percentage, with 8/8 (100%) being the maximum score.

Smell is assessed based on detection, identification, and threshold. In this test, as in the BAST-24, the recognition/memory item was added, since we consider that smell has a cultural component and requires prior exposure to the odorant. Therefore, when asking patients if they have ever smelled it, we first know if they have been previously exposed to that odorant. It also tells us about the patient's olfactory memory.

Rose (Phenylethyl Alcohol) Threshold Test

Six geometric dilutions were presented in glass jars placed 3 cm below the nostrils. The lowest dilution was presented first (1/1000) and progressively increased (1/500, 1/100, 1/50, 1/10, and 1/1 corresponding 15% from the pure essence) until the patient could detect the smell. The scale was reversed to lower concentrations when the odor was correctly identified in 2 successive tests, or towards higher concentrations when the odor was not recognized. The threshold was defined as the mean of the last 2 scale reversals [16].

Smell Diskettes Olfaction Test

Our objective was to validate our test in a healthy population against a screening test capable of identifying normality from abnormality. To do so, we used the Smell Diskettes Olfaction Test (SDOT) test.

SDOT is composed of 8 odorants (coffee, vanilla, peach, smoke, orange, rose, chocolate, and vinegar), which are applied using reusable diskettes as odor applicators. These floppy disks are made of polyester and measure 5 × 6 cm and can be opened to release odors and closed after testing.

The test is based on a triple-forced multiple choice (0 to 8 correct answers). Normal scores are defined as 6.2 (1.0) for the age group 18-50 years and 6.0 (0.9) for the age group 51-50 years.

University of Pennsylvania Smell Identification Test

We used the University of Pennsylvania Smell Identification Test (UPSIT) test to be able to determine our cut-off points for hyposmia and anosmia in the affected population.

UPSIT is a self-administered olfactory identification test comprising 40 items (available in Spanish). It provides an absolute indication of loss of smell (anosmia; mild, moderate, or severe hyposmia), as well as a relative indication based on percentiles related to age and sex, with a test-retest r of 0.94.

In order to compare it with our test, which comprises 8 odorants, we reduced the UPSIT classification to 3 categories: anosmia, hyposmia (including mild, moderate, and severe categories), and normosmia.

Statistical Analysis

Frequency and mean (SD) were calculated for the demographic and clinical characteristics of the participants. We performed an independent-sample *t* test to compare means between the sexes, and a Pearson correlation analysis was used to analyze the correlation between smell outcomes and age.

Agreement between BOT-8 and the cotton swab was determined using the weighted κ statistic, as described by Cohen [17]. The maximum κ statistic is 1.00, which indicates perfect agreement, with 0 indicating no agreement. We assessed the weighted κ statistic for strength of agreement using the guidelines of Fleiss et al [18]. Poor agreement was <0.40, good agreement was 0.40 to 0.75, and excellent agreement was ≥0.76.

The Pearson correlation was calculated between the BOT-8 items and the VAS, UPSIT, and SDOT scores. ("poor" is less than 0.3, "fair" is 0.3 to 0.5, "moderately strong" is 0.6 to 0.8, and "very strong" is >0.8) [19].

The Cronbach α coefficient was calculated to determine the reliability of BOT-8 (the Cronbach α coefficient should have a minimum value of 0.7 for preliminary research) [20]. The test-retest reliability was assessed using the Cohen weighted κ coefficient for ordinal scales.

The performance of BOT-8 was assessed based on sensitivity, specificity, and positive and negative predictive values. The cut-off point for anosmia was set at ≤18 for UPSIT. A receiver operating characteristic curve was constructed for the BOT-8 cut-off point.

Data were managed and the statistical analysis was performed using IBM SPSS Statistics for Windows, Version 21 (IBM Corp., Armonk, NY, USA) with the α level set at 0.05.

Table 2. Demographics and Clinical Characteristics of the Controls (Healthy Volunteers) and Cases (Self-Reported Olfactory Dysfunction)

Characteristics	Controls	Cases
Mean (SD) age, y	47.7 (18.3)	51.0 (16.8)
Female sex, No. (%)	57 (47.5)	107 (54.9)
Smoking history, No. (%)		
– Current/Past	41 (34.2)	32 (16.6)
– Never	79 (65.8)	161 (83.4)
Septal deviation, No. (%)	83 (69.2)	64 (34.0)
Inferior turbinate hypertrophy, No. (%)	21 (17.5)	47 (25.0)

Results

Demographics

The first group comprised 120 healthy volunteers whose mean (SD) age was 47.7 (18.3 [range, 18-89]) years. Of these, 57 (47.5%) were women (age, 47.1 [18.1] years; range, 21-89) and 63 (52.5%) were men (age, 48.2 [18.6] years; range, 18-87).

