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Development of the ETOC: A European Test of Olfactory Capabilities*

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SUMMARY

A number of smell tests designed to evaluate human olfactory capabilities have been published, but none have been validated cross-culturally. The aim of this study was therefore to develop a reliable and quick olfactory test that could be used to evaluate efficiently the olfactory abilities of a European population. This test, named ETOC and based on a combination of a supra-threshold detection task and an identification task, was designed to be a cross-cultural tool that would measure the decline in olfactory performance with ageing. Two versions of the ETOC, one easy and one less easy, were used to test the olfactory performance of European citizens in three countries (France, Sweden and the Netherlands). The results indicated that neither version of the ETOC is culture-dependent, and that both give scores that well reflect the decrease in olfactory abilities with increasing age. A retest session showed that the less easy (and final) version of the ETOC is also highly reliable.

Key words: human, olfactory capabilities, test, ageing

INTRODUCTION

Even if olfaction is, of our five senses, the one to which we attach the least importance, it is still extremely present and influential in our everyday life and its day-to-day quality. Odours can influence mood, cognition and behaviour (for a review, see Herz, 2002). It has in particular been demonstrated by Schiffman et al. that pleasant odours can influence the mood of middle-aged men (Schiffman et al., 1995a) and women (Schiffman et al., 1995b). Olfaction is also an alarm sense, in that it allows even very slight changes in our environment (e.g., smoke, fire, gas leaks) to be detected and prevents our eating food that is "off" (Stevens and Cain, 1987).

Olfaction is the key to our relationship with food, as palatability is mainly mediated by the olfactory system. As compared to taste, olfaction plays a major role in the identification of food (Murphy, 1985) and there are significant age-associated changes in chemosensory perception that have the capacity to interact with dietary selection and nutrition. Thus, a more complete understanding of age-associated changes in olfaction and, to a lesser extent, taste may provide some insight into factors involved in dietary selection. Because compromised nutritional status is a problem for significant numbers of elderly people, dietary selection may be particularly important for the health and well-being of the elderly population (Murphy, 1993). Thus odour information may alter nutritional behaviour, condition the pleasure of eating and drive food preferences (De Jong et al., 1999; Schiffman, 1999), and, even if olfactory impairment is not directly related to low nutritional intake or status, it probably influences quality of life due to loss of appetite, lowered hunger feelings, and the perception most foods as bland (De Jong et al., 1999; Schiffman, 1999).

Hence, studies on food consumption, food preferences and, in some ways, nutritional studies could benefit from their panellists being assessed for olfactory and other sensory sensitivity. Quite an easy way to evaluate olfactory sensitivity is by olfactory tests. Many of these have been proposed during the last 20 years (Doty, 1992, 2001). An overview of the existing tests is given in Table 1.

First, it can be seen that, among all the possible tasks for testing olfactory function (Doty, 1992), only a few are actually used in the available olfactory tests. Thus, all the tests presented in Table 1 except one (AST) are more or less based on

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Table 1. Survey of published olfactory tests.

