Unawareness of Olfactory Dysfunction and its Association with Cognitive Functioning in Middle Aged and Old Adults

Eike Wehling1,2,* Steven Nordin3, Thomas Espeseth4, Ivar Reinvang4, Astri J. Lundervold1,2

1Department of Biological and Medical Psychology, University of Bergen, Norway
2Kavli Research Centre for Aging and Dementia, Haraldsplass Deaconesses Hospital, Bergen, Norway
3Department of Psychology, Umeå University, Sweden
4Department of Psychology, University of Oslo, Norway

*Corresponding author at: Department of Biological and Medical Psychology, University of Bergen, Jonas Lies vei 91, 5009 Bergen, Norway.
Tel.: +47-55586209; fax: +47-55589873.
E-mail address: eike.wehling@psych.uib.no (E. Wehling).

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Abstract

The objective of this study was (a) to investigate the accordance of self-reported and objectively assessed olfactory functioning and (b) to compare performance on cognitive tests of individuals unaware of their olfactory dysfunction with individuals aware of their olfactory status. Two hundred forty participants, constituting two age groups, were evaluated with the Scandinavian Odor Identification Test, a question of self-evaluated olfactory function, tests of cognitive function, and a memory questionnaire. The proportion of individuals being unaware of an olfactory dysfunction was high in both middle aged (86%) and old (78%) participants. Performance on neuropsychological tests showed that persons unaware of their olfactory dysfunction performed poorer on tests of verbal learning and memory and attention/processing speed compared to individuals aware of a normal olfactory status as well as individuals aware of their olfactory dysfunction. The clinical relevance of unawareness of olfactory dysfunction, as suggested earlier, needs further investigation and stresses the need of an extensive multi-modal and longitudinal assessment of unawareness of sensory and cognitive function to learn more about the facets of the concept of unawareness.

Keywords: Odor identification; Olfactory dysfunction; Unawareness; Aging; Cognitive decline; Olfaction

Introduction

Olfactory function, as all sensory modalities, is typically compromised by increased chronological age. Prevalence rates for objectively assessed olfactory dysfunction, by means of cued odor identification tasks, have been suggested to increase from 11% to 24% in middle-aged individuals to 37%–70% at the age of 70 years (Bräemerson, Johansson, Ek, Nordin, & Bende, 2004; Murphy et al., 2002). Also prevalence rates for self-reported olfactory impairment have shown to increase in higher age groups from 2.0%, to 2.7% and 4.6% in age groups 55–64 years, 65–74 years and 75 years and older, respectively (Hoffman, Ishii, & Macturk, 1998). Recognizing one’s own abilities and disabilities is part of meta-cognition, a person’s internal knowledge on cognitive functioning, responsible for monitoring and regulation of behavior. Orfei, Robinson, Bria, Caltagirone, and Spaletta (2008) defined unawareness of dysfunction as the inability to recognize deficits and to assign a correct meaning of these deficits and their possible functional implications. Thus, in the context of this study, a person’s meta-cognitive knowledge refers to a person’s knowledge about how much he/she can rely on information in this case coming from the nasal cavity. Research on meta-cognitive knowledge on olfactory abilities is sparse. Studies including both self-reports and objective assessment indicate that older adults often are unaware of an olfactory loss. Murphy et al. (2002) found that 9.4% of a sample of 53–97-year-old individuals reported impaired olfactory function, whereas an objectively tested dysfunction by means of an odor identification task was shown in 24.5%. Using an olfactory detection task, Nordin, Monsch, and Murphy (1995) found that more than 70% of normal elderly individuals who reported a normal sense of smell were hyposmic or
anosmic. Unawareness of olfactory dysfunction is also found in patients from smell and taste disorder clinics: White and Kurtz (2003) found that 42% of the patients reported an olfactory ability that did not match an objectively assessed ability. Although they did not find significant differences in the frequency of erroneous self-evaluations between young and older adults, they suggested that specific types of meta-cognitive errors are related to the speed of olfactory loss, i.e., either a meta-cognitive error of deficit unawareness associated with slow olfactory loss (as seen in aging) or an underestimation of the performance level occurring in patients experiencing a quick loss of olfactory function (e.g., a loss following an upper respiratory infection). They further proposed that these specific types of meta-cognitive errors may correspond to the speed at which clinical syndromes, such as Alzheimer’s disease (AD), are acquired.

