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EROL scale: A new behavioural olfactory measure and its relationship with anxiety and depression symptoms

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Introduction: The main objective of this study was to develop and validate a new olfactory measure that assesses the influence of olfaction on several emotional, behavioural, and cognitive issues: The Relational Scale of Olfaction (EROL). A secondary objective was to explore the relationship between the olfactory function and the anxiety and depression symptoms by means of EROL and the Hospital Anxiety and Depression Scale (HADS). A positive relationship between anxiety symptoms and the olfactory function was hypothesized. Regarding depressive symptoms, a significant relationship with the olfactory scores was not expected.

Method: Psychometric properties of EROL scale and correlations between HADS and EROL were tested in a sample from the general population.

Results: EROL showed an adequate level of test-retest reliability (ICC=.748) and good internal consistency (Cronbach's alpha=.761). Convergent validity with other olfactory measures was satisfactory. A one-factor solution was found for the scale. HADS showed a significant relationship with EROL ($r=.280$, $p<.01$), but the analysis through dimensions revealed that only the anxiety subscale correlated significantly and moderately with the olfactory measure ($r=.325$, $p<.001$), whereas the correlation with the depression subscale was non-significant ($r=.146$, $p>.05$).

Conclusions: Given that EROL displayed good psychometrical properties, it appears as a suitable tool to assess the olfactory function in general population. The relationship between this olfactory scale and anxiety symptoms found in this study is an interesting issue that requires further research.

Key words: Olfaction, Scales, Reliability, Validity, Anxiety

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La escala EROL: Una nueva medida olfatoria conductual y su relación con los síntomas ansiosos y depresivos

Introducción: El objetivo principal de este estudio fue desarrollar y validar una nueva escala olfatoria que evalúa la influencia del olfato en diferentes cuestiones emocionales, conductuales y cognitivas: La escala relacional sobre el olfato (EROL). El objetivo secundario consistió en explorar la relación entre la función olfatoria y los síntomas de ansiedad y depresión mediante la escala EROL y la Escala Hospitalaria de Ansiedad y Depresión (HADS). Se hipotetizó una relación positiva entre los síntomas de ansiedad y la función olfatoria. En cambio, no se esperó ningún tipo de relación significativa entre los síntomas depresivos y la medida olfatoria.

Metodología: Se evaluaron las propiedades psicométricas de la escala olfatoria y se calcularon las correlaciones entre EROL y HADS en una muestra de la población general.

Resultados: EROL mostró un nivel adecuado de fiabilidad test-retest con un coeficiente de correlación intraclass de 0.748. El alfa de Cronbach de 0.761 indicó una buena consistencia interna. La validez convergente con otras escalas olfatorias fue satisfactoria. El análisis factorial presentó una solución unidimensional. Se halló una relación significativa entre las escalas EROL y HADS ($r=0.280$, $p<0.01$), pero el análisis por subescalas reveló que sólo la dimensión de ansiedad correlacionaba significativamente y de forma moderada con la medida olfatoria ($r=0.325$, $p<0.001$), mientras que la correlación con la de depresión no fue significativa ($r=0.146$, $p>0.05$).

Conclusiones: Las adecuadas propiedades psicométricas de la escala EROL indican que es un instrumento útil para valorar la función olfatoria en la población general. La relación que se ha hallado entre esta escala y los síntomas de ansiedad es un tema que requiere más investigación.