Author(s)	Year	Test name	Test duration	Country	Sample size	Test retest	Subject differences	Method
Cain	1983 1988 1989	CCCRC	35 min	USA	> 700		Age, gender, diseases, olfactory disorders.	1/ Threshold. N-butanol. 2AFC 4-correct–in-a-row method. Separate nostrils. Odours in squeeze bottles 2/ Identification. 10 odours (score on 7+1). Forced choice among 20 (or 16) descriptors. Odours in jars. Separate nostrils. Feedback.
Doty *et al.*	1984 (a,b) 1985	UPSIT	15 min	USA	> 3000	r=0.918	Age, gender, culture, smoker, disease, olfactory disorder, malingering.	Identification of 40 encapsulated odours. 4AFC. Scratch-and-sniff technique.
Wright Kurtz *et al.*	1987 2001	Odorant confusion matrix (OCM)	15 min	USA	480		Disease.	Identification of 10 odours presented 10 times each (100 stimuli or 121 if a blank is added). Forced choice in list of 10 names. Pattern of odorant identification and misidentification.
Hendriks	1988	GITU		Netherlands	221		Age, gender, olfactory disorders	Identification of 18 or 36 odours. Forced choice either among 4 alternatives or among a list of 24 for 18 odours to identify. "Everyday life" odours. Odours in jars.
Corwin	1989 1992	YN-OIT		USA			Age, Disease.	Based on 20 UPSIT odours. Yes or no matching of a descriptor to a proposed odour.
Takagi	1989	T&T olfacto-meter		Japan	> 1000		Olfactory disorders.	Thresholds of detection and recognition for 5 odorants. Odours on slips of filter paper. Separate nostrils.
Anderson *et al.*	1992	SDOIT		USA	Young children		Age.	Identification of 10 odours. Forced choice using an array of 20 visual stimuli. Odours in jars.
Eloit and Trotier	1994			France	84		Olfactory disorder, disease.	Odours in bottles. 1/ Threshold to 5 odorants. 2/ Identification of 6 odorants. Odours in bottles.
Doty *et al.*	1995 1996	CC-SIT MOD-SIT	5 min	USA Europe Asia	> 3000	r=0.71	Age, gender, olfactory disorders.	Identification of 12 encapsulated odours. 4AFC. Scratch and sniff technique.
Kobal *et al.*	1996		5 min	Germany	152	r=0.73	Gender, olfactory disorder, age.	Identification of 7 odours in pens. Forced choice among 4 alternatives.
Robson *et al.*	1996	Combined olfactory test		UK and New Zealand	227		Olfactory disorder.	1/ Threshold for n-butanol. Odours in plastic containers. 2/ Identification of 9 odours. 4AFC. Odours in jars.

Table 1. continued.

Author(s)	Year	Test name	Test duration	Country	Sample size	Test retest	Subject differences	Method
Hummel *et al.* Kobal *et al.*	1997 2000	Sniffin' Sticks		Germany Switzerland Austria Australia Italy USA	> 1000	r=0.72	Age, olfactory disorder.	Odours in pens. 1/ Threshold for n-butanol. Triple forced choice paradigm. Single staircase method. 2/ Discrimination: 16 odorant triplets. Identify the pen having the different smell. Forced choice. 3/ Identification: 16 odours. 4AFC.
Davidson and Murphy	1997	AST	5 min	USA	100		Olfactory disorder.	Detection of isopropanol. Measure as distance from nose.
Ahlskog *et al.*	1998	CA-UPSIT		Guamanian Chamorro	57		Neuro-degenerative disease. Educational level.	Identification of 20 encapsulated odours. 4AFC. Scratch-and-sniff technique.
Nordin	1998 2001	SOIT	15 min	Sweden Finland	> 600	r=0.79	Age, gender, olfactory disorder.	Identification of 16 odours in bottles. 4AFC.
Kremer *et al.*	1998		4 min	Germany Netherlands	>200		Hyposmia.	6 aromas sprayed into open mouth. Odours in nasal sprays.
McCaffrey *et al.*	2000	PST		USA	40		Discrimination between Alzheimer's Dementia and major depression.	Identification of 3 encapsulated odours. 4AFC. Scratch-and-sniff technique.
Kobal *et al.*	2001	"Random" test	10 min	Germany	273	r=0.71	Gender, olfactory disorder.	Labelling of 16 concentrations of two odorants randomly presented.
Hummel *et al.*	2001	"Four-minute odor identification test"	4 min	Germany	1,012	r=0.78	Age, olfactory disorder.	Identification of 12 odours. 4AFC. Odours in pens.

odour identification. This task can only be used to evaluate olfactory sensitivity if familiar odours are used and if the test is based on a multiple-choice procedure (Cain and Krause, 1979). Such a procedure will then circumvent the olfactory-verbal gap that frequently separates an odour from its name (Cain and Krause, 1979; Dubois and Rouby, 2003). A survey of odour identification ability displays more than just adequate sensory functioning; it also affords information on memory and linguistic processing (Cain and Gent, 1986). However, a major problem with odour identification is that it shows great culture dependence (Doty et al., 1985; Thomas-Danguin et al., 2001).

