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Development and Psychometric Validation of the Taste And Smell Tool for Evaluation (TASTE) Questionnaire

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IMPORTANCE The human senses of taste and smell are essential in everyday life. However, as clinical testing of the senses and patient-reported sensory problems are often diverging, additional validated questionnaires are essential for the evaluation of chemosensory impairments.

OBJECTIVE To develop an instrument with all relevant domains concerning chemosensory dysfunction and quality of life using modern psychometrics.

DESIGN, SETTING, AND PARTICIPANTS The study was designed as a questionnaire study for developing a new instrument. The study started in 2019 and was completed in 2022. Patients with chemosensory dysfunction were recruited from a specialized smell and taste clinic at an ear, nose, and throat department in Denmark. Healthy participants with no history of chemosensory dysfunction were recruited through social media.

MAIN OUTCOMES AND MEASURES Eight domains were included (distorted chemosensation, emotional, food and meals, social, hygiene, danger, work, and relationship), and 35 items were generated based on review of the existing literature and interviews with patients and experts. Participants were tested with the Major Depression Inventory, 36-Item Short Form Health Survey, Taste Sprays, and Sniffin' Sticks for chemosensory function. Descriptive statistics were calculated for all items. Reliability, internal consistency, and validity were investigated, and a Rasch model was fitted. Healthy controls (n = 39) filled out the questionnaire for comparison of known-groups validity. Confirmatory factor analysis was performed. Finally, item reduction was performed, resulting in a final version with 21 items in 8 domains.

RESULTS The study included responses from 316 patients, 183 women (58%) and 133 men (42%), with a mean (SD) age of 57 (15.1) years. Rasch model fit was acceptable with $P > .05$ for all items. An 8-dimensional confirmatory factor analysis model showed a better fit than a bifactor confirmatory factor analysis model. Cronbach α ranged from 0.65 to 0.86. Criterion validity with the Sniffin' Sticks, Taste Sprays, Major Depression Inventory, and the 36-Item Short Form Health Survey was satisfactory. The test-retest reliability was good in all domains, ranging from 0.55 to 0.86. All domains were discriminative, except the social and work domains.

CONCLUSIONS AND RELEVANCE In this survey study, the instrument was validated with 8 domains related to chemosensory dysfunction and quality of life. All items had good internal consistency, test-retest reliability, interitem correlations, item-total correlations, and Rasch model fit. The questionnaire appears suitable for use in clinical and research settings.

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Supplemental content

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Olfaction and gustation are essential in everyday life. Gustation refers to the basic tastes of sweet, salty, bitter, sour, and umami and is evolutionarily advantageous by allowing ingestion of beneficial substances, such as minerals and high-energy sugars, and avoiding bitter-tasting poisons and sour-tasting spoiled foods; in modern days, it primarily provides pleasure and enjoyment of food.[1] Olfaction refers to smells from the outside world—orthonasal olfaction—and the flavor of substances—retronasal olfaction. Olfaction is involved in several human functions guiding and influencing behavior due to hedonic, social, and defense purposes. This is apparent in food ingestion and enjoyment, danger avoidance, and social communication.[2] The importance of the senses becomes apparent if impairment strikes. Olfactory dysfunction can be quantitative or qualitative. Quantitative olfactory impairment consists of a reduced (hyposmia) or lost (anosmia) sense of smell. Qualitative olfactory impairment consists of distorted smells (parosmia) or phantom smells (phantosmia). Gustatory impairment similarly consists of quantitative impairment with reduced (hypogeusia) or lost (ageusia) sense of taste and qualitative impairment with phantom basic taste sensations (phantogeusia) and distorted basic taste sensations (parageusia). Gustatory dysfunction is prevalent in up to 5% of the general population,[3] while olfactory dysfunction affects up to 20%.[4] Olfactory impairment often reduces quality of life[5] and causes several daily life problems ranging from decreased enjoyment of food and beverages to increased or decreased eating, difficulties in cooking, ingesting spoiled food, failing to perceive fire or gas incidents—even problems with personal hygiene, in social situations, personal relationships, and at work.[6-12]

