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Barcelona Smell Test - 24 (BAST-24): validation and smell characteristics in the healthy Spanish population*

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SUMMARY

***Objectives**: Smell tests for clinical use have been developed in different countries, but no single test has gained general acceptance. The objectives of the study were to evaluate the smell outcomes in a Spanish population.*

***Methods**: A prospective study on healthy volunteers (n = 120) without olfactory disturbances was performed. The volunteers were differentiated by gender, age, and smoking habit groups. We used a new olfactory test, the Barcelona Smell Test 24 (BAST-24) that consists of 24 odours scoring smell detection, identification, and forced choice.*

***Results**: Volunteers showed the highest scores on smell detection for both 1st (99%) and 5th cranial nerve (98%) odours. Spontaneous smell identification (54.7% and 59.3%) and forced choice (72.2% and 42.6%) scores were lower than those of smell detection, for both 1st and 5th cranial nerves respectively. On smell identification, volunteers scored higher in the left than in the right nostril. Females had better smell identification for both 1st and 5th cranial nerves (62.8%, 66.7%) than males (50.3%, 58.8%). Non-smokers had higher scores (65%) than smokers (59%) on smell identification for the 5th CN.*

***Conclusions**: For smell identification, females, non-smokers, and left nostril had higher scores than males, smokers, and right nostril respectively. BAST-24 is a good and reliable method to test the olfactory function in the clinical practice.*

Key words: Barcelona smell test 24 (BAST-24), laterality, age, gender, smoking

INTRODUCTION

Advances in the technology of psychophysical measurement and the proliferation of easy-to-use tests to measure the olfactory function have increased our understanding of the sense of smell in humans, including the functional influencing factors such as age, gender, exposure to toxic agents, and various rhinologic and neurodegenerative diseases, including Alzheimer's and Parkinson's disease [1].

Smell and taste problems result in more than 200.000 visits to physicians annually in the United States, affecting 1% to 2% of the general population [2]. One of the important research issues has been to establish whether increased sensory problems, or/and cognitive changes, cause the observed age-related deficits in odour recognition, memory and identification [3].

Until today, no single test has gained general acceptance in the clinical routine. Among the reasons for the lack of an universal test we may find the use of specialized materials, associated costs, lack of standardization and poor reproducibility of the results. Thus, those tests are still limited to specialized chemosensory smell and taste clinics.

Odour-identification tests for clinical use have been developed in different countries. The Pennsylvania Smell Identification Test (UPSIT) [4] and the Connecticut Chemosensory Clinical Research Center identification test (CCCRC) [5] have been developed in the USA, while the sniffin' sticks tests [6] and the Smell Diskettes Test [7] have been used in Europe. However, the nature of odour identification, closely related to familiar aromatic items, usually limits the use of olfactory tests to the country of region where they have been developed and validated.

The Barcelona Smell test-24 (BAST-24) is a new olfactory test which reproducibility and validation has been studied in the healthy, Spanish population. The objectives of the study using the BAST-24 were: first, to evaluate the smell outcomes in a Spanish population differentiated by age groups, gender, and smoke habit; second, to determine the difference between smell characteristics when tested in both nostrils apart or simultaneously; and third, to assess the reproducibility and validation of the test.

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Table 1. Epidemiologic data of the study population.

	n	Males	Females	Mean age
Volunteers	120	60	60	42 ± 1.7
Smokers	50	28	22	38 ± 2.1
Non smokers	70	32	38	45 ± 2.4

MATERIALS AND METHODS

Study population

One hundred twenty healthy volunteers without subjective olfactory disturbances were included in the study from January 2001 to February 2003. The study population constituted of 60 males and 60 females with a mean age of 42 ± 1.7 years (ranging from 15 to 85 years) with subjective normal sense of smell (Table I). The study was performed in the Rhinology Unit (ENT Department, Hospital Clinic, Barcelona, Spain). Approval for this study was obtained from the Ethic's Committee of our institution and a signed informed consent was obtained from all volunteers.