More than one third of the tests presented in Table 1 include a detection task that may be very brief (AST) or quite long when using a 3AFC-5-in-a-row method as in the Sniffin'Sticks test. However, as reviewed by Kurtz et al. (2001), threshold tests present intrinsic difficulties. Thus, inability to detect the presence of one particular odorant does not necessarily indicate anosmia to all other odorants (Amoore, 1977). Conversely, normal performance on a simple threshold detection test does not imply that the patient is free of olfactory complaints. Furthermore, olfactory thresholds seem to be more variable than those in other sensory systems (Cain, 1977). Hummel et al. (1997) also suggested that threshold tests may be more subject to training effects than are identification or discrimination tests. It is nevertheless noteworthy that threshold tests are of particular value in liability cases, as inspection of results may expose cheating (Cain et al., 1988). However, while threshold detection measurements seem to be more directly related to sensitivity, it has been shown that threshold and identification tests can measure the same property, as scores on the two tasks are very closely correlated (Cain, 1982; Cain et al., 1986; Cain et al., 1988). Thus, in view of their ease of use, speed of administration, and resolution, identification tasks appear to be preferable.

Only one test listed in Table 1 (Sniffin'Sticks) uses a discrimination task. The use of odour discrimination in olfactory testing has a certain appeal. It is easier to administer than threshold measurement, and seems to be less language-dependent

than is identification. Moreover, discrimination can be included in testing procedures using several tasks and giving composite scores. It has been claimed that composite scores may be better suited for the evaluation of the olfactory function than any isolated measure of olfactory performance (Cain and Rabin, 1989; Hummel et al., 1997). However, we recently showed that, even if odour discrimination seems to be a non-verbal task (Hummel et al., 1997) it is to some extent dependent on culture, probably via familiarity effects (Thomas-Danguin et al., 2001).

All the tests presented in Table 1 were developed for clinical purposes, to discriminate impaired patients from those with no deficit (Cain et al., 1983, Cain et al., 1988). These powerful tools have significantly increased the understanding of the sense of smell in humans, including the functional influences of such factors as age, gender, exposure to toxic agents, and various disease states (review by Doty, 2001). As far as we know, however - although the CC-SIT (see Table 1) was indeed created by selecting those items in the UPSIT that were the most familiar for European and Japanese as well as US residents - none of the tests in Table 1 have been cross-culturally validated.

Therefore the aim of our study was to develop a reliable and quick olfactory test that could be used to evaluate the olfactory ability of a European population efficiently. This test was not designed for direct clinical use but rather for sensory analysis studies, as an indicator of olfactory performance of subjects and panellists. I.e., our main goal in developing this test was to obtain a cross-cultural tool that would measure the decline in olfactory performance with ageing. Considering the heavy procedure needed to measure reliable olfactory thresholds, we defined a procedure based on a combination of a supra-threshold detection task and an identification task.

We here present the results of two experiments related to the development of the olfactory test named ETOC (European Test of Olfactory Capabilities). We examined (i) its Europe-wide validity, (ii) its sensitivity to ageing, and (iii) its reliability.

MATERIAL AND METHODS

Experiment 1: ETOC first version, a cross-cultural olfactory test

Participants

A total of 261 persons (mean age 51.8; 56.3% women) were tested with a first version of the test (ETOC V1). All subjects were living independently, although some, especially the oldest, were living in adapted residences. Eighty-four subjects participated in France (mean age 43.5; 69.0% women), 87 in Sweden (mean age 55.5; 51.7% women) and 90 in the Netherlands (mean age 55.9; 48.9% women). Most of the participants came to the laboratories by themselves; a few were tested at home or in centres they went to for social activities.

Olfactory test ETOC V1

The ETOC, which needs less than 20 minutes to be completed, is based on blocks of four vials (15 ml). The four vials of a block are presented simultaneously to the subject. Only one vial out of the four contains an odour. The whole test is made up of 16 blocks, which correspond to 16 different odours.

Each block is identified by a number (from 1 to 16). This number is the same for all four vials of a given block. Next to the number, there is a letter (A to D) that differentiates the four vials in the block.

Odorous material is dissolved in odourless mineral oil and the whole solution is absorbed on a specific absorbent to avoid any leakage during vial manipulation.

The 16 odours used are: vanilla, cloves, apple, eucalyptus, cinnamon, fuel-oil, pine, garlic, cut grass, anise, orange, fish, rose, thyme, lemon and mint.

Procedure

To evaluate the subject's olfactory performance, a succession of 16 test blocks were proposed and, at each stage, subjects were given a detection task followed by an identification task.

The subjects had therefore to detect the odorous vial and to point it out in the block (4-Alternative-Forced-Choice (4AFC) procedure). Then, subjects had to identify the odour detected by selecting the right descriptor between four that were proposed (4AFC procedure).

