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Self-Reported Mini Olfactory Questionnaire (Self-MOQ): A Simple and Useful Measurement for the Screening of Olfactory Dysfunction

Lai-quan Zou, PhD; Lena Linden, MD; Mandy Cuevas, MD; Marie-Luise Metasch, MD; Antje Welge-Lüssen, MD; Antje Hähner, MD; Thomas Hummel, MD

Objectives: Olfactory dysfunction is a common problem. However, too little attention has been paid to questionnaires used to evaluate quantitative olfactory dysfunction. Therefore, the current study aimed to develop a simple self-reported Mini Olfactory Questionnaire (Self-MOQ) for the screening of quantitative olfactory dysfunction in clinical practice.

Methods: Two hundred and eighty-five patients who had subjective complaints of olfactory disorder participated. The Sniffin’ Sticks test score was used to define functional anosmia, hyposmia, or normosmia. We assessed the factor structure as well as internal consistency, convergent validity, and discrimination performance.

Results: The results showed that the final version of the Self-MOQ included only one factor with five items. The Self-MOQ has a good internal reliability (Cronbach’s α = 0.84) and validity (r = −0.60, P < 0.001). The receiver operating characteristic analyses indicated that the Self-MOQ as compared to a visual analogue scale (VAS) is an effective measure for discriminating normosmic from hyposmic/anosmic patients, anosmic patients, and hyposmic patients.

Conclusion: The Self-MOQ is a simple, reliable and valid questionnaire to screen olfactory dysfunction in clinical practice that appears to be superior to the use of VASs but does not replace olfactory testing.

Key Words: Anosmia, hyposmia, reliability, validity, ROC.

Level of Evidence: 4

INTRODUCTION

Recent studies have shown that olfactory dysfunction is a common problem. Several large population-based studies using validated olfactory tests have reported that anosmia and hyposmia—the inability or decreased ability to smell—occurred in 19% to 24%1–4 (depending on age and literature) in the general population. Olfactory dysfunction may reduce quality of life, whereas the sense of smell plays a vital role in many areas such as food enjoyment, cooking, avoidance of danger, and social communication.5

Reliable, standardized psychophysical tests for evaluating the olfactory function in humans are available. The Sniffin’ Sticks test6 (Burghart; Wedel, Germany) and the University of Pennsylvania Smell Identification Test7 (Sensonics Inc., Haddon Heights, NJ) are the two best known tests in clinical practice and research. These tests are easy to implement and have a good reliability and validity. However, during many general health exams these tests are not available because they require a certain amount of time and are costly. In these situations, olfactory function in patients is often evaluated based on patient self-assessment using a single question, such as “How would you estimate your sense of smell?” Participants are asked to mark their performance on a visual analogue scale (VAS) of 100 mm length, the left end of the scale indicating no olfaction and the right end indicating perfect olfaction. Several studies demonstrated that subjective ratings of olfactory ability were moderately related to the Sniffin’ Sticks test scores in patients who were aware of their olfactory dysfunction.8–10 However, simply ratings of the degree of olfactory function on a VAS may be misleading. Up to now, it appears that too little attention has been paid to the questionnaires used to self-assess olfactory function. The Questionnaire for Olfactory Dysfunction, developed by Frasnelli and Hummel,11,12 is widely used in a clinical context, but it concerns qualitative olfactory dysfunction (i.e., parosmia) and quality of life. There has long been a need for psychometric tools with established validity and reliability that screen quantitative olfactory dysfunction (i.e., anosmia and hyposmia) in patients reporting olfactory problems when psychophysical testing is not available.

The current study aimed to 1) develop a simple and useful self-reported Mini Olfactory Questionnaire (Self-MOQ) for the screening of quantitative olfactory dysfunction in clinical practice, 2) investigate the correlation between the Self-MOQ scores and Sniffin’ Sticks test scores, and 3) analyze the ability of the Self-MOQ score to discriminate normosmic from hyposmic/anosmic patients, anosmic patients, and hyposmic patients.
scores, and 3) determine the cutoff points of Self-MOQ score by receiver operating characteristic (ROC) curves.