Inclusion and exclusion criteria

All subjects were healthy, community volunteers of middle socioeconomic class. Individuals with neurodegenerative disorders such as Alzheimer and Parkinson diseases, and nasal disorders such as polyps, chronic rhinosinusitis, or allergic rhinitis were excluded from the study.

Study Design

Half of the volunteers (n=60) were tested for smell on both nostrils apart while the other half (n=60) were tested simultaneously at both sides. When the smell test was performed on both nostrils, smell outcomes from the best nostril were used for further statistical evaluation. Volunteers were differentiated in 6 different age groups (10 males, 10 females): group A, up to 20 years old; group B, from 21 to 30 years old; group C, from 31 to 40 years old; group D, from 41 to 50 years old; group E, from 51 to 60 years old; and group F, older than 60 years old.

To compare the results of our smell test with an already validated and standardized smell screening method, all volunteers (n=120) were also tested using the Smell Diskette Test [7].

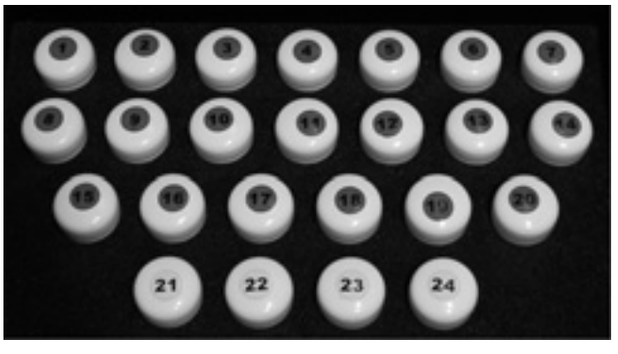

Figure 1. The Barcelona Smell Test (BAST-24). Odours are located in a solid base in hermetic numbered boxes: there are 20 odours to test the 1st cranial nerve (olfactory nerve) and 4 odours to test the 5th cranial nerve (trigeminal nerve).

Subjective Olfactometry

1. BAST-24 (Figure 1). Twenty-four chemical compounds (odorants) were selected for inclusion in the BAST-24: a) 20 odours to assess the 1st cranial nerve (1st CN, olfactory): banana, gasoline, lemon, rose, onion, smoked, anise, coconut, vanilla, melon, mandarin, bitter almond, pineapple, cheese, strawberry, mushroom, eucalyptol, clove, turpentine, and peach; and b) 4 odours to asses the 5th cranial nerve (5th CN, trigeminal): formol, vinegar, ammonia, and mustard (Table II). Hermetic containers were designed to contain the different odorants, according to the recommendations of the Meeting of the German Society for Otorhinolaryngology [6]: 1) odorants producing little or no trigeminal excitation (lemon); 2) odorants producing a mixed but balanced stimulation of both the trigeminal and the olfactory nerve (eucalyptol); and 3) stimuli which would produce a strong trigeminal excitation (mustard).

The smell test was performed in a quiet, noise isolated, well-ventilated room, with controlled humidity and temperature (21-23°C). All the odorants were located in hermetic glass jars. The explorer and volunteers did not wear perfumes, lotions, and creams the day of examination. The odorant jar should stay at 1 cm of the nose and with no contact with explorer's finger and patient's face. Monthly, the superficial material of each jar odour is removed to maintain freshness of the odorants and the smell box set is changed every 3 months.

A questionnaire similar to the one used in the National Geographic Smell Survey was used to evaluate the olfactory function [8]. After being exposed 5 seconds to each odour, volunteers were asked by the investigator to answer a number of questions: 1) to test smell detection: "did you smell something?"; 2) to test smell identification: "did you recognize this odour?"; and 3) to test smell forced choice: "which of this four odours did you smell?". The first two questions had two possible answers: yes (1) or no (0), while the third question had four forced multiple choice answers. The test was repeated for each of the 24 odours.

For all three smell characteristics, the total score was 0 to 20 (0-100%) for odours of the 1st cranial nerve and 0 to 4 (0-100%) for odours of the 5th cranial nerve. Approximately 20 minutes were needed to test the entire battery of odours. The time should be doubled when both nostrils were examined separately.