The subjects received the 16 test blocks, an instruction sheet and an answer sheet. Following an ecological procedure, subjects were instructed to smell successively each vial of a given block in a natural way, without any restraint, then to record their answer and to follow on with the next block. Subjects recorded their answers on the answer sheet by circling the letter corresponding to the odorous vial in the block (detection task) and then circling the descriptor, among the four proposed for the block, which matched their perception of the odour (identification task). Answer sheet and instruction sheet had been translated into local languages.

Scores

Three different scores were calculated from the ETOC results. First, taking the detection task alone, a detection score was calculated (/16), corresponding to the number of vials correctly pointed out. Then, from the number of correct identifications, an identification score was calculated (/16). It should be noted that, when the detection was not correct – i.e., when a non-odorous vial was selected - then the answer to the identification task was considered wrong, even if the right descriptor had been chosen. This scoring procedure reduces to 1/16 the probability of identification by chance when the odour is not perceived. Finally, by adding the detection score to the identification score, a composite test score was derived, expressed as a percentage of the maximum total score (i.e., 32/32). This scoring system gives greater weight to detection, as detection is already taken into account in the identification score.

Table 2. Mean results obtained with ETOC versions N°1 and N°2.

	Detection				Identification				Composite score			
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
ETOC version N°1												
All three countries	15.5	1.3	7	16	13.3	2.7	0	16	90.0%	11.4%	31.3%	100%
France	15.7	0.8	10	16	14.0	2.3	4	16	92.7%	9.2%	50.0%	100%
Sweden	15.6	1.0	10	16	12.7	2.7	0	16	88.4%	10.7%	43.8%	100%
The Netherlands	15.3	1.7	7	16	13.1	2.8	2	16	88.9%	13.4%	31.3%	100%
ETOC version N°2												
Both countries	14.9	2.3	1	16	11.9	3.5	0	16	83.8%	17.3%	6.3%	100%
France	14.9	2.5	1	16	11.9	3.6	0	16	83.7%	18.0%	6.3%	100%
Sweden	15.1	1.6	9	16	11.8	3.1	1	15	84.1%	14.3%	31.3%	96.9%

Experiment 2: second version ETOC, a reliable olfactory test sensitive to ageing

A total of 160 persons (mean age 51.2; 58.8% women) were tested with the second version of the test (ETOC V2). 127 subjects participated in France (mean age 50.1; 59.8% women), and 33 in Sweden (mean age 55.1; 54.5% women).
Of these 160 subjects, 51 were previously tested with the first version of the ETOC. In France, 20 persons were thus re-tested (mean age 53.1; 50% women) 10 weeks after their first testing session. In Sweden, 31 subjects were re-tested (mean age 62.6; 54.8% women) one week after their first testing session.

RESULTS

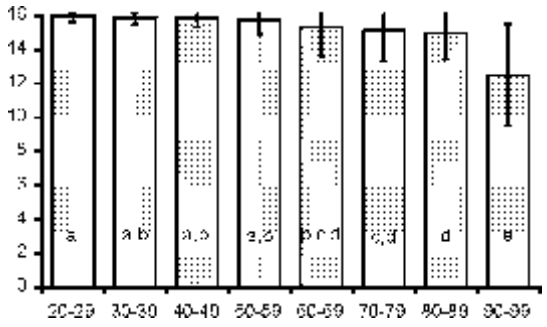
An overview of the results of experiment 1 is given in Table 2.
A three-way analysis of variance (ANOVA; country and gender as factors and age as covariate; α=0.05) was conducted on composite, detection and identification scores respectively. In all three analysis, there emerged an overall age-effect (Composite score [$F(1,249) = 57.3$, $p < 0.0001$]; Detection [$F(1,249) = 21.4$, $p < 0.0001$]; Identification [$F(1,249) = 66.6$, $p < 0.0001$]). No significant effect was found for country (Composite score [$F(2,249) = 0.62$, $p = 0.54$]; Detection [$F(2,249) = 0.81$, $p = 0.44$]; Identification [$F(2,249) = 0.40$, $p = 0.67$]) or for gender (Composite score [$F(1,249) = 0.08$, $p = 0.77$]; Detection [$F(1,249) = 0.004$, $p = 0.95$]; Identification [$F(1,249) = 0.14$, $p = 0.71$]). No significant interactions between factors were found.
On the basis of these three-way ANOVA results, data were then pooled for 10-year step age groups. Table 3 summarises the number of subjects in each age group and the mean age of each group.
A one-way ANOVA (age group; α=0.05) confirmed the apparent decrease in mean score with increasing age (Composite score [$F(7,253) = 15.3$, $p < 0.0001$]; Detection [$F(7,253) = 6.9$, $p < 0.0001$]; and Identification [$F(7,253) = 16.9$, $p < 0.0001$]). Post-hoc comparisons (Fisher PLSD; α=0.05) showed that the scores begin to decrease as of the age of 60, for both Detection and Identification (see Figures 1a, 1b, 1c).