Palabras clave: Olfacción, Escalas, Fiabilidad, Validez, Ansiedad

INTRODUCTION

Data from animal models and human studies currently imply numerous and complex effects of smell on behaviour, cognition, and specially on emotional responses.¹⁻³ The sense of smell differs from most other senses in its heavy affective loading. The reason for this emotional predominance is that the olfactory system has direct anatomic and phylogenetic linkages to the limbic system, making it the sensory system most closely related to parts of the brain which appear to mediate emotion.^{4,5} However, several studies suggested that odours do not affect everybody in the same way, neither in the same magnitude.^{6,7} This variability may pertain to psychobiological propensities controlled by genetic determinants, individual exposure effects, gender, development or health, or to more general influences linked to cultural biases or expertise.⁸

Taking into account the impact of odours in our lives and the existence of these individual differences, at a research level, it's very useful to have at our disposal instruments that allow us to measure it. There are several questionnaires in which adult people give self-reports related to their sense of smell,^{6,7,9-11} but there are interesting olfactory issues and some shades that the existing olfactory scales do not cover. The incorporation of these topics would contribute to increase the content validity of the set of instruments assessing the olfactory construct. Taking this into account, a new scale was developed by the authors of the present study: The Relational Scale of Olfaction (original Spanish name: *Escala Relacional sobre el Olfato* (EROL)). These items were developed taking into account the phylogenetic function of olfaction on mating behaviour¹², safety and attractiveness that odours can provide¹³, as well as the reported influence of olfactory stimuli on space perception¹⁴.

The main purpose of this study was to develop and validate this new olfactory scale (EROL). In addition to this aim, another issue was also addressed. Taking into account the close relationship between the emotions and the sense of smell, the secondary objective of this study was to assess the relationship between the olfactory function and emotional states as anxiety and depression at the symptomatic level. It must be noted that since the study has been developed in the general population, the link between the olfactory function and mental diseases such as anxiety or affective disorders was not approached. Olfactory function has been the object of several investigations in clinical and general population^{15,16}, but to our knowledge, there is no study assessing the relationship between these emotional states and self-reported measures as EROL scale. It was hypothesized that there would be a positive relationship between anxiety symptoms and the influence of odors on the emotional, behavioural and cognitive aspects assessed by EROL scale. Thus, participants with higher anxiety symptoms would score higher on the

olfactory measure for several reasons: firstly, some studies reported lower olfactory detection thresholds in neurotic individuals¹⁵ and faster detection of emotionally valenced odours in neurotic and anxious individuals, as well as a stronger perception of these odorants in women high in trait anxiety¹⁷. Secondly, several studies suggested that neurotic and anxious people could be more sensitive and reactive to sensorial stimuli such as loud noise, unpleasant visual stimuli, bitter taste and pain than stable and calm people.¹⁸⁻²² Thus, it is possible that olfaction could be another sensorial modality to which these people could be more sensitive. Regarding the depressive sphere, the data in the clinical and general population are conflicting: some studies showed a reduced sensitivity^{16,23-28}, others a normal sensitivity²⁹⁻³³, and only one study reported an increased response²⁹. Taking these data into account, we did not expect a significant relationship between the olfactory scores and depressive symptoms.

METHOD

Participants and procedure

The sample consisted of 100 Caucasian adult subjects (41 female and 59 male) between 19 and 45 years (mean age of 30.81 years and standard deviation of 7.27 years). The recruited subjects were from Barcelona's province (Catalonia, Spain), and their socioeconomic and cultural status was middle. The sample size was calculated according to the recommended 10:1 ratio of number of subjects to number of test items³⁴, so about 100 patients were necessary. The inclusion criteria in our study were that participants should be between 18 and 45 years, and should be physically and psychologically able to complete the questionnaires. The upper age limit was established as the probability of suffering some conditions that could alter the olfactory function increases strongly from 45 years onwards^{35,36}. According to the literature on possible causes of olfactory dysfunction^{16,37,38}, the exclusion criteria were the following: (1) any condition that could alter the airflow to the olfactory receptors, (2) any condition that could damage the olfactory membrane or the central nervous system structures involved in olfaction, (3) systemic disturbances that could alter the sense of smell, and (4) psychiatric conditions such as schizophrenia and major depressive disorder. From the initial sample of 106 participants, 6 were excluded as they met one or more of these exclusion criteria (i.e., 1 epilepsy, 1 diabetes, 1 nasal polyposis, and 3 smoking more than 10 cigarettes a day).