**MATERIALS AND METHODS**

**Participants**

Two hundred and eighty-five patients (125 men, 160 women, aged 17–86 years, mean age 56.93 ± 14.67 years) presenting to the Smell and Taste Clinic of our department at Technische Universität Dresden, Dresden, Germany were studied from November 2018 until May 2019. All patients had subjective complaints of olfactory disorder. The patients presented to the clinic for various reasons: suspected idiopathic olfactory disorder (95 patients), suspected postviral olfactory disorder (84 patients), sinusosal olfactory disorder (53 patients), suspected post-traumatic olfactory disorder (47 patients), suspected neurodegenerative olfactory disorder (1 patient), and others (5 patients). The investigations were approved by the local ethics committee.

**Psychophysical Olfactory Function**

Orthonasal olfactory function was assessed using the Sniffin' Sticks test, including olfactory threshold (T), olfactory discrimination (D), and olfactory identification (I). The participants’ maximum scores for each subsection of the Sniff’ Sticks test was 16. Results from the three tests were presented as a composite TDI score (range 1–48) and then used to define functional anosmia (TDI ≤16), hyposmia (16 < TDI < 31), or normosmia (TDI ≥31). Examinations were performed bilaterally testing both nostrils simultaneously.

**Visual Analogue Scale**

Participants were asked to mark their olfactory function on a VAS of 100 mm length, the left end indicating no olfactory function and the right end perfect olfactory function. The mark was then converted into a score ranging from 0 to 100.

**Self-Reported Mini Olfactory Questionnaire**

Based on review of the existing literature and on clinical experience, we developed the initial Self-MOQ, which consists of 14 true/false items (see Table I). The items are formulated as personal statements, which reflect complaints about olfactory problems in daily life (e.g., “I like to look around the flower shop, but I cannot smell anything”).

**Statistical Analysis**

Statistical analyses were performed using SPSS 22.0 (IBM SPSS Statistics for Windows, Version 22.0., Armonk, NY). Exploratory factor analysis (EFA) was performed with principal component analysis. Factors with eigenvalues greater than 1 were extracted using the OBLIMIN (PROMAX) rotation. The Cronbach’s α coefficient was calculated to determine the questionnaire’s reliability. The Pearson’s coefficient of correlation between the Self-MOQ score and the TDI total score was calculated to determine the questionnaire’s convergent validity.

ROC curves were used to assess and compare the discriminating performance of the Self-MOQ, and VAS was used to predict olfactory dysfunction (hyposmia and anosmia). The alpha level was set at P < 0.05. Specifically, MedCalc version 11.5 (MedCalc Software,Mariakerke, Belgium) was used to analyze the ability to discriminate between: 1) normosmic and anosmic or hyposmic patients; 2) normosmic and hyposmic patients; and 3) normosmic and anosmic patients. To compare the discrimination performance of the Self-MOQ and VAS, a nonparametric approach was used to compare ROC curves by comparing areas under two correlated ROC curves, as described by DeLong et al.

**RESULTS**

**Demographics**

The mean threshold score of the Sniffin' Sticks test was 2.57 ± 2.41; the mean discrimination score was 8.15 ± 3.32; and the mean identification score was 7.62 ± 3.91. The mean TDI score was 18.19 ± 8.35. Based on the TDI score, 128 patients (44.9%) were considered as functionally anosmic (TDI: 10.71 ± 2.77); 130 patients (45.6%) were considered as hyposmic (TDI: 22.27 ± 4.52); and 27 patients (9.5%) were considered as normosmic (TDI: 34.02 ± 1.85), despite the presence of complaints of olfactory dysfunction.

**Exploratory Factor Analysis**

Item-total correlation analyses were performed on the 14 items of the initial version Self-MOQ. The results showed that all the items had moderate or high correlations with the total score (0.55 < r < 0.83). Before the EFA, Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity test were conducted to evaluate the sampling adequacy. The results showed that the KMO value was 0.923, and the Bartlett’s sphericity test was significant ($\chi^2 = 1831.57, df = 91, P < 0.001$), indicating that the sample met the criteria for EFA. Principal component factor analysis was performed using Varimax rotation with Kaiser
normalization. Two factors were obtained according to the criterion of eigenvalue greater than 1 (6.59 and 1.03, respectively) and explained 54.46% of the total variation. Items were removed if 1) the communal values were lower than 0.4 (item 7); 2) factor-loading values were lower than 0.4 (none); and 3) factor-loading values were higher than 0.3 on more than one factor and the difference was lower than 0.4 (item 7); 2) factor-loading values were lower than 0.4 on more than one factor and the difference was lower than 0.3 (items 14, 11, 8, 12, and 6). Finally, eight items (MOQ total) were reserved; five items were loaded onto the first factor (MOQ_1: items 1, 3, 5, 9 and 13) and accounted for 50.059% of the variance; and three items were loaded onto the factor two (MOQ_2: items 2, 4 and 10), which accounted for 12.591% of the variance.