At that point, the test appeared to be a cross-culturally valid olfactory tool. However, even though an influence of age on scores had been demonstrated, we wanted the test to be more sensitive to ageing. Therefore, we designed a second version in which the difficulty was increased by reducing certain concentrations. For this second version of the ETOC, neither odorants nor testing and scoring procedures were changed.

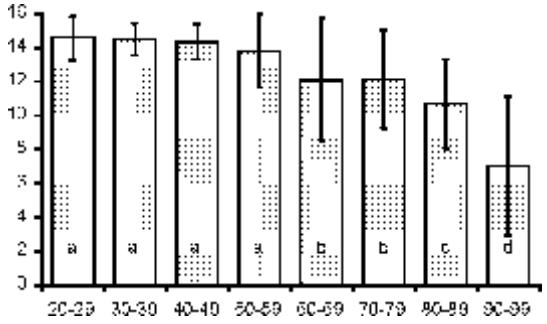
An overview of the results of experiment 2 is also given in Table 2.
Analysis of variance did not indicate any significant country effect on scores (Composite score [$F(1,158) = 0.013$, $p = 0.91$]; Detection [$F(1,158) = 0.246$, $p = 0.62$]; Identification [$F(1,158) = 0.023$, $p = 0.88$]); there was no gender effect (Composite score [$F(1,158) = 0.90$, $p = 0.35$]; Detection [$F(1,158) = 0.003$, $p = 0.96$]; Identification [$F(1,158) = 2.39$, $p = 0.12$]). Distributing subjects in successive 10-year age groups (table 3) confirmed a highly significant effect of age (Composite score [$F(1,152) =$

Table 3. Details of age groups of subjects tested with ETOC V1 and ETOC V2.

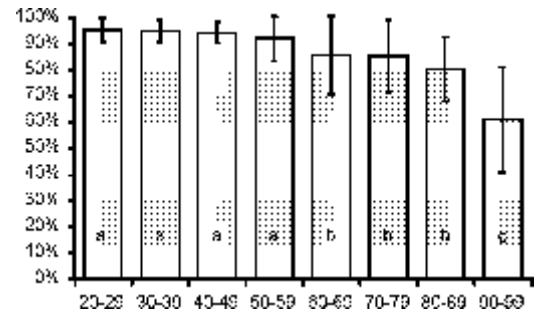
Age group (years)	ETOC Version N°1			ETOC Version N°2		
	Number of subjects	Mean age (yrs)	S.D.	Number of subjects	Mean age (yrs)	S.D.
20-29	58	25.2	2.7	42	22.3	2.3
30-39	31	34.6	3.0	16	34.8	3.2
40-49	33	44.2	3.4	15	44.5	3.3
50-59	39	53.8	2.4	17	55.5	2.3
60-69	30	65.1	3.2	31	64.7	2.8
70-79	44	74.5	3.3	21	74.1	2.8
80-89	22	82.7	2.4	14	81.5	2.4
90-99	4	91.8	2.9	4	94.5	3.3