Participants were recruited by word of mouth from authors and took part in the study voluntarily and without receiving economical compensation. The questionnaires were introduced as ones of odours and mood, whose purpose it was to learn about the role of the odours in our lives, and how people perceive them in their environment. All

Table 1	EROL scale
	1.- Does smelling good or wearing cologne help you to cope with tense situations? ^a 2.- Can you identify your partner by the way he/she smells? ^a 3.- Can the odours stimulate your sexual behaviour? ^a 4.- Can the odours brake your sexual behaviour? ^a 5.- Have you ever noticed your sense of smell becoming sharper in any situations? (For example, when you are hungry, anxious, when you go through your periods, ...) ^a 6.- Do you feel less self-assured when you don't wear cologne/perfume? ^b 7.- Do you feel more attractive when you wear cologne/perfume? ^c 8.- Dou you feel less self-assured when you don't wear deodorant? ^b 9.- Do you feel more attractive when you wear deodorant? ^c 10.- Can some odours make you feel the space smaller than it is? ^a 11.- Can some odours make you feel the space wider than it is? ^a
	Choices: ^a never, seldom, sometimes, often and always (range 0-4); ^b about the same self-assurance, a little less self-assurance, and a lot less self-assurance (range 0-2); and ^c about the same attractive, a little more attractive, and a lot more attractive (range 0-2).

participants read and signed an informed consent form after study procedures had been fully explained. Sociodemographic data, including age, sex, race, ethnic group, and cultural and socioeconomic status were recorded. The anonymity of the participants' answers was preserved. The protocol for the study was reviewed and approved by the Ethics Committee of Clinical Investigation of the Parc de Salut Mar. This study was carried out in Catalonia (Spain) during 2009/2010. It was coordinated by the Department of Psychiatry of the Parc de Salut Mar in Barcelona, Spain.

Concerning the construction of EROL, the authors held discussions on the topic of odours to generate the items of the scale. An exhaustive literature review on the olfactory scales was performed and the items were designed according to the olfactory issues and shades that the existing olfactory scales do not cover. The content of the 11 items of the scale was related to topics such as the degree of self-assurance and attractiveness that odour masking products can provide, the impact of odours on sexual behaviour, the familiarity of certain odours (partner), the influence of odours on the space perception, and some situations in which the olfactory acuity could be higher. The EROL score was calculated as the sum of the 11 items, with higher scores indicating more influence of odours on the emotional, behavioural and cognitive aspects that the scale assesses. Table 1 shows the items content and the response format for each one of them.

Instruments

In addition to EROL scale, other olfactory measures were administered to the participants in order to assess the convergent validity of the scale: The Affective Impact of

Odors scale (AIO)⁶ and the Odor Awareness Scale (OAS)⁷. They were selected according to their good psychometrical properties in their original and Spanish versions.³⁹

The AIO scale is an 8-item scale that asks about the impact of liked and disliked smells on reactions to new foods, new places, new cosmetic/health products and new persons. The response format for these 8 items is a four-point scale (scored 0-3). The AIO scale is calculated taking the mean of 8 items, with higher scores indicating more impact of odours on liking the aforementioned topics.

The OAS is a 32-item scale designed to assess self-reported awareness of odours in the environment. Thus, OAS captures a person's tendency to notice, pay attention to, or attach importance to odours in the environment, covering situations like food and drink, civilization, nature, and man. Response categories are not always the same, but vary considerably. Five-point scales are used in most cases. Higher scores indicate higher odour awareness. The OAS score is calculated as the sum of the items.