The second group comprised 195 patients with self-reported OD. The mean age was 51.0 years (16.8). Of these, 107 (54.9%) were women (49.2 [16.6] years; range, 23-86), and 88 (45.1%) were men (53.5 [16.8] years; range, 18-86).

The demographics and clinical characteristics of the cohort are presented in Table 2.

BOT-8

Among the healthy volunteers, the detection score was 100%, the memory/recognition score 37.5%-100% (mean, 94.5% [13.4%]), and the identification score 62.5%-100% (mean, 89.6% [10.8]). Women outperformed men in the memory/recognition and identification scores. The most frequently identified smell was lemon (n=119, 99.2%), followed by mint (n=118, 98.3%), and the least frequently identified was coffee (n=96, 80%). The mean rose (phenylethyl alcohol) threshold test score was between 2 (1/10 dilution) and 6 (1/1000 dilution) (mean, 4.14 [0.80]). The BOT-8 examination time was 3 to 18 minutes (mean, 6.6 [2.8]). Olfactory test scores in healthy volunteers are summarized in Table 3.

The Pearson correlation between smell identification and age, together with the same analysis by memory score, showed no significant differences (r=–0.17, P=0.062 and r=–0.10, P=0.26, respectively) (Figure 2).

In patients with OD, the mean BOT-8 detection score was 86.0% (32.8), the memory/recognition score was 73.2% (37.9), and the identification score was 77.1% (34.2). Mean examination time was 3.6 minutes (2.4). No differences were found between the sexes in detection, memory, or identification. The mean rose threshold test score was 3.1 (1.9). Olfactory test scores in OD patients are summarized in Table 4.

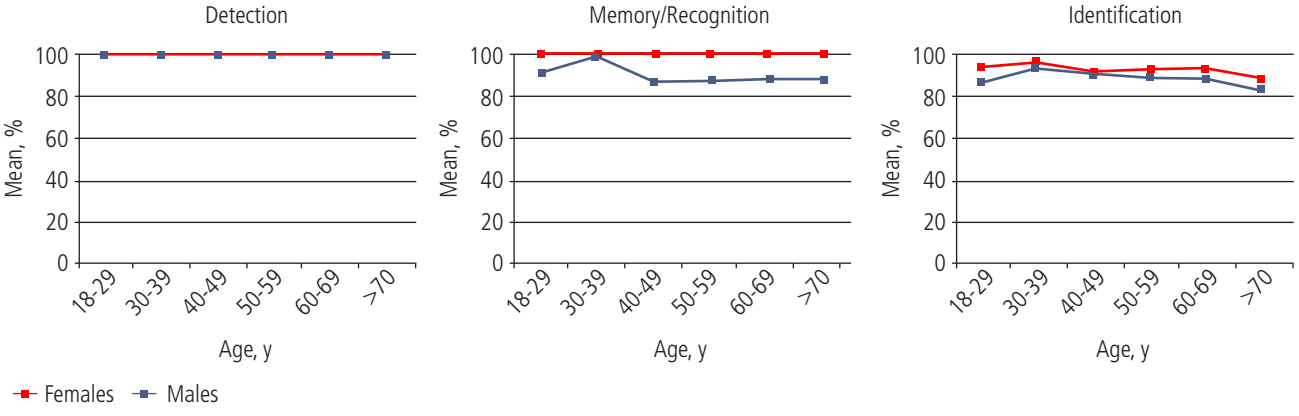

Figure 2. 8-Odorant Barcelona Olfactory Test. Smell detection, memory/recognition, and identification by sex (females vs males) and by age group.