1a. Detection

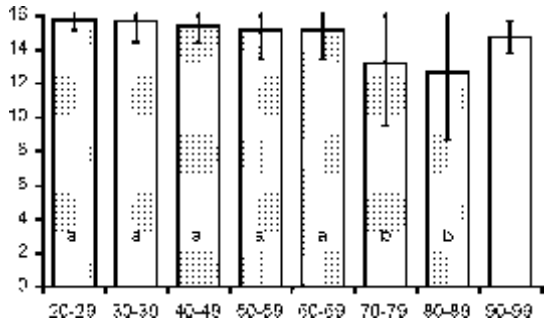


1b. Identification

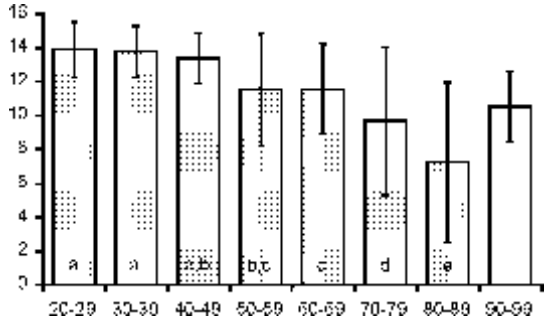


1c. Composite score

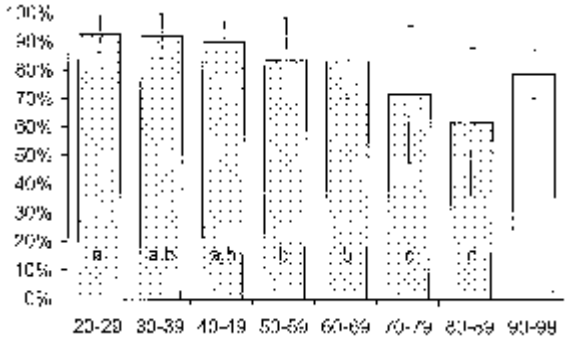
Figure 1. Change in score with age for version N°1 of ETOC.



2a. Detection



2b. Identification



2c. Composite score

Figure 2. Change in score with age for version N°2 of ETOC.

9.84, $p < 0.0001$]; Detection [$F(1,152) = 5.72$, $p < 0.0001$]; Identification [$F(1,152) = 11.80$, $p < 0.0001$]). As previously observed with the first version of the test, test scores decreased as age increased (Figures 2a-c).

It is noteworthy that the four subjects of the oldest age group (mean age 94.5) obtained higher average scores than younger subjects, especially as compared to the 70-79 and 80-89 year-old age groups.

ETOC V2 retest

The mean (± SD) ETOC V2 composite scores on test and re-test were 85.2% (± 9.8%) and 84.8% (± 10.2%) in France and 84.1% (± 14.6%) and 85.5% (± 16.7%) in Sweden respectively. A two-way ANOVA (country by test session with repeated measures across test sessions) showed no significant effect of country [$F(1,49) = 0.003$, $p = 0.95$], or of test session [$F(1,49) = 0.36$, $p = 0.55$], and no country by test occasion interaction [$F(1,49) = 0.88$, $p = 0.35$]. The rho coefficient on Spearman correlation analysis was r_{20}=0.92 in France [slope = 0.95 ($p < 0.0001$), constant term = 0.04 ($p = 0.63$)], r_{31}=0.89 in Sweden [slope = 1.02 ($p < 0.0001$), constant term = -0.004 ($p = 0.96$)], and r51=0.90 for the two countries taken together [slope = 1.003 ($p < 0.0001$), constant term = 0.005 ($p = 0.94$)].

Comparison between ETOC V1 and ETOC V2

Considering that we did not observe any effect of the country on ETOC scores, in either version, a two-way ANOVA (ETOC version by age group) was performed on the composite scores of the two versions of the ETOC. A significant effect of test version was found [$F(1,405) = 4.22$, $p = 0.041$], as well as an effect of age group [$F(7,405) = 11.62$, $p < 0.0001$]. A highly significant interaction between ETOC version and age group was also demonstrated [$F(7,405) = 4.37$, $p = 0.0001$], with lower scores for elderly as compared to younger subjects on ETOC V2 than on ETOC V1 (figures 1.c. and 2.c.). Post-hoc mean comparison (Scheffé; α=0.05) showed a difference of 6.2% ($p<0.0001$) between the mean composite scores of the first and second versions. This difference was 2.5% ($p=0.024$) for the 20-

29 year-old age group and increased up to 18.2% (p=0.007) for the 80-89 year-old age group.