2. Smell Diskette Test

The smell test BAST-24 was compared with the Smell Diskette Test, a commercially available and validated smell test developed in 1999 in Zurich and widely used in the perfume and flavour industry as odorant applicators [7]. The test has eight polyester diskettes containing different odorants in a high suprathreshold concentration (coffee, vanilla, smoke, peach, pineapple, rose, coconut, and vinegar). The diskettes are opened to release the odour and closed when the test is done.

Table 2. Odorant characteristics used in the BAST-24 Olfactometry. First twenty odours for the 1st cranial nerve and last five odours for the 5th cranial nerve.

Odour number	Chemical component	Additives (concentration)	Odour
1	Anetol	PEG 400 (30%)	anise
2	Gamma Nonalactone	PEG 400 (10%)	coconut
3	Citral	PEG 400 (30%)	lemon
4	Ethiyl Vainilline	PEG 400(10%)	vanilla
5	Cade	PEG 400 (1%)	smoked
6	Cis-6-nonenal	PEG 400 (30%)	melon
7	Iso-amyl acetate	PEG 400 (10%)	banana
8	Mandarine oil	PEG 400 (25%)	mandarin
9	Benzaldehide	PEG 400 (10%)	bitter almoud
10	Benzen	PEG 400 (100%)	gasoline
11	Caproate of allyllo	PEG 400 (10%)	pineapple
12	Butiric acid	PEG 400 (10%)	cheese
13	Disulfuro of dipropyl	PEG 400 (1%)	onion
14	Pheniletilico alcohol	PEG 400 (10%)	rose
15	Aldehydo c-16	PEG 400 (10%)	strawberry
16	Champagnol	PEG 400 (1%)	mushroom
17	1-8-CINeol	PEG 400 (10%)	eucalyptol
18	Eugenol	PEG 400 (10%)	clave
19	Betapineno	PEG 400 (30%)	turpentine
20	Aldehydo c-14	PEG 400 (20%)	peach
21	Formol	PEG 400(10%)	fomol
22	Acetic acid	PEG 400(20%)	vinegar
23	NH4	PEG 400(10%)	ammonia
24	Mustard	No additives	mustard

PEG-Poly-ethylene-glycol

The test is self-administered and the answers are designed as a triple forced multiple choice test (image and name of odours), with a total detection and identification scores of 0 to 8.

Statistical analysis

Data analysis was performed with the statistical package SPSS 10.0 for Windows (SPSS Inc, Chicago, Ill). A p value of less than 0.05 was considered statistically significant. The data are presented as mean ± SEM (standard error of the mean). Unpaired Student's *t* test was used to compare smell characteristics between the right and left nostril, smoking, and gender. Pearson correlation coefficients were used to examine the association between smell characteristics and gender, age, and smoking. Kappa test was used to compare BAST 24 and Smell Diskette Test. Kappa statistic suppose we would like to compare two raters using a kappa statistic, but the raters have different range of scores. This situation most often presents itself where one of the raters did not use the same range of scores as the other rater. The reproducibility of BAST-24 and variability over time (at week 1, 2, and 4) was analysed in six volunteers using Cochran Q tests.

RESULTS

For the 1st CN odours, volunteers scored higher on smell detection (99.2%; $p<0.05$) than on identification (54.7%) and forced choice (72.2%). Scores for forced choice were higher than those for identification (Figure 2A). For the 5th CN odours, volunteers scored higher scores for smell detection (98.3%; $p<0.05$) than for identification (59.3%) and forced choice (42.6%). Scores for identification were higher than those for forced choice for the 5th CN (Figure 2B). There were no significant differences for detection between the 1st and 5th CN, but volunteers showed lower identification scores and higher forced choice for the 1st CN than for the 5th CN ($p<0.05$).

Scores of smell identification on the left side for both 1st CN (58.3%; $p<0.05$) and 5th CN (64.3%; $p<0.05$) were higher than on the right side (51% and 54.3%, respectively) (Figure 2A, B). There were no significant effects of nasal laterality on smell detection and smell forced choice for both 1st and 5th CN.