Table 3. Olfactory Test Scores in Healthy Volunteers by Sex[a]

Characteristics	Total (N=120)	Men (N=63)	Women (N=57)	*P* Value[b]
BOT-8				
– Detection	8.0 (0)	8.0 (0)	8.0 (0)	
– Memory	7.6 (1.1)	7.2 (1.4)	8.0 (0.1)	<.001
– Identification	7.2 (0.9)	7.0 (0.9)	7.4 (0.8)	.032
Rose threshold test	4.1 (0.8)	4.2 (0.9)	4.1 (0.7)	.481
BOT-8 time, min	6.6 (2.9)	7.1 (3.2)	6.1 (2.3)	.050
SDOT (Identification)	7.0 (0.1)	7.0 (0.1)	7.1 (0.1)	.337
VAS 0-100 mm for smell loss	14.5 (14.9)	17.4 (15.5)	11.4 (13.6)	.043

Abbreviations: BOT-8, 8-Odorant Barcelona Olfactory Test; SDOT, Smell Diskettes Olfaction Test; VAS, visual analog scale.
[a]Values are expressed as mean (SD).
[b]*P* value for mean difference (men - women).

Table 4. Olfactory Test Scores in Patients With Self-Reported Olfactory Dysfunction by Sex[a]

Characteristics	Total (N=195)	Men (N=88)	Women (N=107)	*P* Value[b]
BOT-8				
– Detection	6.9 (2.6)	6.9 (2.6)	6.9 (2.7)	.920
– Memory	5.9 (3.0)	6.0 (3.0)	5.8 (3.1)	.649
– Identification	6.2 (2.7)	6.0 (2.8)	6.3 (2.7)	.399
Rose threshold test	3.1 (1.9)	3.1 (1.8)	3.2 (2.0)	.774
BOT-8 time, min	3.6 (2.4)	3.2 (1.4)	3.9 (3.0)	.061
UPSIT	22.7 (9.3)	21.5 (9.1)	23.7 (9.3)	.108
VAS 0-100 mm for smell loss	77.0 (3.1)	76.4 (4.3)	77.6 (4.7)	.852

Abbreviations: BOT-8, 8-Odorant Barcelona Olfactory Test; SDOT, Smell Diskettes Olfaction Test; VAS, visual analog scale.
[a]Values are expressed as mean (SD).
[b]*P* value for mean difference (men - women).

The Pearson correlation between smell detection and age was significant for memory/recognition and identification: r=–0.18 (95%CI, –0.31 to 0.04; *P*=.013) and r=–0.19 (95%CI, –0.32 to –0.05, *P*=.008), respectively. No significant correlation was found for detection: r=–0.07 (95%CI, –0.22 to 0.06, *P*=.28).

Reliability (Test-Retest)

The Cronbach α coefficient was 0.837. BOT-8 test-retest reliability demonstrated excellent agreement with a weighted κ statistic of 0.84 and 96.7% observed agreement (95%CI, 0.67-0.99; *P*<.001) (Figure 3).

Agreement Between BOT-8 and Single-use Cotton Swabs

The quadratic κ correlation between disposable swabs and BOT-8 identification was assessed, yielding 98.75% observed agreement and κ=0.79 (95%CI, 0.78-0.81).

VAS Score

In healthy volunteers, the mean VAS score for smell loss was 11.4 (13.6) in women and 17.4 (15.5) in men. The Pearson correlation between the BOT-8 total score for identification and memory/recognition and the VAS was poor (r=–0.086 [*P*=.352] and r=–0.115 [*P*=.210], respectively).

In patients with OD, a significant Pearson correlation was found between the VAS and detection, identification, and memory in BOT-8 (detection, r=–0.73 [95%CI, –0.79 to –0.655], *P*<.001; memory/recognition, –0.79 [95%CI, –0.84 to –0.73], *P*<.001; and identification –0.86 [95%CI, –0.89 to –0.82], *P*<.001).

Correlation Between BOT-8 and Olfactory Tests

In healthy volunteers, the mean SDOT score was 7.0 (0.1) and the BOT-8 identification score was 7.17 (0.9) (Table 3). The Pearson correlation between the BOT-8 identification score and SDOT was strong (r=0.673, *P*<.001).

In patients with OD, the mean UPSIT score was 22.8 (9.3) and the BOT-8 identification score was 6.2 (2.7) (Table 4). The Pearson correlation coefficient between BOT-8 identification and UPSIT was 0.86 (95%CI, 0.82-0.89) (*P*<.001).