As previously mentioned, the relationship between the olfactory measure and anxiety and depression symptoms was studied. Thus, the Hospital Anxiety and Depression Scale (HADS)⁴⁰ was administered to the participants for this purpose. In the review of Bjelland et al.⁴¹ about the validity of the scale, it was found that HADS performed well in assessing the symptom severity and caseness of anxiety disorders and depression in both somatic, psychiatric and primary care patients, and also in the general population. The HADS is a 14-item questionnaire: 7 items constitute the anxiety subscale (HADS-A) and 7 constitute the depression subscale (HADS-D). For each question, the patient is asked to choose a response ranging from 0 points (no symptoms) to 3 points (maximum

Item	Mean	Standard deviation	Item-total correlations	ICC
1	1.78	1.17	.533	.681
2	2.93	1.11	.342	.836
3	2.45	.99	.529	.778
4	2.39	.97	.461	.698
5	1.52	1.21	.263	.792
6	.47	.61	.518	.727
7	.81	.66	.538	.689
8	1.14	.73	.311	.724
9	.59	.70	.411	.556
10	.86	.92	.374	.426
11	.95	1.03	.417	.608

impairment), considering his or her emotional state over the past 7 days. Thus, higher scores indicate greater levels of distress. The caseness is usually defined by a score of 8 or above on the HADS-A and 8 or above on the HADS-D. By the sum of the items of every subscale, three scores can be obtained: HADS-A, HADS-D, and HADS-total. In this study, the translated and validated Spanish version of HADS was used.^{42,43}

Statistical analysis

Data were analyzed using SPSS for Windows, version 18. Descriptive data on mean, standard deviation and range were used for the sociodemographic characteristics and the questionnaires scores.

In the light of a documented higher olfactory performance in women on tests of olfactory function⁴⁴⁻⁴⁶, *t* Student test for independent samples was used to compare the scores between both sexes. Since it has been observed that olfactory function changes with age^{44,47,48}, correlations between this variable and the olfactory scales were tested by Pearson coefficient correlation. HADS measures were also evaluated according to gender (*t* Student test) and age (Pearson coefficient correlation).

Four were the evaluated psychometric properties of the questionnaires. First, the internal consistency of the scale was calculated with Cronbach's alpha coefficient.^{49,50} Second, test-retest reliability analysis was assessed by means of intraclass correlation coefficient (ICC).^{51,52} The interval between test and retest was of one week. Three, convergent validity was evaluated by calculating the Pearson correlation coefficient between EROL and the other olfactory instruments. Four, for the internal structure analysis, an exploratory factor analysis was conducted. A principal axis analysis was performed over the correlation matrix of EROL

scale. Decisions regarding factor retention were based on (1) ratio between eigenvalues, (2) the theoretical interpretability of factors, and (3) the scree test.^{50,53} Finally, the relationship between EROL and HADS scale (total/anxiety/depression) was assessed by Pearson correlation coefficient and the partial correlation coefficients (controlling for the other subscale). Prior to the analysis we assumed the conventional criteria on the interpretation of correlation coefficients as effect size measurement: correlations of .1 indicate a small effect size, .3 a medium effect size, and .5 or above a large effect size.⁵⁴

RESULTS

Scale descriptives

The mean and standard deviation for EROL total score was 16.46 ± 6.21 , with a range between 3-36. Item descriptive data are shown in Table 2. Women scored significantly higher than men ($t(98)=2.232$, $p=.028$), while there was no significant relationship between age and EROL scale ($r=.133$, $p=.18$).

Mean scores and standard deviation of HADS-total were 9.93 ± 5.57 . Scores were higher for anxiety (6.68 ± 3.52) than for depression subscale (3.26 ± 2.85). There were no significant differences for gender on HADS (HADS Total: $t(98)=0.177$, $p=.860$; HADS-A: $t(98)=0.396$, $p=.693$; HADS-D: $t(98)=0.807$, $p=.422$), but a significant and negative correlation was found between age and the anxiety subscale (HADS-A: $r=-.260$, $p=.009$; HADS-D: $r=-.027$, $p=.791$; HADS-Total: $r=-.181$, $p=.071$).