Reliability and Convergent Validity

The Cronbach’s α coefficients were 0.854 (MOQ_total), 0.842 (MOQ_1), and 0.695 (MOQ_2), respectively. The Cronbach’s α coefficient should have a minimum value of 0.7 for preliminary research. The Cronbach’s α of MOQ_2 was less than 0.7; thus, this factor was removed; that is, the final version Self-MOQ only included the factor 1 for further analysis. The Self-MOQ score was significantly moderate correlated with olfactory threshold (r = −0.525, P < 0.001), olfactory discrimination (r = −0.521, P < 0.001), olfactory identification (r = −0.547, P < 0.001), and TDI score (r = −0.597, P < 0.001).

Relationship of the Self-MOQ and Sniffin’ Sticks Scores to the Demographic Variables and VAS

Correlational analyses revealed that Self-MOQ was not significantly related to age (r = 0.106, P = 0.076) and duration of illness (r = 0.065, P = 0.274). When analyzed the relationships in each subgroup (idiopathic, postvirus, sinunasal, and posttrauma) there was significant relationship between Self-MOQ score and age in the postvirus group (r = 0.380, P < 0.001) but not in the other groups (P > 0.05). No such relationship between Self-MOQ and duration of illness was found in each group (P > 0.05). The Self-MOQ scores were significantly low related to age (threshold: r = −0.189, P = 0.002; identification: r = −0.134, P = 0.024; TDI: r = −0.159, P = 0.007; except discrimination: r = −0.112, P = 0.062) and duration of illness (threshold: r = −0.124, P = 0.039; discrimination: r = −0.191, P = 0.001; identification: r = −0.188, P = 0.002; TDI: r = −0.191, P = 0.001). Statistical analyses using t tests detected no significant effects of sex for Self-MOQ and Sniffin’ Sticks test scores (P > 0.05).

In addition, the results showed that there were negative low relationships between VAS and Sniffin’ Sticks test scores (threshold: r = −0.281, P < 0.001; discrimination: r = −0.276, P < 0.001; identification: r = −0.285, P < 0.001; TDI: r = −0.293, P < 0.001). However, when analyzing the relationships for each of the four main subgroups (idiopathic, postviral, sinunasal, and posttraumatic), there was no significant relationship between VAS and Sniffin’ Sticks test scores (P > 0.05). The correlations between VAS, Self-MOQ, and Sniffin’ Sticks test scores are shown in Table II.

ROC Analysis of Self-MOQ Score and VAS With the Olfactory Dysfunction

Table III shows the area under the curve values for Self-MOQ and VAS, as well as the cutoffs—those points at which the sum of sensitivity and specificity are maximized. The ROC curves are represented in Figure 1. The

### Table II

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Discrimination</th>
<th>Identification</th>
<th>TDI</th>
<th>MOQ</th>
<th>VAS</th>
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</thead>
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<td>Threshold</td>
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<td></td>
<td></td>
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<tr>
<td>Discrimination</td>
<td>0.574**</td>
<td>1</td>
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<tr>
<td>Identification</td>
<td>0.574**</td>
<td>0.652**</td>
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<tr>
<td>TDI</td>
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<td>−0.521**</td>
<td>−0.547**</td>
<td>−0.597**</td>
<td>1</td>
</tr>
<tr>
<td>VAS</td>
<td>−0.281**</td>
<td>−0.276**</td>
<td>−0.285**</td>
<td>−0.293**</td>
<td>0.419**</td>
</tr>
</tbody>
</table>

**P < 0.001.

MOQ = Mini Olfactory Questionnaire; Self-MOQ = Self-Reported Mini Olfactory Questionnaire; TDI = Sniffin’ Sticks (threshold, discrimination, identification) total score; VAS = Visual Analogue Scale.