Females scored higher on smell identification (62.8%, 66.7%; $p<0.05$) than males (50.3%, 58.7%) for both 1st and 5th CN respectively (Figure 3A, B). Males and females scored similar on smell detection and forced choice.

No significant changes in smell detection for the 1st CN were observed when increasing the age in all 6 different increasing age groups of our study (Table 3). For smell identification, the group of ≤20 yr scored 48.2% of odours, reaching a maximum score at 21-30 yr (70.5%), and decreasing in the older groups of volunteers. For smell forced choice, the group of ≤20 yr scored 78% of odours, and no significant changes were observed when increasing the age group. No significant differences in smell detection for the 1st CN were observed between males and females along all age-stratified groups (Table 3). Smell identification scores in females were higher than in males in almost all age groups, reaching statistical difference in the group of 41-50 yr (72.5% versus 44%, $p<0.05$) and 51-60 yr (67% versus 36%,

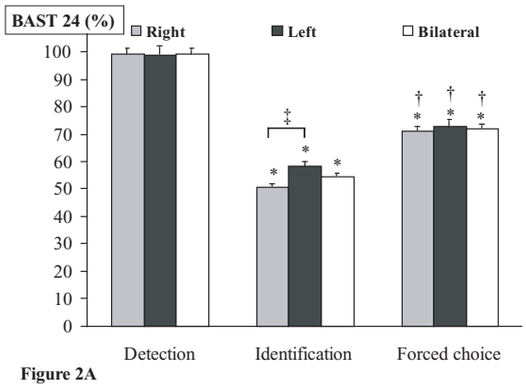

Figure 2A

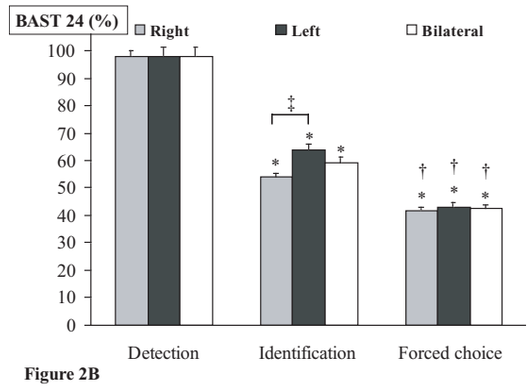

Figure 2B

Figure 2. The effect of nasal laterality on the sense of smell. Smell characteristics of odours corresponding to the 1st (A) and 5th (B) cranial nerves. * p<0.05, smell identification and forced choice compared to smell detection; † p<0.05, smell identification compared to forced choice; and p < 0.05, left nostril compared to right nostril.

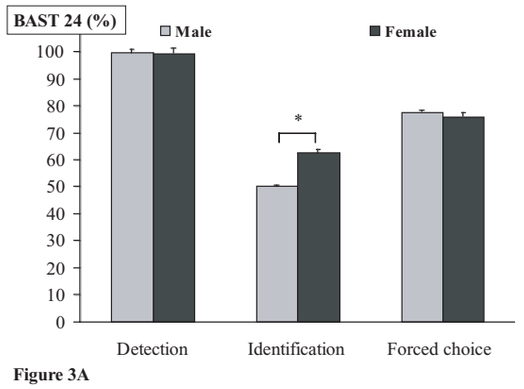

Figure 3A

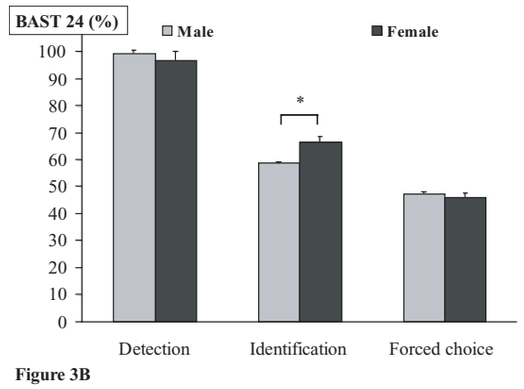

Figure 3B

Figure 3. The effect of gender on the sense of smell. Smell characteristics of odours corresponding to the 1st (A) and 5th (B) cranial nerves. * p<0.05, compared between male and female.