Psychometric properties of the scale

Reliability

Cronbach's alpha coefficient was .761, indicating good internal consistency. Item-total correlations ranged from .263 to .538. ICC for total score was .748, showing a good agreement between test and retest scores. The value of ICC for items ranged from .426 to .836. Information related to the contribution of each item to the reliability of the scale can be seen in Table 2.

Convergent validity

EROL scale was significantly and highly correlated ($p<.001$) to both AIO ($r=.534$) and OAS ($r=.625$) scores. These correlations suggested a good level of convergent validity.

Internal structure analysis

Theoretical and empirical reasons supported the retention of a single factor: The scale was constructed assuming unidimensionality of the construct; the ratio between the first and the second eigenvalue was over 2 and the same decision should be taken according to the scree test. So, we considered that the internal structure of the scale could be satisfactorily explained with a one-factor solution. The percentage of explained variance was 26.53%. All the items loaded on this factor above .3 except item 5 (Table 3).

HADS and olfactory scale

EROL correlated positively and significantly with HADS total scores ($r=.280$, $p<.01$). However, the analysis through subscales showed that the relationship between the olfactory scale and HADS was moderated in magnitude and significant for anxiety ($r=.325$, $p<.001$), whereas for the depression dimension the relationship was non-significant ($r=.146$, $p>.05$). We computed the correlation of EROL with the two subscales when controlling for the other one. The partial correlation of EROL with HADS-A adjusted for HADS-D was almost unchanged ($r=.295$; $p=.003$). For the depression subscale, when controlling for anxiety, the correlation dropped to almost zero ($r=.028$, $p=.779$).

DISCUSSION AND CONCLUSIONS

The main aim of the present study was to develop and validate EROL scale, a new olfactory measure. Likewise, a secondary objective was to study the relationship between the olfactory function and anxiety and depression symptoms. This work was conducted in the general population.

The available data support that EROL scale meets psychometric criteria for establishing validity and reliability. Cronbach's alpha coefficient was of .761, suggesting that items of EROL were globally interdependent and homogeneous in terms of the construct they measured. Item-total correlations also gave support to an adequate level of internal consistency of the scale. However, there was a low consistent element in the scale (item 5: Have you ever noticed your sense of smell becoming sharper in any situations?) which also showed a low factor loading. It could be explained by the content differences regarding the other items. Item 5 asks about situations in which the olfactory acuity could be higher while the other items ask about the influence of olfaction on emotions, behavior and cognition. In spite of this, item 5 was not deleted from the scale as it was considered interesting with regard to the content.

Likewise, ICC for the total scale score (.748) showed that test-retest reliability was adequate, pointing out that EROL

Table 3	Factor loadings of the items of EROL scale and the percentage of explained variance (%)
1	.647
2	.395
3	.593
4	.539
5	.224
6	.654
7	.701
8	.434
9	.559
10	.319
11	.360
Explained variance (%) 26.53	

displayed a good stability with an interval of one week. Even so, there was a low stable element in this scale (item 10: Can some odors make you feel the space smaller than it is?). One possible explanation could be that the influence of olfaction on space perception is an unknown phenomenon for most people and therefore it is difficult to respond to this question. Item 11 asks about the same information but in relation to a wider space perception and it was one of the three items with the lowest stability.

Convergent validity was good since EROL scale correlated substantially and positively with both olfactory scales used as external criteria. As regards the internal structure, factor analysis extracted only one dimension for the scale. It suggests that items of EROL can be satisfactorily described as an unidimensional factor that includes questions linked to the relationship between olfaction and emotional, behavioural and cognitive aspects.