Contingency Table for Anosmia and Receiver Operator Characteristic Curve

In OD patients, the UPSIT score was categorized as normal or abnormal following the ≤18 cut point for anosmia. Using this value, a receiver operating characteristic curve was

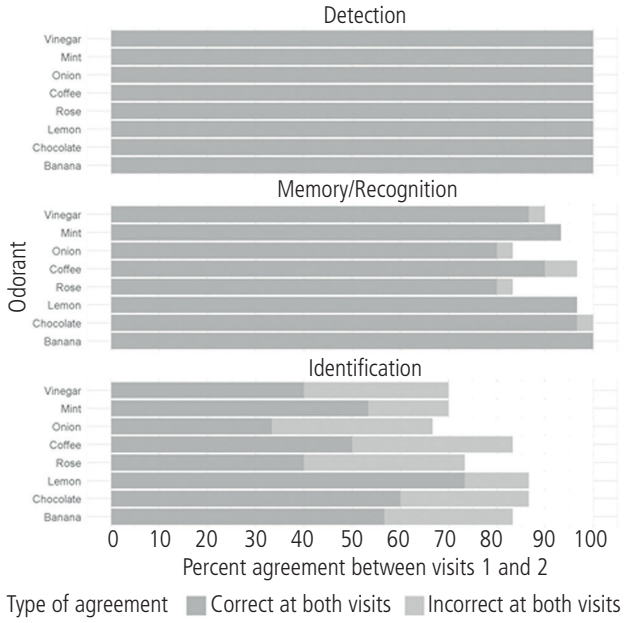

Figure 3. Percent agreement in test-retest for correct identification of each odorant included in the 8-Odorant Barcelona Olfactory Test for detection, memory/recognition, and identification. Shading indicates types of agreement present (correct determination at both visits vs incorrect determination at both visits).

plotted (Figure 4). The area under the curve (AUC) was 0.833 (95%CI, 0.762-0.904). Acceptable sensitivity and excellent specificity for anosmia was defined as ≤3 in BOT-8 (sensitivity, 0.673 [95%CI, 0.546-0.801]; specificity, 0.993 [95%CI, 0.979-1.000]). The positive likelihood ratio and the negative likelihood ratio were 0.972 (95%CI, 0.919-1.000) and 0.893 (95%CI, 0.845-0.941), respectively (Table 5).

The same analysis for the hyposmia cut point revealed an AUC of 0.451 (95%CI, 0.377-0.524). Sensitivity was 0.088 (95%CI, 0.041-0.136) and specificity 0.814 (95%CI, 0.714-0.913). The positive likelihood ratio and the negative likelihood ratio were 0.522 (95%CI, 0.318-0.726) and 0.279 (95%CI, 0.212-0.346), respectively.

Discussion

In the present study, we developed and validated a supraliminal orthonasal olfactory test for adults. The advantages of the BOT-8 smell test are the short time needed for application (around 3 to 6 minutes) and the fact that it is easy-to perform and reusable. Recently, the pediatric Barcelona Olfactory Test-6 (pBOT-6), which includes an identification and threshold test and was validated for Spanish children, demonstrated high sensitivity and specificity for detecting hyposmia [21].

We recorded a Cronbach α coefficient of 0.837, which indicates good internal consistency and excellent agreement in test-retest reliability. Moreover, the correlation coefficient was good when compared with the SDOT test (r=0.67) and very good when compared with UPSIT (r=0.86) in patients with OD. The BOT-8 identification score of ≤3 demonstrated acceptable sensitivity and excellent specificity for anosmia (0.673 and 0.993, respectively).

The COVID-19 pandemic has highlighted the importance of validating the test safely for patients and health professionals. Application of cotton swabs with the odorant yielded excellent agreement, thus showing the test to be safe. We encourage application of disposable swabs and single-use tests, as recommended in guidelines [8]. Using this approach as an alternative when evaluating patients is less expensive than the single-use tests and safer in viral pandemic situations.

A recent meta-analysis by Wang et al [22] concluded that females outperformed males among young adults aged 18 to 50 years [23]. The OLFACAT survey revealed a similar result for all age groups in the Catalan population [15]. In our cohort, healthy females scored slightly better, with better olfactory outcomes than males. No differences in sex were found in the case of patients with OD.

We found higher identification scores in younger participants than in older ones. However, this tendency did not reach statistical significance in healthy volunteers (*P*=.06); in our opinion, the tendency would have been significant in a larger sample. We recorded higher identification and memory/recognition scores in younger patients (*P*=.013 and *P*=.008, respectively).