Devanand and colleagues (2000) argued in the same direction finding that the combination of reduced odor identification ability (low performance on an odor identification task) and unawareness of this olfactory dysfunction were highly predictive for AD at follow up. They concluded that the combination of unawareness and low performance on an odor identification task seems to contribute uniquely to the prediction of time to develop AD. Also another longitudinal study confirms that unawareness of deficits of functional abilities may be predictive of dementia in people with mild cognitive impairment (MCI) (Tabert et al., 2002). Yet, the significance of subjective reports of cognitive function as an early indicator of cognitive change in healthy elderly individuals has been and is still a matter of debate (Reisberg & Gauthier, 2008). It is well documented that aging individuals frequently complain about memory dysfunction that is not always reflected in their test performance (Lovelace and Twohig, 1990) and may relate to a number of factors, such as commonly held beliefs about memory (Magnussen et al., 2006) or affective symptoms or physical health problems (Comijs, Deeg, Dik, Twisk, & Jonker, 2002). In their review, Jonker, Geerlings, and Schmand (2000) concluded that individual characteristics and the context in which complaints are expressed may be decisive. That is, complaints in a clinical setting may have a different validity than responses to a questionnaire in population-based studies.

Besides the age-related olfactory decline, olfactory dysfunction is a well-known phenomenon in neurodegenerative diseases, e.g., AD or Parkinson’s disease (Doty, 2003). Since the magnitude of the olfactory impairment seems similar, dysfunction is not specific to any of these diseases (Mesholam, Moberg, Mahr, & Doty, 1998). While the literature seems consistent in finding impaired odor identification in AD patients (Doty, 2003), results on impaired sensitivity seem to be somewhat more variable (Knupfer & Spiegel, 1986; Koss, Weiffenbach, Haxby, & Friedland, 1987). Even studies including both sensitivity and identification tasks have provided conflicting results when asking whether deficits in detection and identification occur independently or are associated. Some authors found that AD patients showed impaired odor identification while their sensitivity level remained preserved (Larsson et al., 1999; Serby, Larson, & Kalkstein, 1991), while others found deficits in both detection sensitivity and identification (Doty, Reyes, & Gregor, 1987; Morgan, Nordin, & Murphy, 1995; Murphy, Gilmore, Seery, Salmon, & Lasker, 1990). Morgan and colleagues (1995) suggested that impaired detection sensitivity in AD may contribute to the observed deficit in odor identification performance, but that additional cognitive components seem to contribute to an impairment.

Due to the prominence of these deficits, a number of studies have followed elderly individuals longitudinally to examine pathways of olfactory performance. Following community-dwelling older adults, Graves et al. (1999) found that odor identification performance could be a better predictor of cognitive decline than results on a global test of cognitive functioning. Other longitudinal studies have demonstrated that performance on odor identification tasks predominantly predicts decline in episodic memory functioning and perceptual speed (Swan & Carmelli, 2002; Wilson, Arnold, Tang, & Bennett, 2006). These findings underline the close association between odor identification performance and several cognitive domains.

The aim of the present study was to compare self-reports of olfactory functioning and test performance on the Scandinavian Odor Identification Test (SOIT; Nordin, Brämerson, Lidén, & Bende, 1998) in middle aged and old adults. Based on prior findings, we hypothesized that a significant increase of SOIT defined olfactory dysfunction with age, whereas the proportion of self-reported olfactory dysfunction was not expected to increase in old participants. Secondly, we investigated cognitive function in participants with and without SOIT defined olfactory dysfunction and awareness of such dysfunction. We expected that participants unaware of their SOIT-defined dysfunction would show lower cognitive function compared to participants aware of their normal olfactory status and as participants aware of their dysfunction.

Methods

Participants

A total of 264 volunteers participated. They were part of a larger study on cognitive aging, brain function, and genetic markers. Recruitment was carried out through advertisement in local newspapers. All participants were native speakers of Norwegian, had completed obligatory basic education (7 years in this cohort), were living independently in their own
homes, and gave their informed consent to participation. The project was approved by the Regional Committee for Research Ethics of Southern Norway and performed according to the Declaration of Helsinki on guidelines for biomedical research involving human subjects (World Medical Association, 1997).