### Table III

<table>
<thead>
<tr>
<th>Normosmic vs. Anosmic/Hyposmic</th>
<th>Normosmic vs. Hyposmic</th>
<th>Normosmic vs. Anosmic</th>
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</thead>
<tbody>
<tr>
<td>Cutoff</td>
<td>AUC</td>
<td>P Value</td>
</tr>
<tr>
<td>MOQ</td>
<td>3.50</td>
<td>0.85 ± 0.04</td>
</tr>
<tr>
<td>VAS</td>
<td>0.28</td>
<td>0.65 ± 0.03</td>
</tr>
</tbody>
</table>

AUC = area under the curve; MOQ = Mini Olfactory Questionnaire; Se = sensitivity; Sp = specificity; Self-MOQ = Self-Reported Mini Olfactory Questionnaire; VAS = Visual Analogue Scale.
discrimination performance of the Self-MOQ was significantly greater than the discrimination performance of VAS when assessing the ability to discriminate between 1) normosmic and hyposmic/anosmic patients ($P = 0.0001$), 2) normosmic and anosmic patients ($P < 0.0001$), and 3) normosmic and hyposmic patients ($P = 0.003$).

**DISCUSSION**

A simple and useful psychometric tool appears to be needed for the screening of quantitative olfactory dysfunction (i.e., functional anosmia and hyposmia) in patients reporting olfactory problems in clinical practice, and the current cross-sectional study was conducted to address this issue. Based on the results of the EFA and reliability analysis, the final version Self-MOQ only included one factor (5 items). The Cronbach’s $\alpha$ coefficient for the Self-MOQ was 0.842, demonstrating good internal consistency. In addition, the convergent validity results showed significant negative correlations between the Self-MOQ score and Sniffin’ Sticks scores, thus indicating that the questionnaire is an efficient tool to measure olfactory dysfunction.

The ROC analyses indicated that the Self-MOQ is an effective measure for discriminating between normosmic and hyposmic/anosmic patients, normosmic and anosmic patients, and normosmic and hyposmic patients. For the sample in the current study, the optimal scores were 3.5, 4.5, and 3.5 for distinguishing normosmic from hyposmic/anosmic patients, anosmic patients, and hyposmic patients, respectively. At the optimal cutoff scores, the measure had good sensitivity and specificity. In addition, the Self-MOQ differentiated normosmic from hyposmic or anosmic patients better than the VAS.

The results of current study showed that there was a negative relationship between VAS and Sniffin’ Sticks test score in each subgroup (idiopathic, postviral, sinonasal, and posttraumatic). Landis et al.\textsuperscript{18} showed that there was also no significant correlation between subjective olfactory ability and Sniffin’ Sticks scores in patients with ototorhinolaryngological complaints but reportedly normal olfaction. Therefore, the results of our study emphasize that olfactory self-assessment using VAS are not congruent with results from psychophysical assessment of olfactory function. To some degree, the same also applies to the results from the Self-MOQ. This supports the interpretation that subjective ratings of olfactory function are overshadowed by a multitude of different aspects, such as motivation to seek counseling for olfactory loss or coping with this situation.\textsuperscript{16}

The objective olfactory function evaluated by the Sniffin’ Sticks decreased with age in the present study, consistent with results from of Hummel et al.\textsuperscript{17} Interestingly, the results of the whole sample in the current study seem to indicate that subjective olfactory function evaluated with the Self-MOQ does not change with age. Similarly, Croy et al.\textsuperscript{18} reported that the significance of the sense of smell did not change with age. However, there was a significant relationship between Self-MOQ score and age in the postviral group but not in the other subgroups (idiopathic, sinonasal, and posttraumatic). The reason may be that the participants barely noticed the olfactory dysfunction, which often seems to be the case when olfactory loss occurs gradually as in age-related olfactory dysfunction, which may allow other senses like taste and trigeminal function to gradually replace the sense of smell,\textsuperscript{18} for example, during eating and drinking.

A limitation of this study is that we did not analyze the test–retest stability of the questionnaire scores over time. Further research will address this issue. Another limitation is that we did not compare the performance of patients from different cultures in the Self-MOQ. This needs to be addressed in future study. Notwithstanding this limitation, the 5-item Self-MOQ proved to be easy to administer, and it took participants about 2 minutes to...
fill in. Scoring of the Self-MOQ was generally achieved within 0.5 minutes.

CONCLUSION
The Self-MOQ has been shown to be a simple, reliable, and valid questionnaire to screen olfactory dysfunction in clinical practice that appears to be better than using a VAS scale. However, this does not replace olfactory testing.

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