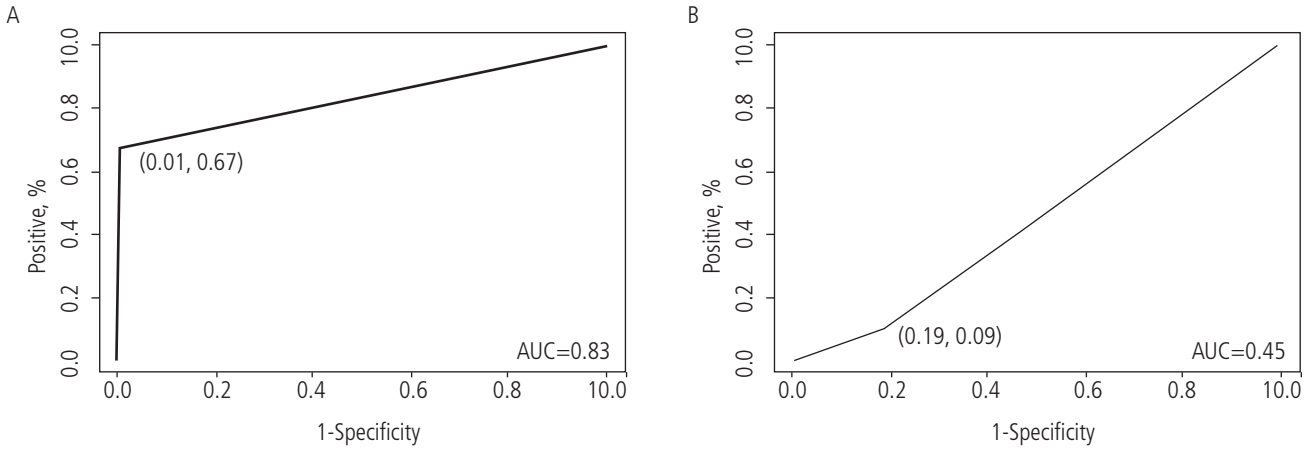

Figure 4. Receiver operator characteristic curve for anosmia (A) and hyposmia (B). AUC indicates area under the curve.

Table 5. Contingency Table for Patients With Olfactory Dysfunction[a]

BOT-8	UPSIT		Total, No.	
	Normal	Abnormal		
Unimpaired	142	17	159	NPV=0.893 (95%CI, 0.845-0.941)
Impaired	1	35	36	PPV=0.972 (95%CI, 0.919-1.000)
Total, No.	143	52	195	
	Sp = 0.993 (95%CI, 0.979-1.000)	Se = 0.673 (95%CI, 0.546-0.801)		

Abbreviations: BOT-8, 8-Odorant Barcelona Olfactory Test; NPV, negative predictive value; PPV, positive predictive value; Se, Sensitivity; Sp, specificity; UPSIT, University of Pennsylvania Smell Identification Test.
[a]UPSIT abnormal, ≤18, BOT-8 impaired, ≤3.

We found a poor correlation between the VAS and BOT-8 scores in healthy volunteers. Similar results were obtained by Zou et al [24], who reported that subjective ratings of olfactory function are overshadowed by many different aspects, such as motivation to seek counseling for loss of smell or coping with this situation. In contrast, in patients with OD, the VAS score correlated very well with scores for detection, identification, and memory/recognition in BOT-8.

The low reliability of self-reported olfactory function (eg, based on a VAS) and the numerous difficulties associated with the actual tests in daily practice (time-consuming, expensive, and mostly not reusable) reveal the need for more cost-effective OD tests. The BAST-24 is a validated Spanish cross-cultural smell test [25], whose main disadvantage is the long completion time (20-40 minutes). The UPSIT [26] is a validated single-use test applied throughout the world, with the considerable advantage that it can be self-administered, although it also has a high cost per test. Sniffin' sticks [27], which is also applied worldwide, is reusable and affordable, although it is not disposable or single-use. In addition, transmission of COVID-19 by fomites continues to be a controversial issue [28].

The cost of commercially available tests for assessment of OD precludes their widespread use in clinical practice [29]. The need for more cost-effective tools in this area makes BOT-8 a good option owing to its fast application, reasonable cost per kit, and the fact that it can be reused with or without disposable cotton swabs over its 1-year lifetime.