The participants were initially interviewed, and those with previous or present neurological or psychiatric disorders, head trauma, or a history of substance abuse were excluded. Although none of the participants reported a former or current diagnosis of depression, they were asked to fill in The Beck Depression Inventory (BDI; Beck, Steer, and Brown, 1987) as depressive symptoms may interfere with cognitive abilities (Porter, Gallagher, Thompson, & Young, 2003). Participants were excluded from the olfactory assessment due to cold/nasal congestion ($n=6$), nausea ($n=2$), and due to not answering the question about self-reported olfactory function ($n=5$). Based on earlier research indicating that a certain level of sensitivity is necessary to be able to identify odorous stimuli, participants underwent a sensitivity screening. A simplified version of the Connecticut Chemosensory Clinical Research Center (CCCRC) Threshold Test (Cain, 1989) was used to describe the participants in terms of normosmia, hyposmia, or anosmia with respect to detection sensitivity. A two-alternative, forced choice ascending method of limits was used with two concentrations of butanol dissolved in deionized water: 55 ppm and 4444 ppm. Starting with the weakest concentration, the participant was presented with the odorant and a blank solution in randomized order, and asked to indicate which of the two presentations smelled stronger. An incorrect choice on any trial (choosing the blank solution) led to an increase in concentration, whereas a correct choice led to repeated presentation of the concentration until four consecutive correct choices for one concentration were given. Trials were approximately 90 s apart to avoid adaptation. Detection of 55 ppm butanol was categorized as normosmia, detection of 4444 ppm but not 55 ppm as hyposmia, and no detection of 4444 ppm as anosmia. One participant was classified as anosmic and was therefore excluded from further analyses. Ten individuals were not evaluated with this task due to time restrictions and were therefore excluded from analyses.

The final sample consisted of 240 participants, 166 women (69%) and 74 men, aged 45–79 years. To study age-specific associations between cognitive impairment and unawareness of olfactory dysfunction, the sample was divided into two age groups based on earlier findings indicating that a considerable drop in olfactory function often occurs in the sixth decade of life (Brämerson et al., 2004). The groups were labeled “middle aged” (45–64 years, $n=128$; $M=56.1$ (SD 5.2)) and “old” (65–79 years, $n=112$; $M=69.4$ (SD 3.0)). Sample characteristics and self-reported factors potentially causing olfactory dysfunction (Nordin, Brämerson, Murphy, & Bende, 2003) are presented in Table 1. The age groups did not differ in gender distribution ($\chi^2 (1) = 0.5$, $p>.4$). Analyses revealed a single significant difference between age groups with respect to years of education ($t=4.24$, $p<.01$), indicating that the group of old individuals had significantly less years of education than individuals in the middle aged group.

**Subjectively Assessed Olfactory Function**

The participant’s self-reported olfactory function was assessed with the question “How would you estimate your sense of smell?”. The response alternatives were “increased sense of smell”, “normal sense of smell”, and “decreased sense of smell”. For the current study, the first two response alternatives were referred to as normal olfactory function and the third alternative

<table>
<thead>
<tr>
<th>Table 1. Sample characteristics and distribution of factors with potential effect on olfactory performance as well as olfactory status based on detection threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender (%)</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>% (women/men)</td>
</tr>
<tr>
<td><strong>Education (years; mean ± SD)</strong></td>
</tr>
<tr>
<td>$14.5 ± 3.1$</td>
</tr>
<tr>
<td><strong>IQ, WASI (mean ± SD)</strong></td>
</tr>
<tr>
<td><strong>Depression (BDI) (mean ± SD)</strong></td>
</tr>
<tr>
<td><strong>Olfactory statusa (%)</strong></td>
</tr>
<tr>
<td>70/30</td>
</tr>
<tr>
<td><strong>Smoker (%)</strong></td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td><strong>Nasal sinus disease (%)</strong></td>
</tr>
<tr>
<td>21</td>
</tr>
<tr>
<td><strong>Polyposis (%)</strong></td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td><strong>Allergic nasal symptoms (%)</strong></td>
</tr>
<tr>
<td>23</td>
</tr>
<tr>
<td><strong>Seasonal allergy (%)</strong></td>
</tr>
<tr>
<td>24</td>
</tr>
<tr>
<td><strong>Repeated substance exposureb (%)</strong></td>
</tr>
<tr>
<td>14</td>
</tr>
</tbody>
</table>