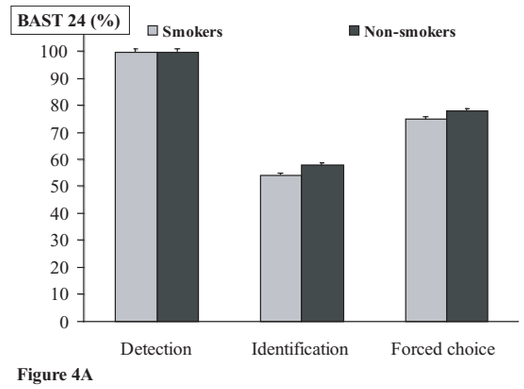

Figure 4A

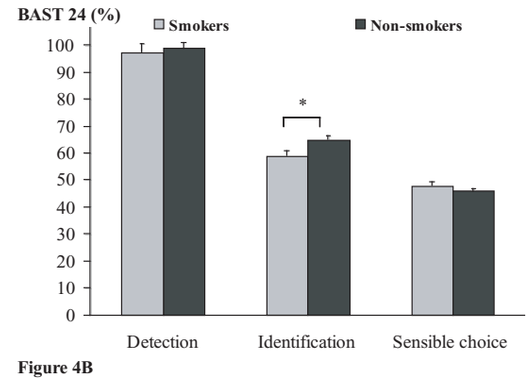

Figure 4B

Figure 4. The effect of the smoke habit on the sense of smell. Smell characteristics of odours corresponding to the 1st (A) and 5th (B) cranial nerves. * p<0.05, compared between smokers and non-smokers.

p<0.05). Smell forced choice scores in females were lower than in males for the three younger groups (from <20 to 40 yr), the difference being significant in the groups of ≤20 yr (69.5% versus 86.5%, p<0.05) and 21-30 yr (73% versus 86%, p<0.05). In contrast, forced choice scores were higher in females than in males for the three older groups (from 41 to >60 yr), the difference being significant only in the group of 51-60 yr (80% versus 68.5%, p<0.05).

For the 5th CN, volunteers scored 96.2% on smell detection in the group of ≤20 yr, and no significant changes were observed in the older age groups (Table 4). A high score was assessed (100%) in the group of >60 yr. For smell identification, the group of ≤20 yr scored 58.7% of odours, increasing in the group of 21-30 yr (68.7%), and decreasing again for the older groups of volunteers (53% to 65%). Like for smell detection the highest identification score was assessed (71.2%) in the group

Table 3. The sense of smell (olfactory nerve stimuli) in age groups depending on gender and smoking habit.

		≤ 20 yr	21-30 yr	31-40 yr	41-50 yr	51-60 yr	>60 yr	n
Detection (%)	total	100	99.2 ± 0.5	100	99 ± 0.6	100	100	120
	M	100	100	100	99 ± 1	100	100	60
	F	100	98.5 ± 1.1	100	99 ± 0.7	100	100	60
	S	100	100	100	99.2 ± 0.7	100	100	50
	NS	100	98.5 ± 1.1	100	98.8 ± 0.8	100	100	70
Identification (%)	total	48.2 ± 4.9	70.5 ± 4.3	55.5 ± 4	58.2 ± 6.9	51.5 ± 4.9	55.2 ± 5.4	120
	M	46 ± 5.7	63 ± 5.4	61 ± 6.6	44 ± 10.3	36 ± 4.3	52 ± 7.2	60
	F	50.5 ± 8.1	78 ± 6.1	50 ± 4.3	72.5 ± 7.3 *	67 ± 5.6 *	58.5 ± 8.2	60
	S	39 ± 7.1	79 ± 4.3	57.5 ± 7.8	49.2 ± 14.3	46.5 ± 7.7	56.2 ± 5.5	50
	NS	59.4 ± 4.4 *	62 ± 6.6 *	54.1 ± 4.5	63 ± 7.5	56.5 ± 6.2	55 ± 6.6	70
Forced choice (%)	total	78 ± 4.1	79.5 ± 2.5	77.7 ± 2.6	75 ± 3.4	74.2 ± 2.2	76.7 ± 4.5	120
	M	86.5 ± 3.4	86 ± 2.4	80 ± 3.2	72 ± 5.9	68.5 ± 2.7	73.5 ± 7.7	60
	F	69.5 ± 6.6 *	73 ± 3.4 *	75.5 ± 4.2	78 ± 3.3	80 ± 2.6 *	80 ± 4.9	60
	S	71.3 ± 6.3	79 ± 3.9	80 ± 5.1	70 ± 8.2	75 ± 4.1	75 ± 9.3	50
	NS	86.1 ± 3.5 *	80 ± 3.4	76.2 ± 2.8	77.6 ± 2.8	73.5 ± 2	77.1 ± 5.3	70