DISCUSSION

The aim of the study presented here was to develop a quick olfactory test, usable in the whole of Europe, providing scores closely related to sensitivity and its evolution with age. Considering that it is very difficult, tedious and time consuming for both subjects and experimenters to follow the threshold determination procedures needed to obtain relevant thresholds, it was decided to use identification as a basic schedule in the ETOC. It was pointed out in the Introduction that Cain (1982) and Cain et al. (1986, 1988) have shown that scores on threshold and on identification tests are very closely correlated. Moreover, identification tests, due to the diversity of odour items used, are more enjoyable to take than are repetitive detection schedules, and thus especially well accepted by elderly people.

It has been established that it is an advantage to have composite scores (Cain and Rabin, 1989, Hummel et al., 1997), identification ability was not scored alone, as in most of the short olfactory tests already available, but was accompanied by an above-threshold detection score. Stevens and Cain (1987) have shown that reduction of intensity perception above threshold is closely related to threshold elevation. The present detection task, based on above-threshold intensities, is also more related to everyday life behaviour and thus requires little cognitive involvement.

The testing procedure used in the ETOC, by measuring above-threshold detection and identification separately, differentiates non-verbal sensory capacities from verbal identification. These two tasks can provide separate information on the peripheral processes linked to perception on the one hand and on more central and cognitive processes on the other. This could be a key issue in ageing studies, as it can give cues on sensory or more cognitive ageing processes (Murphy et al., 1991; Larsson et al., 2000).

The ETOC uses odours in bottles and is based on the subjects' sniffing behaviour, which is an ecological sampling procedure and thus gives optimum odour perception (Laing, 1983).

Olfactory identification tests are well suited for convenient olfactory ability measurements. However, there has been discussion as to whether such tasks are not closely dependent on culture, memory and familiarity - that is, on the individual's experience with the presented odours. As a consequence, one of the main problems encountered in identification-based tests is that the results might differ from one country to another. For that reason, there have been several short identification-based olfactory tests developed for single-country use (see Table 1). Furthermore, most of the already available olfactory tests were designed for diagnosing hyposmia, and seem to be too easy (Thomas-Danguin et al., 2001) to be able to discriminate between healthy people. These tests cannot powerfully enough discriminate small differences in olfactory sensitivity that may be of interest and relevant in sensory analysis and consumer studies. These are the reasons why, on the basis of previous studies (Thomas-Danguin et al., 2001), we took pains with stimulus selection: the odours used in the test were carefully selected to avoid the influence of culture as much as possible. Furthermore, we tried to make the test more difficult than those usually designed for clinical purposes. One of the ways we chose to make the test more difficult was by manipulating the alternatives used in the identification procedure.

People are not good at naming even very familiar odours (Engen, 1987), which is why an alternative forced choice procedure needs to be used for the identification task if exploitable data are to be ensured. However, it is well known that, in a four-word alternative forced choice (4AFC) identification procedure, the influence of the alternatives proposed is very significant (Cain and Gent, 1986; Rouby and Dubois, 1995). Engen (1987) demonstrated this effect with two groups of subjects who had to identify the odour of grapes. The first group of subjects received an answer sheet with the correct name (grapes) and a diverse set of alternatives (pizza, turpentine and cloves). The second group received an answer sheet that contained the correct name (grape) and alternatives from the same category (melon, plum and strawberry). The results of this experiment indicated that the first group scored 93.3% correct answers and the second group only slightly over 50%. Following this idea, we tried to modulate the level of difficulty from one odour to another by using more or less closely related alternatives (Rouby and Dubois, 1995). We selected alternative odour names which firstly referred to highly discriminable odours that are not likely to be confused in direct comparisons, and secondly were common in all European countries, so as to make the words easily translatable from one language to another and to minimise any cultural bias at this level.

The results of our first experiment clearly showed that the ETOC gives similar results in France, Sweden and the Netherlands. Our results did not show any clear gender effect, as had been observed in other previous studies (Doty et al., 1984a; Nordin et al., 2002). The gender effect is, however, very subtle in odour identification and not robust enough to be detected in small samples (Doty et al., 1985).

The main differences in scores were due to ageing: i.e., older people have on average poorer olfactory abilities than do younger ones. This is in accordance with most published findings (Van Toller et al., 1985; Doty, 2001). We observed that identification scores decreased much more with age than did above-threshold detection scores.