*aCCCRC Threshold Test.

bExposures included: Herbicides, acid smoke, metal dust, industrial solvents, wood dust, and formaldehyde.
was referred to as olfactory dysfunction. All participants rated their sense of smell before they were assessed with the detection threshold test and the identification test.

Objectively Assessed Olfactory Function

The SOIT was used to objectively assess olfactory function. The test has adequate psychometric properties (test–retest reliability \( r = .79 \), validity \( r = .76 \); Nordin et al., 1998) and is valid for use in Norwegian samples (Wehling, 2009). Olfactory dysfunction was defined according to the diagnostic criteria for young adults: hyposmic: SOIT score of 10–12 (2 SDs below the mean) and anosmic: SOIT score \(< 10\) (4 SDs below the mean) (Nordin et al., 1998) as the objective was to investigate age-related change in olfactory function.

The test includes the 16 odorants: pine needle, peppermint, juniper berry, violet, anise, clove, vanilla, almond (bitter), orange, cinnamon, lemon, lilac, vinegar, tar, ammonia, and apple. Ammonia (1.0 M), tar and vinegar are natural products, while the other odorants are natural oils (Stockholm Ether & Essence Manufactory, Stockholm, Sweden). The odorant was injected into a tampon filled to saturation and placed into an opaque, 80 ml glass jar, sealed with a Teflon lock. The stimuli were presented birhinally 1–5 cm under the participants’ nose. A card with four written response alternatives was placed in front of the participant with the instruction to choose the item that most appropriately identified the odor, with a forced-choice procedure. To avoid effects of adaptation, each stimulus was presented for 3–4 s and with an inter-stimulus interval of about 20 s (Cain & Engen, 1969). No time restrictions were given for the participants to make their choice. Testing was conducted in a well-ventilated room without background odor.

Measures of Cognitive Function

To assess different aspects of cognitive functioning, each participant was tested in an approximately 2.5 h session. The tests were administered and scored by well-trained test technicians or psychologists. Average raw scores were used for analyses and normative data calculated from available manuals (as referenced in parentheses) commonly used in Norway were used to characterize levels of cognitive function in the sample. Two subtests from the Norwegian translation of the Wechsler Abbreviated Scale of Intelligence (WASI; Vocabulary and Matrices; Wechsler, 1999) were included to estimate the participant’s age-adjusted intellectual function. To assess different aspects of attention/executive function, we included the Digit Symbol Test (Wechsler Adult Intelligence Scale – III; Wechsler, 2003), the Trail Making Test (TMT) A and B (Reitan & Davidson, 1974; normative data: Heaton, Miller, Taylor, & Grant, 2004), and the Color-Word Interference Test (Delis, Kaplan, & Kramer, 2001). The California Verbal Learning Test (CVLT II; Delis, Kramar, Kaplan, & Ober, 2000) was included to assess different aspects of learning and memory function. For a more detailed description of these tests see Lezak, Howieson, and Loring (2004). The revised version of the Everyday Memory Questionnaire (EMQ) (Baddeley, 1997; Sunderland, Harris, & Gleave, 1984) was included to assess subjective evaluation of memory functioning. The questionnaire is composed of 28 items describing everyday activities supposed to involve different aspects of memory function. The individuals are asked to indicate the frequency with which they encounter each incident on a 9-point scale (1 = not at all during the last 6 months; 9 = more than once a day). In the present study, an overall score was computed to assess the overall level of self-reported memory failures. Thus, a score of 252 would indicate that memory failures occur several times a day. Reliability analyses of the results from the present sample revealed a Cronbach’s alpha of 0.94, indicating good internal consistency of the questionnaire as a whole.