For evaluating the impact of chemosensory impairment, a psychometric tool (questionnaire) is needed. Tools measuring different aspects of olfaction and gustation have been developed for different purposes.[13] However, none have been validated using modern psychometrics or combined gustatory-related and olfactory-related questions for assessment of dysfunction. By combining chemosensory items and domains in an instrument, questionnaire exhaustion is reduced, while maximizing information gained. Furthermore, using modern psychometrics for development of questionnaires allows for comparison of individuals from different populations.[14] The first psychometric model developed was classical test theory.[14,15] Classical test theory has various limitations, including that instruments (questionnaires) depend on the characteristics of the individuals responding to the instrument.[14,16,17] Modern psychometrics, including item response theory and Rasch models, were developed to overcome the limitations of classic test theory by investigating each item of an instrument individually instead of relying on the instrument as a whole. Both respondents and items are placed on the same scale so that item parameters do not depend on the latent trait of the individual, and the individual's latent trait does not depend on the items, allowing for comparison of individuals from different populations.[14] Therefore, the present study aims to develop a thorough scale, the Taste And Smell Tool for Evaluation (TASTE), comprising all relevant domains concerning chemosensory dysfunction, and related quality of life, using modern psychometrics in the development and validation phases.

Key Points

Question Can a thorough questionnaire be developed comprising all relevant domains concerning chemosensory dysfunction using modern psychometric methods and perform well?

Findings In this survey study including 316 patients and 39 healthy controls, the instrument with 8 domains related to chemosensory dysfunction and quality of life performed well, with all items having good internal consistency, test-retest reliability, interitem correlations, item-total correlations, and good fit of the Rasch model.

Meaning The questionnaire appears to be suitable for use in clinical and research settings.

Methods

Study Design

Phase I. Developmental Phase

Conceptual Framework | After the literature review, a multi-item reflective model was chosen, and 8 domains were postulated a priori: distorted chemosensation, emotional, food and meals, social, hygiene, danger, work, and relationship. Furthermore, 4 global domains were included: the ability to smell things in front of the nose, sense aroma in food, taste the basic tastes, and overall health-related quality of life.

Measurement Purposes | The primary purpose is diagnostics, and the scale should be able to discriminate between healthy individuals and those with impairment.

Phase II. Selection and Formulation of Items

Semistructured interviews were conducted in 12 consecutive patients with complaints of olfactory or gustatory dysfunction recruited from a specialized Smell and Taste Clinic (Flavour Clinic, Department of Otorhinolaryngology, Regional Hospital Gødstrup, Herning, Denmark). The same procedure was done using REDCap and physical meetings with 11 international experts on patients with chemosensory dysfunction. Thirty-five items were formulated: 1 for each of the global domains, 4 for distorted chemosensation, 5 for emotional, 5 for food and meals, 3 for social, 5 for hygiene, 3 for danger, 3 for work, and 3 for relationship. The global items were rated on a scale of 0 (no problems) to 10 (severe problems). All other aspects were rated on a scale from 0 (no problems) to 5 (severe problems). A response option of "Don't know/not relevant" was included.

Phase III. Pilot Testing

A combination of *think-aloud* and *probing* methods was used to determine comprehensibility and relevance, including what context participants used to answer and how they interpreted the terms used. This was conducted with 12 consecu-

tive patients from the Flavour Clinic. The experts also reviewed the items for comprehensibility and relevance.

Phase IV. Field Testing

Field testing was conducted with 316 consecutive patient responses at the Flavour Clinic and 39 healthy participants recruited on social media. The data were used for item reduction and to determine dimensionality, validity, and reliability. The final version of the instrument contains 21 items in the original 8 domains.

Data Collection Method | Study data were collected and managed using REDCap electronic data capture tools hosted at Aarhus University.[18,19] The questionnaire was mailed to participants and filled out online at home. The questionnaire was sent within 2 to 3 weeks prior to visiting the Flavour Clinic for patients.

Major Depression Inventory | All patients were scored with the Major Depression Inventory (MDI) to screen for depression and associated symptoms. The scale contains items covering *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition) and *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10)* symptoms for depression and contains 10 items with a score ranging from 0 to 50. A cutoff score of 26 was used for the potential presence of major depression.[20] This was used to investigate differential item functioning in relation to the items and validity of the emotional domain.