* $p<0.05$; M, male; F, female; S, smokers; NS, non smokers.

Table 4. The sense of smell (trigeminal nerve stimuli) in age groups depending on gender and smoking habit.

		20 yr	21-30 yr	31-40 yr	41-50 yr	51-60 yr	>60 yr	n
Detection (%)	total	96.2 ± 2.1	98.7 ± 1.2	98.7 ± 1.2	98.7 ± 1.2	97 .5 ± 1,7	100	120
	M	100	100	97.5 ± 2.5	100	100	100	60
	F	92.5 ± 3.8	97.5 ± 2.5	100	97.5 ± 2.5	95 ± 3.3	100	60
	S	95.4 ± 3.1	97.5 ± 2.5	96.8 ± 3.1	100	97.5 ± 2.5	100	50
	NS	97.2 ± 2.8	100	100	98 ± 1.9	97.5 ± 2.5	100	70
Identification (%)	total	58.7 ± 6.8	68.7 ± 5.1	58.7 ± 6.6	65 ± 7.1	53.7 ± 4.9	71.2 ± 7.3	120
	M	62.5 ± 9.3	62.5 ± 6.7	57.5 ± 10.6	55 ± 9.7	45 ± 6.2	70 ± 11.1	60
	F	55 ± 10.4	75 ± 7.4	60 ± 8.5	75 ± 9.9	62.5 ± 6.7 *	72.5 ± 10.2	60
	S	47.7 ± 10.4	77.5 ± 5.8	62.5 ± 8.2	60.7 ± 14.3	42.5 ± 6.5	75 ± 10.2	50
	NS	72.2 ± 6.5 *	60 ± 7.6	56.2 ± 9.8	67.3 ± 8.2	65 ± 5.5 *	70.3 ± 8.9	70
Forced choice (%)	total	51.2 ± 5.3	52.5 ± 6.3	46.2 ± 5.2	40 ± 6.4	42.5 ± 5.2	48.7 ± 7.6	120
	M	57.5 ± 8.4	55 ± 9,7	55 ± 7.3	32.5 ± 7.5	37.5 ± 6.7	47.5 ± 8.7	60
	F	45 ± 6.2	50 ± 8.3	37.5 ± 6.7	47.5 ± 10.2	47.5 ± 7.9	50 ± 12.9	60
	S	56.8 ± 8.3	55 ± 8.2	40.6 ± 8.1	35.7 ± 14.3	42.5 ± 7.5	56.2 ± 6.2	50
	NS	44.4 ± 5.6	50 ± 9.9	50 ± 6.9	42.3 ± 6.6	42.5 ± 7.5	46.8 ± 9.4	70

* $p<0.05$; M, male; F, female; S, smokers; NS, non smokers.

of >60 yr. For smell forced choice, the group of ≤20 yr scored 51.2% of odours, remaining high at the group of 21-30 yr (52.5%) and decreasing in further age groups (40% to 48%). No significant differences in smell detection for 5th CN were observed between males and females, along all age-stratified groups (Table 4). Smell identification scores in females were higher than in males in almost all age groups, reaching statistical difference only in the group of 51-60 yr (62.5% versus 45%, $p<0.05$). Smell forced choice scores in females were also lower than in males for the three younger groups (from ≤20 to 40 yr) without significant differences. Although not significant, the scores of forced choice were also higher in females than in males for the three older groups (from 41 to >60 yr).