Data Analysis

SPSS version 15 was used for statistical analyses. Descriptive statistics are presented as means (M) ± standard deviations (SDs). Chi-square analyses were used to compare frequencies. To compare group differences, \( t \)-tests were applied after testing for normality (Kolmogorov–Smirnov test) and homogeneity of variance (Levene’s test). These analyses were completed with calculations of effect sizes, i.e., Cohen’s \( d \) for parametric tests. According to Cohen’s definition (Cohen, 1992), an effect size \( \geq 0.15 \) and \(< 0.40 \) represented a small effect, \( \geq 0.40 \) and \(< 0.75 \) represented a medium effect, and an effect size \( \geq 0.75 \) represented a large effect. Analyses were two-tailed except for the comparisons on cognitive measures since we had directed hypotheses (individuals unaware of their dysfunction would perform lower on cognitive measures than individuals correctly evaluating their olfactory function). The alpha-level was set at 0.05.
Results

Olfactory Function

The number of participants with objectively and subjectively assessed olfactory dysfunction in each age group is given in Table 2. Analyses revealed that a higher number of men than women were unaware of their olfactory dysfunction: $\chi^2 (1) = 5.58, p < .02$, and that the group of unaware individuals included more smokers than the group of aware normosmic individuals: $\chi^2 (1) = 8.1, p < .01$. An objectively assessed olfactory dysfunction was found to be more common in the old (32.1%) compared to the middle aged (17.2%) group: $\chi^2 (1) = 7.29, p < .01$, whereas the old group (13.4%) was found not to differ from the middle aged (10.2%) group with respect to subjectively assessed dysfunction: $\chi^2 (1) = 0.61, \text{ ns}$. Among participants with an objectively assessed olfactory dysfunction, 78% of the old and 86% of the middle aged were defined as unaware. The overall sensitivity of self-reported olfactory dysfunction was 19.0%, the specificity was 90.7%, and the overall correct classification rate was 73.3%.

Cognition and Unawareness of Olfactory Dysfunction

According to the normative data on measures of cognitive functioning, the groups showed average to above-average performance according to normative data (Table 3). To explore whether there was a difference in non-olfactory cognitive performance in participants who were unaware of their olfactory dysfunction (diagnosed as hyposmic/anosmic but reported having normal olfactory function) compared to the participants correctly reporting normal olfactory function (normosmic), separate $t$-tests were conducted on raw scores within each age group (Table 3).

Results revealed lower cognitive performance on a number of measures in the groups of participants unaware of their olfactory dysfunction compared to participants correctly reporting normal olfactory function (Table 3). In the middle aged group, statistically significant differences with medium sized effects ($d$) according to the Cohen’s definition were shown on the Stroop-Color Word Interference Test ($d = 0.49$) and the Digit Symbol Test ($d = 0.51$). The group difference for the Delayed Free Recall score from the CVLT indicated a large size effect ($d = 0.76$). In the old group, significant differences with medium sized effects were shown on the Digit Symbol Test ($d = 0.44$), the Total Learning score ($d = 0.52$), and Delayed Free Recall score from the CVLT ($d = 0.48$).

Further analyses comparing cognitive function in individuals unaware of their olfactory dysfunction with those who were aware of their dysfunction were restricted to the old group (unaware of olfactory dysfunction $n = 28$, aware of olfactory dysfunction $n = 8$, and aware of normal olfactory status $n = 69$) due to small cell numbers in one of the middle aged groups (aware of olfactory dysfunction $n = 3$). Analyses comparing performance scores of unaware individuals ($n = 28$) with those aware of their olfactory dysfunction ($n = 8$) revealed a significant difference on the TMT B: $t (34) = 2.05, p < .03$, with a large-sized effect ($d = 0.85$), and a significant difference for the CVLT Total Learning score: $t (34) = -1.94, p < .04$, with a large-sized effect ($d = 0.8$), indicating that the individuals unaware of their olfactory dysfunction showed lower performance on these tasks compared to participants being aware of their dysfunction. Final analyses revealed no significant differences when performance scores of the old correctly reporting a normosmic status ($n = 69$) were compared with performance scores of individuals aware of their dysfunction ($n = 8$).