Sniffin' Sticks | The Sniffin' Sticks (Burghart Messtechnik) are felt-tip-pen–like devices containing odors instead of dye. The olfactory test contains 3 subtests for threshold (T), discrimination (D), and identification (I) abilities. The threshold subtest gives a score of 1 to 16, while discrimination and identification give a score of 0 to 16 each. The scores can be summed, giving a score for overall olfactory function, the TDI score, ranging from 1 to 48. The test has been extensively validated internationally as well as nationally in Denmark.[21,22]

All patients were tested to specify the severity of quantitative olfactory impairment and to investigate criterion validity. The TDI score cutoff values were used, separating participants into groups of anosmia (≤16), hyposmia (≤29.8), and normosmia (>29.8).[22]

Taste Sprays | The Taste Sprays contain salty, sweet, sour, and bitter taste qualities in suprathreshold concentrations.[23] The sprays contain sodium chloride (0.75 g/10 mL water), sucrose (1 g/10 mL water), citric acid (0.5 g/10 mL water), or quinine hydrochloride (0.005 g/10 mL water). Application was performed on the tongue in a pseudorandomized order, and a forced-choice paradigm was used. One point was given for each correctly identified tastant, giving a score of 0 to 4. Gustatory dysfunction was suspected for scores below 4.

SF-36 | A subgroup of the patient population (n = 59) filled out the 36-Item Short Form Health Survey (SF-36), a generic quality-of-life measurement instrument containing 36 questions concerning 8 health concepts: physical functioning, bodily pain, limitations due to physical health, limitations due to personal or emotional issues, emotional well-being, social functioning, fatigue and energy, and general health perceptions.[24] The SF-36 data were used to investigate criterion validity.

Statistical Analysis

Descriptive statistics of mean, standard deviation, floor and ceiling effects, interitem correlation, and item-total correlation were calculated for each item using SAS Studio (SAS Institute Inc). Floor and ceiling effects were determined by the proportion of respondents with the lowest and highest response options. Interitem correlation explores the relationship between scores of items—if it is too high for an item pair, this may reflect redundancy, while too low reflects low internal consistency. Item-total correlation investigates correlation with the total-domain score—the higher, the better.

Content and face validity were assessed by consensus between the experts and patients by investigating whether the instrument adequately reflects the construct and whether the items are comprehensive and relevant. Internal consistency was evaluated using Cronbach coefficient α: greater than 0.8 indicated excellent consistency, and α greater than 0.7 indicated acceptable consistency. Criterion and predictive validity were assessed using Spearman r to compare the questionnaire with olfactory and gustatory function. The emotional domain was compared with the MDI scores, and all domains were compared with SF-36 component scores. Discriminative properties were investigated using known-group validity. For test-retest, Pearson coefficient of correlation was used in 51 participants with repeated answers 1 week to 3 months later.

Rasch analysis investigates the fit between observed and expected item scores, testing monotonicity, ie, item mean scores increase with the domain score. This is formalized using a statistical test of the null hypothesis that the item fits the Rasch model, where P values greater than 5% indicate fit of the model.[25] Rasch analysis also provides an overall test of model fit[26] and tests differential item functioning[27] and local independence.[28] Differential item functioning can be present when responses differ systematically by other factors and was evaluated for age, sex, and groups based on dichotomized MDI scores (>26). When the assumption of local independence was violated, graphical Rasch models were used to model the data.[29] The scales were further evaluated using confirmatory factor analysis (CFA) models for the complete item set. An 8-dimensional CFA model and a bifactor CFA model were fitted. We report the following fit statistics: χ^2, root mean square error of approximation (RMSEA), comparative fit index (CFI), and the Tucker-Lewis index (TLI). Threshold levels for good fit are indicated by χ^2 P value great than .05, RMSEA of 0.05 or less, and CFI/TLI of 0.95 or greater.[30] Rasch analysis was done using DIGRAM (University of Copenhagen)[31] and SAS, version 9.4.[32] The CFA for ordinal items based on polychoric correlations was done using the R package lavaan.[33]

