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The European Test of Olfactory Capabilities (ETOC): Sensitivity to Pathologies, Age, Culture and Gender

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Abstract

There is still no certainty about what a normal smell is. Yet according to studies led in other countries, anosmia (complete absence of smell) and hyposmia (partial deficiency) when cumulated affect 10% to20% of the population. In order to measure these smell deficits, we present a series of results that characterize the perceptual (detection) and semantic (identification) aspects of odor processing in different groups of participants. Our test (ETOC) is sensitive to the level of smell deficiency: it turned out to be well adapted to discriminate between anosmia, hyposmia and normosmia. Whereas the detection score does not differ according to age, the identification score is sensitive to ageing: young adults perform better than children and elderly. On average women identify one odor more than men. ETOC however does not seem sensitive to cultural environment: Canadian and French do not differ in their identification performance. The test makes a diagnostic tool that allows objectivizing smell deficits of various populations.

Key words

Smell deficits, olfactory tests, anosmia, hyposmia

1. Introduction

Olfaction is a key to our relationship to foods, of our approach/avoidance behavior and our alarm reactions against dangerous chemicals (gas and environmental pollutants). On the other hand, our pleasure and quality of life largely depend on our smell capacity, as shown by complaints of

patients who experience a loss of odor sensitivity: mood changes, depression, anxiety about personal hygiene and social interactions, etc. [1].

Not all of us however are aware of our smell function, normal, excellent or impoverished [2]. A central issue in odor perception concerns the characterization and description of olfactory impairment: hyposmia (reduced ability to detect and perceive odors) and anosmia (inability to detect and perceive odors). How can we measure olfactory deficits? Which proportion of the population suffers from such sensory dysfunction? Does prevalence of smell deficits differ according to age and sex? Identifying these dysfunctions in different populations is important especially to neuroscientists and clinicians but also for public health systems, to assess needs and setup treatment strategies.

During the last decades several olfactory tests were published in different countries. They quantify the semantic and/or perceptive aspects of competences. The most famous include the University of Pennsylvania Smell Identification Test (UPSIT) [3], the Connecticut Chemosensory Clinical Research Center (CCCRC) test [4] and the Sniffin' Sticks test [5]. In this paper we present a series of results that clinically validate the European Test of Olfactory Capabilities (ETOC), an olfactory test developed by our team in France.

2. The European Test of Olfactory Capabilities: principle

As described in details in a first publication [6], the ETOC is composed of 16 blocks of four 15 ml flasks (Figure 1). Only one flask per block contains an odorant dissolved in odorless mineral oil (Sigma-Aldrich) soaked on a synthetic absorbent (polypropylene) to optimize odor diffusion.

Figure1. Material of the olfactory test: 16 blocks of 4 flasks among which only one flask contains an odorant. For each block, participants are firstly asked to detect the flask containing the odor, and secondly to identify the detected smell by selecting 1 out of 4 descriptors.

These odorants evoke vanilla, apple, garlic, anise, orange, fish, lemon, mint, cloves, eucalyptus, cinnamon, fuel-oil, pine, cut grass, rose and thyme. The other flasks are blanks that contain only mineral oil soaked on the absorbent. The whole procedure is based on forced choice between 4 alternatives (4-AFC). For each block, participants are firstly asked to detect the flask containing the odor, and secondly to identify the detected smell by selecting 1 out of 4 descriptors. Detection scores range from 0 to 16, identification scores also range from 0 to 16, but only odors that have been correctly detected are taken into account, thus reducing the probability of correct identification by chance.

3. Sensitivity to the degree of olfactory impairment

In order to clinically validate the ETOC, Joussain et al. designed a study [7] including 96 people distributed among 3 groups according to their olfactory diagnostic (i) “anosmics” showing a complete absence of smell; (ii) “hyposmics” exhibiting a partial deficit; and (iii) “normosmics” participants devoid of any smell deficit. The diagnosis was made thanks to a threefold approach combining anamnesis, a clinical examination including nasal endoscopy, and psychophysics tests other than ETOC [4, 5]. To characterize olfactory dysfunction, the detection and identification scores of all 96 participants were compared with an analysis of variance showing very significant differences between groups: scores of the three groups markedly differ on detection ($p<0.001$; figure 2a) as on identification ($p<0.001$; figure 2b), each group significantly differing from the two others ($p<0.001$ for all paired comparisons). In other words, the ETOC significantly discriminates anosmia from both hyposmia and normosmia, and hyposmia from normosmia.

4. Influence of development and of ageing

To check the evolution of performance as a function of age (development and ageing) four age groups were compared in a previous study [8]: children from 7 to 12 years of age (n=15), adolescents from 13 to 17 years (n=15), young adults from 19 to 40 years (n=30) and elderly people from 60 to 75 years (n=30). Interestingly, the four groups do not differ on the sensorial level (no significant difference on detection scores $p>.50$) (figure 2c); identification however of the correctly detected odors differs with age ($p<.05$, figure 2d). The identification curve as a function of age shows the inverted U shape that was described in other studies [3]: young adults show the best scores and significantly differ from children ($p<0.004$) and from people over 60 years ($p=0.05$).

5. Influence of culture

To assess whether the same olfactory measurements can adapt to different environments, the ETOC was further tested in 40 French-speaking individuals, 20 from France and 20 from Canada (Quebec), who share the same language but live in a potentially different olfactory environment [9]. Results did not show any significant difference in detection scores (p>.05; figure 2e) and identification scores (p=.093 ; figure 2f). One can notice however a trend to a better identification performance of French subjects that may indicate that the odorants are slightly more familiar to them.