For the EMQ, a single significant difference was found between the groups of individuals unaware of their olfactory dysfunction and the individuals correctly reporting to be normosmic in the middle aged group: $t (114) = -2.99, p < .01$ (Table 3), indicating that middle aged individuals unaware of their olfactory dysfunction had significant higher scores on the EMQ than middle aged participants with normal olfactory function. Follow-up calculations revealed a large-sized effect ($d = 0.81$).

Table 2. Number of participants with objectively and subjectively assessed normal and olfactory dysfunction according to performance on the SOIT

<table>
<thead>
<tr>
<th>Subjective assessment</th>
<th>Objective assessment</th>
<th>Normal</th>
<th>Dysfunction</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Middle aged</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>96</td>
<td>19</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Dysfunction</td>
<td>10</td>
<td>3</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td><strong>Older</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>69</td>
<td>28</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>Dysfunction</td>
<td>7</td>
<td>8</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>182</td>
<td>58</td>
<td>240</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Means (SD) on cognitive tests in middle aged and old participants classified as unaware of olfactory dysfunction and normosmic performance on several neuropsychological measures compared to individuals with normal olfactory function.

<table>
<thead>
<tr>
<th>Test (s)</th>
<th>Raw scores</th>
<th>Adjusted scores</th>
<th>P-value</th>
<th>Raw scores</th>
<th>Adjusted scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Middle aged</td>
<td>Old</td>
<td></td>
<td>Middle aged</td>
<td>Old</td>
</tr>
<tr>
<td></td>
<td>Unaware (n = 19)</td>
<td>Normosmic (n = 96)</td>
<td>p-value</td>
<td>Unaware (n = 28)</td>
<td>Normosmic (n = 69)</td>
</tr>
<tr>
<td>Digit-Symbol Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>48.6 (8.1)</td>
<td>53.7 (10.3)</td>
<td>0.02</td>
<td>43.5 (7.9)</td>
<td>46.1 (9.7)</td>
</tr>
<tr>
<td></td>
<td>34.8 (7.1)</td>
<td>32.6 (9.1)</td>
<td>ns</td>
<td>46.1 (6.6)</td>
<td>47.0 (8.7)</td>
</tr>
<tr>
<td>TMT-B (s)</td>
<td>75.7 (18.6)</td>
<td>71.0 (21.4)</td>
<td>ns</td>
<td>48.8 (7.1)</td>
<td>49.7 (9.0)</td>
</tr>
<tr>
<td>Color-Word Interference Test (s)</td>
<td>59.3 (10.5)</td>
<td>53.4 (12.5)</td>
<td>0.03</td>
<td>10.4 (1.8)</td>
<td>11.8 (2.6)</td>
</tr>
<tr>
<td>Total learning, CVLT</td>
<td>50.5 (10.2)</td>
<td>53.8 (9.8)</td>
<td>ns</td>
<td>55.4 (9.8)</td>
<td>57.9 (10.7)</td>
</tr>
<tr>
<td>Delayed free recall, CVLT</td>
<td>10.9 (3.3)</td>
<td>12.9 (2.5)</td>
<td>0.002</td>
<td>0.3 (0.9)</td>
<td>0.8 (0.9)</td>
</tr>
<tr>
<td>Everyday Memory Questionnaire</td>
<td>87.0 (33.6)</td>
<td>63.5 (28.4)</td>
<td>0.002c</td>
<td>64.4 (36.0)</td>
<td>64.0 (32.2)</td>
</tr>
</tbody>
</table>

*aBased on normative data from test-manuals (t-scores except for Color-Word Interference Test and Delayed free recall (CVLT) where means (SD) from scaled scores are presented).

*bOne tailed.

*cTwo tailed.

Discussion

The objective of the present study was to investigate unawareness of olfactory dysfunction in middle aged and old adults as well as associations between cognitive functioning and unawareness of olfactory dysfunction. Our findings revealed that about 24% of all individuals in the sample were classified as having an olfactory dysfunction, and that 81% of these were unaware of this dysfunction. Of particular interest was the finding that participants unaware of their olfactory dysfunction showed lower performance on several neuropsychological measures compared to individuals with normal olfactory function.