Data were analyzed according to age and gender. There was no significant relationship between age and EROL scale. However, there was a slight trend towards a negative relation. It has been largely observed that olfactory function changes with age and markedly decreases above the 55-60 years.^{44,47,48} However, some studies reported that above 35 years, this function begin to decrease.^{47,48} In our sample of participants aged by 19 to 45 years, the results partially supported these data since the trend was present, but not reach statistical significance. Concerning gender, our results agree with the literature since many studies showed a higher performance in women on tests of olfactory function.⁴⁴⁻⁴⁶

A secondary aim of this study was to analyze the relationship between HADS and EROL scales. Results

pointed out a positive link between both measures. In people scoring high on HADS, the olfaction had a greater influence on situations that EROL collected. However, the analysis through subscales showed that, as it was hypothesized, the relationship between both measures was significant for anxiety, but not for depression subscale. One tentative and provisional explanation would be that compared to individuals with depressive symptoms, those with anxiety could be more sensitive or more affected at emotional, behavioural and cognitive level by odours. There are several studies suggesting that neurotic and anxious people could be more sensitive and reactive to sensorial stimuli, such as loud noise, unpleasant visual stimuli, bitter taste and pain than stable and calm people.¹⁸⁻²² It is possible that olfaction could be another sensorial modality to which these people could be more sensitive. Pause et al.¹⁵ reported that neuroticism was a predictor of a higher olfactory sensitivity and according to Eysenck's theory, anxiety correlates highly with neuroticism⁵⁵. Chen and Dalton¹⁷ observed faster detection of neurotic and anxious individuals to emotionally valenced odours (pleasant/unpleasant) as compared to neutral odours. In addition, women high in trait anxiety perceived the emotionally valenced odorants as stronger, compared to the neutral one. Concerning the depressive subjects, the data in the clinical and general population are discrepant.^{16,23-33} For example, Pause et al.^{23,24} found a reduced sensitivity in major depressive disorder and these findings were replicated later by other researchers^{25,26}. Pollatos et al.²⁸ reported a negative correlation between olfactory sensitivity and depressive symptoms in a sample from the general population. By contrast, other studies showed that olfactory measures did not differ between depressive subjects and healthy controls.²⁹⁻³³ To our knowledge, only one study found a higher olfactory sensitivity in depressive patients²⁹. These inconsistent data could explain the non-significant relationship between HADS-D and EROL in our study. Finally, the low scores on HADS depression subscale in this sample, could also explain the lack of relationship between this subscale and the olfactory measure. Mean scores of HADS depression subscale were lower than those of anxiety subscale and far from the cut-off point. Thus, it is possible that if participants in this study had very low depressive symptoms, no significant relationship could have been established between depression subscale and the olfactory measure, if this relation exists.

This study had several limitations. Firstly, potential participants who suffered some conditions that could alter markedly the olfactory sense were excluded through standard interview, without exploring these conditions in depth. Secondly, the sample size of this study was small. Future research could be addressed to study this olfactory scale with larger sample sizes, in order to test its

psychometric properties again. Thus, data will be statistically highly robust and it will allow the inspection of the less satisfactory items and also a more complex factor analysis. And thirdly, the low depressive symptoms in this sample has not made possible to ascertain in a conclusive manner the relationship between the olfactory measure and depression sphere.

In view of the results of this study, it would be interesting to assess how patients with anxiety disorders score on this scale and also to test them by objective methods. So far, scientific research has paid little attention to the olfactory function in the anxiety sphere, not only in general population, but also in clinical settings. In the psychiatric field, schizophrenia and depressive disorders have been the object of many investigations about this sense¹⁶, but anxiety disorders are often neglected. Taking into account the third limitation of this study, it would be worth assessing again the relationship between the olfactory measure and depressive symptoms in a sample from the general population with higher depressive symptomatology.

This study has yielded the following conclusions: EROL is a new olfactory scale that displayed good psychometrical properties. Thus, it appears as a suitable research tool to assess the olfactory function. Participants with higher scores on HADS anxiety subscale were more influenced by olfaction in situations collected by EROL. Although it may be too soon to draw conclusions, it seems that olfaction could have a greater importance among subjects with anxiety symptoms. Thus, it is necessary to conduct more investigations in anxious individuals to carefully study the olfactory function in this population.

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