Following these observations, we wanted to see whether a significant decrease in olfactory ability could appear before the age of 60. It was therefore decided to make the test more powerful by increasing its difficulty, especially in the case of the detection task as this was expected to increase its sensitivity to ageing. A second version of the test was developed in which

the intensity of some odours was lowered. The hypothesis here was that, in modifying odour intensity only, the "cross-cultural" portability of the test would be kept at the same level. The results of the second experiment bore out this hypothesis, as no statistically significant differences were found between scores obtained in France and in Sweden.

It was further proved that the second version of the ETOC really is more difficult than the first, as lower scores were obtained. Detection scores were lower, especially for older groups (although not for the very oldest). This was also true for identification, and confirmed that a lower concentration makes an odour less identifiable. The second version of the test consequently seemed to be more sensitive, especially to age, than the first. In fact, post hoc analysis on composite scores revealed that with the first version of the test, scores remained stable until the age of 60, then decreased significantly; this would seem to be mainly due to loss of identification ability. In experiment 2, however, with the second version of the ETOC, the decrease appeared at the age of 50. Again, the effect was mainly related to a decrease in identification ability. These results demonstrated that the ability to identify odours decreases significantly before the age of 60 or 65, even though above-threshold detection remains at quite a high level until 60 years of age.

Stevens and Cain (1985) already showed the influence of intensity perception on odour identification. Perceived intensity plays a major role in predicting odour naming, suggesting that variation in intensity perception is a major constituent for successful odour identification (Larsson et al., 2000). Thus, when the intensity of an odour decreases, there may result a lack of information at olfactory system entry, which could affect identification. Murphy et al. (1989) suggested that the elderly may perceive the chemosensory world through a veil of presumably internal noise. Perhaps the presence of such noise in some way alters the identity of odours (Murphy et al., 1991). Thus, it seems reasonable to argue that the lack of olfactory information, or noise at peripheral level, could alter the olfactory image to be compared to images in memory - a process needed in order to recognise the odour. In that sense, Murphy et al. (1991) indicated that the salience of "chemical search images" (Freeman, 1983) arises from a dynamic process of perception that may fail with age.

We mentioned above that the results of this second experiment showed that, on average, people over 90 years of age obtained better scores on the test as compared to people between 70 and 89 years of age. Although there were only four subjects in the former age group, this observation agrees with recent data concerning the very old and their abilities, which are far superior to those generally attributed to them (Elsner, 2001). We may, however, consider them as rather exceptional from a sensory point of view, besides their ability to survive.

The test-retest assessment of the second version of the ETOC showed that even though the difficulty had been increased, the test remained highly reliable, the test-retest correlation being very strong. Moreover, no significant general shift in performance occurred between test sessions, whatever the interval (one or ten weeks) between test and retest, indicating great stability of the test over time.

CONCLUSION

The ETOC olfactory test is a re-usable and portable test-kit for the evaluation of olfactory capabilities. It has been designed for self-administration and needs less than 30 minutes to be completed, even with for elderly people (mean administration time = 22 minutes). The ETOC includes both verbal (odour identification) and non-verbal (above-threshold odour detection) approaches. Moreover, it is possible to calculate a single composite test score reflecting the subject's capacities with regard to odorous stimuli. The test may be used in several European countries, as the choice of targets and distractors has been made with ease of translation into various languages in mind.

Thus, the ETOC has been validated in three European countries (France, Sweden and the Netherlands). It was in particular demonstrated that there was no influence of country on the scores. The very specific and ecological testing procedure enabled the number of correct identifications made by chance to be reduced in a 4x4AFC procedure.

A final, less easy version of the ETOC has been developed by lowering the odour intensities so as to make the test more sensitive to loss of olfactory ability with age. This version, tested in France and Sweden, seems to keep the "cross-cultural" quality of the first version. This version has been proved reliable, with very strong test-retest correlation.

This final version of the ETOC appears to be more powerful than the first one, especially in terms of sensitivity, and gives highly reliable scores. We are currently testing people from other European countries, in order to demonstrate the advantages of using this quick test as an indicator of olfactory ability. It would also be interesting to relate sensitivity loss with age, in terms of detection or identification, to other factors occurring during life span. Moreover, as demonstrated by Wysocki and Gilbert (1989), people lose their ability to identify some odours more than others with age, and age-related changes in odour identification may prove to be item-specific; we are currently carrying out experiments along these lines. The ETOC is thus now being used in sensory laboratories in several European countries. The results obtained will be used to build up normative data from a large number of subjects and to extend the cross-cultural validation of the test.

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