In accordance with our hypothesis and earlier population-based studies of individuals aged ≥50 years (Brämerson et al., 2004; Murphy et al., 2002), the results revealed an increase in diagnosed olfactory dysfunction. The results confirmed our hypothesis that the proportion of individuals reporting olfactory dysfunction would not increase significantly with age. Among the middle aged participants, 86% were unaware of an olfactory dysfunction, while the proportion was slightly lower in the old group (78%). Furthermore, results showed that men were more likely to be unaware of their olfactory dysfunction than women.

In comparison to White and Kurtz (2003), who reported that 41% of elderly individuals were unaware of their olfactory dysfunction, our results better matched the findings of Nordin and colleagues (1995), reporting that 77% of elderly individuals were unable to accurately estimate their olfactory ability. However, both studies differed from ours: White and Kurtz (2003) examined patients from a smell and taste clinic, thus their patients could be expected to be more attentive of a dysfunction. Nordin et al. (1995) used a detection sensitivity task to assess smell dysfunction, while our data were based on a cued identification task. In retrospect, this latter aspect may highlight an important issue in the assessment of unawareness of olfactory dysfunction. By posing the rather general question (“How would you estimate your sense of smell”) in our study, participants may have either referred to their detection sensitivity or their ability to identify odors although their answers were solely related to an identification task. It is not possible to untangle this issue within the current study. To get an indication, we conducted an additional analysis using the data from the detection screening task to categorize participants. 

An important finding was that the majority of the participants were able to correctly judge their olfactory status, indicated by a correct classification rate of 73%. Yet, the low sensitivity rate (19%) is in agreement with earlier findings revealing that self-reports of olfactory dysfunction show poor accuracy in older individuals (Murphy et al., 2002; Nordin et al., 1995). Thus, our findings support the notion that changes in sensory functions in aging occur rather unnoticed as they take place gradually. Nevertheless, it is notable that self-reports of olfactory dysfunction in elderly individuals seem to be considerable lower (e.g., our study 12% and 9.5%; Murphy et al., 2002) compared to reports on impairment in auditory (33%; Campbell, Crews, Moriarty, Zack, & Blackman, 1999) or visual systems (18%; Campbell et al., 1999). Changes in these systems also
occur progressively with age, and even though an explanation has to remain speculative at this point, it is assumable that the auditory and visual systems are more pertinent to everyday activities and thus that impairment is noticed earlier. Another argument may be that an assessment of vision and auditory systems may be easier accessible.

So far, little systematic research has investigated the impact of olfactory dysfunction on everyday life, but recent studies suggest that quality of life, nutritional intake, or interpersonal relations may be affected by olfactory dysfunction (Hummel & Nordin, 2005).

An important finding in the present study was that individuals unaware of their olfactory dysfunction showed lower performance on tests of memory function and processing speed/attention compared to participants with normal olfactory function. Following Devanand and collaborators’ (2000) argumentation, this could indicate that a number of the unaware individuals could potentially be at risk for cognitive decline. In fact, some of the scores indicating a significant difference between groups are known to be among the most sensitive markers for cognitive decline and subsequent dementia, i.e., the delayed free recall and total learning scores from the CVLT (Albert, Blacker, Moss, Tanzi, & McArdle, 2007; Albert et al., 1999; Grober & Kawas, 1997; Grober et al., 2008). However, concerns against this suggestion must be acknowledged. First, it is unlikely that individuals as young as those in the middle aged group should be on the verge of developing dementia. Secondly, the normative data were not supportive for a status close to dementia or cognitive impairment: Performance in all groups was about average according to the established norms on all cognitive measures. Since this does not eliminate the risk of including individuals who might be in the preclinical phase of dementia in a cross-sectional study such as ours, we examined how many participants performed at least 1.5 SDs below normative data in their age group on the delayed memory measure, an often used cut-off score to define MCI (Petersen et al., 1999). Only two participants in the middle aged and none in the old group performed below this cut-off. This strengthens the argument that it was highly unlikely that several participants in the sample were in a phase of an imminent diagnosis of dementia.