Our study is subject to a series of limitations. We applied the test exclusively in Spanish patients and did not compare the performance of the test on patients from other cultures. Therefore, we recommend that the test be validated in other cultures. Furthermore, the test we chose for validation in the healthy population is not among the most widely used in the current literature and discriminates only between abnormality and normality. Therefore, in order to define cut-off points for hyposmia and anosmia, we used the UPSIT, which does have cut-off points for hyposmia and anosmia and has been validated in the Spanish population [26].

Conclusions

BOT-8 is an efficient, fast, and easy-to-perform method for assessing smell threshold, detection, recognition/memory, and identification in adults in clinical practice. The test correlated very well with validated smell tests and showed high agreement in test-retest reliability. In the setting of the COVID-19 pandemic, disposable cotton swabs showed high agreement with the original test and proved to be a safe and economic alternative to self-administered single-use smell tests. Therefore, we propose our test as a useful screening tool for OD in Spanish patients and one that can be used not only by ENT specialists, but also by allergists, chest physicians, internists, and general practitioners.

Acknowledgments

We are grateful to Eduard Hermosilla and Johanna Caro for their help with the statistical analysis.

Funding

The authors declare that no funding was received for the present study.

Conflicts of Interest

- Isam Alobid: Consultant for Roche, Novartis, GlaxoSmithKline, Viatris, Menarini, MSD, and Salvat.
- Joaquim Mullol: member of national or international advisory boards. JM has received speaker fees and funding for clinical trials and research projects from ALK, AstraZeneca, Genentech, GlaxoSmithKline, Glenmark, Menarini, Mitsubishi-Tanabe, MSD, Mylan-MEDA Pharma, Novartis, Regeneron Pharmaceuticals, SANOFI-Genzyme, UCB Pharma, and Uriach Group.

The remaining authors declare that they have no conflicts of interest.

References

1. Hummel T, Landis BN, Hüttenbrink K-B. Smell and taste disorders. GMS Curr Top Otorhinolaryngol Head Neck Surg. 2011;10:Doc04.
2. Hummel T, Whitcroft KL, Andrews P, Altundag A, Cinghi C, Costanzo RM, et al. Position paper on olfactory dysfunction. Rhinol Suppl. 2017;54(26):1-30.