Smokers (50 volunteers) and non-smokers (70 volunteers) showed similar scores for detection and forced choice for both for both 1st and 5th CN, but non-smokers had higher scores (65.4%; $p<0.05$) than smokers (59%) on smell identification for the 5th CN (Figure 4A, B).

For the 1st CN, no significant differences in smell detection were observed between smoker and non-smoker volunteers, along all age groups (Table 3). Smell identification scores in non-smokers were higher than in smokers in the group of ≤20 yr (59.4% versus 39%, $p<0.05$), while in the group of 21-30 yr the scores were higher in smokers (79% versus 62%, $p<0.05$). Forced choice scores in non-smokers were higher than in smokers in the group of <20 yr (86.1% versus 71.3%, $p<0.05$).

For the 5th CN, no significant differences in smell detection were observed between smokers and non-smokers, along all age groups (Table 4). Smell identification scores in non-smokers were higher than in smokers in the group of <20 yr (72.2% versus 47.7%, $p<0.05$) and 51-60 yr (65% versus 42.5%, $p<0.05$). In contrast, forced choice scores were higher in smokers than in non-smokers in the groups of ≤20 yr, 21-30 yr, and >60 yr, while non-smokers scored higher in the middle age groups (from 31 to 50 yr), but without reaching a statistical significance.

The variability of this test was analysed whether individual test items changed significantly as well as the importance of learn-

ing in 3 repeated tests assessed at 0, 2 and 4 weeks. Using Cochran Q tests, we compared six volunteers in smell detection, identification, and forced choice of the 24 odours. Only two odorants (rose and strawberry) showed a significant ($p<0.05$) change from the new to old tests in forced choice (rose: $Q=6$; $df=2$; $p<0.049$/strawberry: $Q=6.5$; $df=2$; $p<0.038$).

To calculate the concordance for smell detection and forced choice scores, we compared seven common odours between the BAST 24 test and smell diskettes test using the Kappa (STATA) test for all 120 volunteers (Table 5). Subject showed similar scores for smell detection and forced choice scores for vanilla, smoke, pineapple, and rose, but there were significant differences for coconut, peach, and vinegar for smell detection scores.

DISCUSSION

Our studies provide normative values for routine clinical use of the BAST-24 in 120 healthy volunteers. The main findings of our study showed that: 1) Smell detection was very high in both 1st and 5th CN odours and higher than identification and forced choice, but no important differences related to age were observed. 2) Females scored higher than males on smell identification for both the 1st and 5th CN. 3) Non-smokers scored higher than smokers on smell identification for the 5th CN. 4) Smell identification was scored slightly higher in the left than in the right nostril for both the 1st and 5th CN. 5) BAST 24 was found to be a valid, reliable, and reproducible test.

In our study, healthy volunteers showed higher scores on smell detection than on spontaneous identification and forced choice. The increase on smell identification observed in the group of 21-30 years compared to the group of ≤20 years could be related to odour learning during youth while a progressive decrease was observed in older groups. No differences between age groups were observed on smell detection and forced choice. The lack of differences among group ages in our study could be related to the selection criteria of our healthy smelling population. Other studies showed that when population age increases, the olfactory function became impaired [9,10]. The highest loss of olfactory function in the general population occurs after age 65 [11]. Among this older population, 50% of people between 65 and 80 year old and over 75% of people older than 80 years have a significant loss of smell detection. On average, women have not only a better ability of smell but also a longer one than men [11]. The causes of smell loss in the elderly are probably multifactorial: upper respiratory viral infections and inflammatory nasosinusal diseases, head trauma, cribiform plate calcification, iatrogenic mechanisms (surgery, medications), as well as systemic disorders and their treatments [9]. The olfactory function is compromised in urban residents and workers in some industries, including the paper and chemical manufacturing industries [11]. There exists a high prevalence of age-related deficits in odour naming, probably in association to age-related impairments of odour memory. Of particular interest is the relationship between aging-related deficits in odour identification and other aspects of cognitive functioning. By definition, odour identification is a semantic memory task referring to an individual general knowledge or experience with a specific odorant [12,13].