An alternative explanation of the positive association between cognitive performance and awareness of olfactory dysfunction is that individuals with higher cognitive functioning are more attentive to their abilities. This argumentation is supported by the finding that participants aware of their dysfunction performed better on cognitive tests than unaware participants. Although, the only statistically significant differences were found on the TMT-B and the Total Learning Score from the CVLT, we argue that this may be due to the lack of statistical power because of the small group sizes. Furthermore, equal performance levels (no significant differences) between the group of individuals correctly evaluating themselves as normosmic and individuals aware of their olfactory dysfunction as well as lower performance levels in individuals unaware of their dysfunction compared to individuals aware of their dysfunction strengthen the suggestion of a difference in meta-cognitive attention between the groups.

The results in the current study support earlier findings showing that performance on cognitive measures of memory and attention/processing speed are linked to odor identification performance in old adults (Finkel, Pedersen, & Larsson, 2001; Larsson, Finkel, & Pedersen, 2000; Larsson, Oberg, & Bäckman, 2005; Royall, Chiodo, Polk, & Jaramillo, 2002; Swan & Carmelli, 2002; Wehling, Nordin, Espeseth, Reinvang, & Lundervold, 2010; Westervelt, Ruffolo, & Tremont, 2005;) and strengthen suggestions that these functions rely on the integrity of some of the same neuroanatomical structures, in particular hippocampal/limbic regions (Jones-Gotman et al., 1997; Murphy, Jernigan, Fennema-Notestine, 2003).

A somewhat surprising result was found when comparing groups with respect to scores on the EMQ. Middle aged individuals unaware of their olfactory dysfunction reported the highest rate of memory difficulties compared to the other groups. The relationship between self-reports of memory functioning and objective memory functioning is complex (Reisberg & Gauthier, 2008). Besides being proposed as an early symptom for cognitive impairment or dementia (Reisberg & Gauthier, 2008), memory complaints have been associated with several other factors, e.g., health status, neuropsychiatric symptoms (e.g., depression and anxiety), and personality characteristics (Comijs et al., 2002). Thus, a number of factors may have contributed to the results. Despite our general attitude that complaints should always be taken seriously, we argue that the findings here may give little cause of concern: The average score of 85 on the EMQ in the middle aged group corresponds to a mean frequency rating for each item of less than once a month, and an average score of 65, as shown in the remaining groups, indicates memory failures a few times within a period of 6 months, which may not have consequences for daily functioning.

This study has limitations. As mentioned earlier, we have to acknowledge that our question concerning awareness of olfactory dysfunction is global and that more specific questions about detection sensitivity and identification could further contribute to an understanding of the complex construct of unawareness of olfactory dysfunction. Furthermore, the background variables indicated a significantly higher number of smokers in the group of unaware participants. It is a common belief that smoking has an adverse effect on the ability to smell. However, results have not always been conclusive: Effects have, in particular, been shown on detection sensitivity and perceived intensity (Ahlström, Berglund, Berglund, Engen, & Lindvall, 1987; Hubert, Fabitz, Feinleib, & Brown, 1980; Joyner, 1964; but see also Pangborn, Trabue, & Barylko-Pikielna, 1967; Venstrom & Amoore, 1968) and Pye, Schwartz, and Doty (1990) clearly documented an adverse effect of smoking on odor identification...
performance. However, it could also be suggested that smokers may pay more attention to their sense of smell (eventually motivated by the common belief that smoking impairs the sense of smell) and thus have a more realistic view of their functional status than nonsmokers have. Since this seemed not to be the case in our study, we reran our analyses excluding current smokers which did not change our results. Thus, even though smoking may have influenced odor identification performance to some extent, they did not account for the found effects.

In summary, the present study reveals that unawareness of olfactory dysfunction increases with older age. Middle aged and old (non-demented) individuals unaware of their olfactory dysfunction performed more poorly on a number of cognitive tests than individuals aware of their olfactory status. Based on our findings, we suggest that unawareness of olfactory dysfunction may be a rather normal phenomenon in aging individuals, although the impact on everyday life needs to be determined. The clinical relevance of unawareness of olfactory dysfunction as suggested by Devanand and collaborators (2000) needs further investigation and stresses the need of an extensive multi-modal and longitudinal assessment of unawareness of sensory and cognitive function to learn more about the facets of the concept of unawareness.

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Conflict of Interest

None declared.

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