3. Villwock JA, Li J, Moore C, Chiu AG, Sykes KJ. Affordable Rapid Olfaction Measurement Array: A Novel, Essential Oil-Based Test Strongly Correlated with UPSIT and Subjective Outcome Measures. Ann Otol Rhinol Laryngol. 2020;129(1):39-45.
4. Mullol J, Mariño-Sánchez F, Valls M, Alobid I, Marin C. The sense of smell in chronic rhinosinusitis. J Allergy Clin Immunol. 2020;145(3):773-6.
5. Marin C, Langdon C, Alobid I, Mullol J. Olfactory Dysfunction in Traumatic Brain Injury: the Role of Neurogenesis. Curr Allergy Asthma Rep. 2020;20(10):55.
6. Langdon C, Alobid I, Quintó L, Valero A, Picado C, Marin C, et al. Self-perception of olfactory dysfunction is associated with history of Traumatic Brain Injury: post-hoc analysis from the OLFACAT survey. Rhinology. 2019;57(6):460-8.
7. Marin C, Vilas D, Langdon C, Alobid I, López-Chacón M, Haehner A, et al. Olfactory Dysfunction in Neurodegenerative Diseases. Curr Allergy Asthma Rep. 2018;18(8):42.
8. Noel J, Habib A-RR, Thamboo A, Patel ZM. Variables associated with olfactory disorders in adults: a U.S. population- based analysis. World J Otorhinolaryngol - Head Neck Surg. 2017;3(1):9-16.
9. Mullol J, Alobid I, Mariño-Sánchez F, Quintó L, de Haro J, Bernal-Sprekelsen M, et al. Furthering the understanding of olfaction, prevalence of loss of smell and risk factors: a population-based survey (OLFACAT study). BMJ Open. 2012;2(6):e001256.
10. Croy I, Nordin S, Hummel T. Olfactory disorders and quality of life: an updated review. Chem Senses. 2014;39(3):185-94.
11. Sorokowska A, Oleszkiewicz A, Minovi A, Konnerth CG, Hummel T. Fast Screening of Olfactory Function Using the Q-Sticks Test. ORL J Otorhinolaryngol Relat Spec. 2019;81(5-6):245-51.
12. Mullol J, Alobid I, Mariño-Sánchez F, Izquierdo-Domínguez A, Marin C, Klimek L, et al. The Loss of Smell and Taste in the COVID-19 Outbreak: a Tale of Many Countries. Curr Allergy Asthma Rep. 2020;20(10):61.
13. Izquierdo-Dominguez A, Rojas-Lechuga MJ, Mullol J, Alobid I. Olfactory Dysfunction in the COVID-19 Outbreak. J Investig Allergol Clin Immunol. 2020;30(5):317-26.
14. Briner HR, Simmen D. Smell diskettes as screening test of olfaction. Rhinology. 1999;37(4):145-8.
15. Olaguibel JM, Alobid I, Alvarez Puebla M, Crespo-Lessmann A, Domínguez Ortega J, García-Rio F, et al. Functional Examination of the Upper and Lower Airways in Asthma and Respiratory Allergic Diseases: Considerations in the Post-SARS-CoV-2 Era. J Investig Allergol Clin Immunol. 2021;31:17-35.
16. Pierce JD Jr, Doty RL, Amoore JE. Analysis of position of trial sequence and type of diluent on the detection threshold for phenyl ethyl alcohol using a single staircase method. Percept Mot Skills. 1996;82(2):451-8.
17. Cohen J. Weighted: nominal scale agreement with provision for scaled disagreement or partial credit. Psychol Bull. 1968;70(4):213-20.
18. Fleiss JL, Levin B, Paik MC. Statistical Methods for Rates and Proportions. 3rd ed. Hoboken, NJ: John Wiley & Sons; 2003.
19. Chan YH. Biostatistics 104: correlational analysis. Singapore Med J. 2003;44(12):614-9.
20. Nunnally J. Psychometric Methods. New York, NY: McGraw-Hill; 1978.
21. Mariño-Sánchez F, Valls-Mateus M, Fragola C, de Los Santos G, Aguirre A, Alonso J, et al. Pediatric Barcelona Olfactory Test–6 (pBOT-6): Validation of a Combined Odor Identification and Threshold Screening Test in Healthy Spanish Children and Adolescents. J Investig Allergol Clin Immunol. 2020;30(6):439-47.
22. Wang X, Zhang C, Xia X, Yang Y, Zhou C. Effect of gender on odor identification at different life stages: a meta-analysis. Rhinology. 2019;57(5):322-30.
23. Oleszkiewicz A, Schriever VA, Croy I, Hähner A, Hummel T. Updated Sniffin' Sticks normative data based on an extended sample of 9139 subjects. Eur Arch Otorhinolaryngol. 2019;276(3):719-28.
24. Zou LQ, Linden L, Cuevas M, Metasch ML, Welge-Lüssen A, Hähner A, et al. Self-reported mini olfactory questionnaire (Self-MOQ): A simple and useful measurement for the screening of olfactory dysfunction. Laryngoscope. 2020;130(12):E786-E790.
25. Cardesín A, Alobid I, Benítez P, Sierra E, de Haro J, Bernal-Sprekelsen M, et al. Barcelona Smell Test - 24 (BAST-24): validation and smell characteristics in the healthy Spanish population. Rhinology. 2006;44:83-9.
26. Doty RL, Frye RE, Agrawal U. Internal consistency reliability of the fractionated and whole University of Pennsylvania Smell Identification Test. Percept Psychophys. 1989;45(5):381-4.
27. Kobal G, Hummel T, Sekinger B, Barz S, Roscher S, Wolf S. "Sniffin' sticks": screening of olfactory performance. Rhinology. 1996;34(4):222-6.
28. SARS-CoV-2 and Surface (Fomite) Transmission for Indoor Community Environments. Centers for Disease Control and Prevention (CDC). https://www.cdc.gov/coronavirus/2019-ncov/more/science-and-research/surface-transmission.html. Accessed 12 April 2021.
29. Patel ZM, Wise SK, DelGaudio JM. Randomized controlled trial demonstrating cost-effective method of olfactory training in clinical practice: essential oils at uncontrolled concentration. Laryngoscope Investig Otolaryngol. 2017;2(2):53-6.

Manuscript received May 28, 2021; accepted for publication May 6, 2022.

Isam Alobid
Joaquim Mullol

Rhinology and Skull Base Unit
ENT Department, Hospital Clinic
C/ Villarroel, 170
08035 Barcelona, Spain
E-mail: isamalobid@gmail.com
jmullol@clinic.cat