Using BAST 24, we have observed that males and females score similar smell detection and sensible choice, while females score higher smell identification than males for both 1st and 5th CN. In the last decades, major non-clinical findings, derived from olfactory tests including UPSIT, have concluded that women have a better sense of smell than men. Doty et al. [11] have recently reported that olfactory detection is higher in female than in men across the whole human life span. However, the explanation for these gender differences is not yet clear. Using the UPSIT test, females at all ages showed higher smell scores than age-matching males, supporting the concept that disparities in circulating hormones cannot totally explain gender-related olfactory differences [14]. Gender differences may possibly reflect anatomical and physiological variations in the structure of the olfactory mucosa, the olfactory neural pathways, or the endocrine system [9]. Recently, a multicenter study of 1.036 subjects using a standardized method of sniffin' sticks and studying odours identification and discrimination could not demonstrate significant differences between sexes [15]. In addition, no significant differences in smell function were found between sexes when trigeminally mediated sensations where investigated [16].

Using BAST-24 test, we demonstrated that smokers and non-smokers scored similar scores for detection and forced choice for both the 1st and 5th CN, but non-smokers scored higher scores than smokers on smell identification for the 5th CN. Some studies have demonstrated an association of smoking habit with the impairment of the smell function, with a dose-related effect of cigarette smoking [17,18]. The decrement in olfactory function associated to smoking habit is present in ex-smokers and the recovery to pre-smoking levels, when possible, takes for years and depends on the duration and amount of smoking [11]. Thus, the influence of smoking in the decrease of smell function may be used to emphasize the advise to give up smoking in the management of smell disorders, as one of the important elements of treatment [19]. However, other studies have reported little, if any, influence of smoking on smell sensitivity [20,21].

Table 5. Comparison between BAST 24 and smell diskettes tests.

	Coconut	Smoke	Peach	Pineapple	Rose	Vanilla	Vinegar
Detection	99.2*	100	99.2*	100	100	100	99.2*
Forced choice	85	98.3	53.3	57.5	90	76.7	63.3

* $p< 0.05$.

Our study demonstrated that smell identification, but not detection and smell forced choice, was slightly higher when the left nostril was tested compared to the right nostril. The smell lateralization has been investigated for suprathreshold measures of olfactory performance. Recently, Bromley and Doty [22] and Cain [5] found an important additive intensity in smell detection when it was tested bilaterally. Similarly, von Skramlik [23] described an additive effect for different odours, finding that an odour tested in both nostrils seemed to be stronger than when tested in one side only. Odour memory recognition is facilitated by odour presentation to both nostrils suggesting a central additive integration [22]. Frasnelli et al. [24] investigating two odours (butanol and phenylethylalchol), using two different administration techniques, and testing different sides, demonstrated that there are no major differences in odour detection thresholds between the best and both nostrils. The results may be contradictory due to potential special features of the olfactory system. However, some consensus is emerging concerning the fact that, if both hemispheres are involved, one may dominate the other in the olfactory process. Although many studies have revealed a greater impact of the right hemisphere in the processing of olfactory information, this dominance has not been clearly established. In addition, some reports state that smell detection process would not be lateralized whereas higher-order olfactory tasks which involve memory processes and lexical aspects could be lateralized [25].

CONCLUSION

In conclusion, our study demonstrates that BAST 24 is a valid, reliable, and reproducible test for the Spanish population and it is a useful method for smell screening in the routine clinical practice. BAST 24 could be a helpful test to diagnose and to control nasal pathologies such as rhinosinusitis, nasal polyposis, and anosmia (head trauma, infections, neurodegenerative diseases, etc.).

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