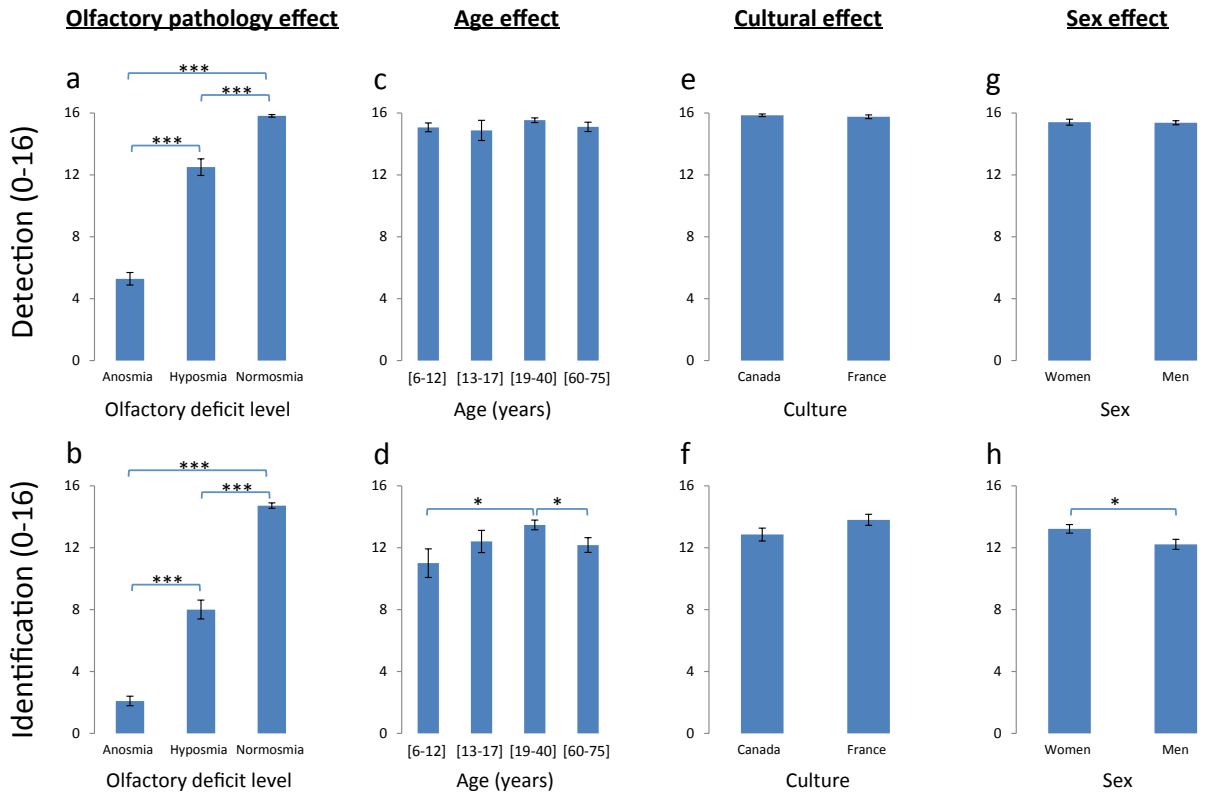

Figure 2. Validation of the ETOC. Detection scores (top) and identification scores (bottom) of different populations under study. Effect of smell pathology on detection (a) and identification scores (b) of the three diagnostic groups; (c-d) effect of age; (e-(f) effect of culture ; (g-h) effect of sex. * and *** correspond to significant differences at the statistical thresholds of 0.05 and 0.0001 respectively.

6. Influence of sex

Several studies show a superiority of women in odor identification [10]. To assess whether the ETOC is sensitive to sex, the data of the two previous studies (130 subjects [8,9]) were used to compare the performance of the 65 women and 65 men. As expected, whereas detection scores did

not significantly differ between men and women, ($p>.05$; figure 2g), women identify on average one odor more than men ($p<.02$; figure 2h).

Conclusions

The purpose of this paper was the clinical validation of the ETOC, an olfactory test already used in several European countries [6]. Detection and identification performances of healthy and diseased populations were discriminated, and the test proved to be especially sensitive to the age class: children, adolescents, young or aged adults. Moreover little or no variation was shown between cultural groups. Lastly, the test proved to be sensitive to sex, a result that corroborates previous studies and confirms its sensitivity.

As regards use, ETOC is well adapted to the clinic: it is quick (15 to 20 minutes), easy to understand and self-administrated. In the ENT examination, it can replace the subjective questionnaires which turned out to be unreliable [2]. In neurological examination it allows characterizing olfactory function in subjects who are not aware of their deficit – elderly, Parkinson or Alzheimer patients [11].

Our results strengthen the comparison led between ETOC and two other tests, the Sniffin' Sticks [5] and the CCRC [4] which showed a strong correlation of scores between ETOC and the two other identification tests [12], and a good separation between anosmia and normosmia. Moreover, the detection by itself being correlated with the identification score of the two other tests [12], this allows a nonverbal evaluation of subjects who do not wholly master language or meet understanding difficulties. The test proved to be a diagnostic tool in a scientific and clinical frame and allows assessment of smell deficits in various populations.

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