Ethics

The study was conducted following the Helsinki Declaration. Approval from the regional ethics committee for research

projects (Central Denmark Region) was obtained with project number 1-10-72-1-19. Patients provided written informed consent for research participation. The COSMIN checklist for reporting and study design was used.[34]

Results

Participants

The population included 316 patient responses, 183 from women (58%) and 133 from men (42%), with a mean (SD) age of 57 (15.1) years. Testing of chemosensory function was performed in 255 patients with causes including 101 postinfectious (39.6%), 63 idiopathic (24.7%), 36 sinonasal (14.1%), 31 posttraumatic (12.2%), 5 congenital (2%), 4 iatrogenic (1.6%), and 4 medication related (1.6%). Of the postinfectious cases, 18 were polymerase chain reaction–verified COVID-19. Five patients were diagnosed as other (2%), and 6 with no smell loss (2.4%). Seventy-nine patients self-reported both parosmia and phantosmia, 3 reported phantosmia, and 30 reported parosmia. Duration of dysfunction was estimated in 238 patients with a median (range) of 700.5 (65-11 270) days. Relevant comorbidities of patients included obstructive sleep apnea in 4 patients and asthma in 12 patients. Chronic rhinosinusitis was ruled out for patients without sinonasal disorders with combined computed tomography scans of the nose and sinuses and endoscopy of the nose. With the Sniffin' Sticks, 115 (45.1%) were anosmic, 132 (51.8%) hyposmic, and 8 (3.1%) normosmic. The patients had a mean (SD) Sniffin' Sticks threshold score of 2.07 (1.66) ranging from 1 to 8.5, a mean (SD) discrimination score of 7.62 (3.07) ranging from 0 to 14, a mean (SD) identification score of 8.23 (3.8) ranging from 0 to 16, and a combined mean (SD) TDI score of 17.91 (7.11) ranging from 1 to 37. For the Taste Sprays, 20 patients (7.8%) failed to correctly identify the sprays, indicating hypogeusia.

Instrument and Scale Properties

The final items of the instrument are included in **Table 1** and descriptive statistics for all items in **Table 2**, and the full instrument can be seen in eAppendix in the Supplement. Cronbach α ranged from 0.65 to 0.86 for all domains (Table 2). Eighteen items showed floor effects, and 9 items showed ceiling effects. None of the interitem correlations were low. All items in all domains had high item-total correlations confirmed by fit of items to the Rasch model (Table 2) and by overall model fit for all subscales (results not shown). No evidence of differential item functioning was disclosed, except for item 1 with sex. The 8-dimensional CFA showed better fit (χ^2 = 255.3; df = 161; P < .001; CFI = 0.96; TLI = 0.95; RMSEA = 0.072 [90% CI, 0.055-0.088]) than the bifactor CFA (χ^2 = 462.5; df = 168; P < .001; CFI = 0.879; TLI = 0.848; RMSEA = 0.124 [90% CI, 0.111-0.138]).

The latent variables of the domains all correlated positively (**Table 3**). The lowest correlation was between the distorted chemosensory and the relationship domains, while the highest correlation was between the danger and hygiene domains.

Validity and Test-Retest Reliability

Criterion validity with the Sniffin' Sticks was investigated. All domains were negatively correlated with the threshold subtest, except for distorted chemosensation (**Table 4**). This was also the case for the identification subtest. The discrimination subtest was positively correlated with the distorted chemosensation, emotional, food and meals, social, work, and relationship domains. The hygiene and danger domains were negatively correlated with the discrimination subtest. The Taste Sprays were used for criterion validity, and all domains correlated negatively (Table 4).

The MDI was used to investigate criterion validity (Table 4). All domains were positively correlated with MDI. The emotional, work, and social domains had the highest correlation, ranging from 0.54 to 0.59. The other domains' correlations ranged from 0.13 to 0.37.

The SF-36 was used to investigate criterion validity with quality of life and was divided into physical and mental component scores. All domains were negatively correlated with both components, except for work and relationship for the physical component, where correlations were 0.05 and 0.00, respectively (Table 4).

The test-retest reliability was investigated. Results showed it was moderate to good in all domains, ranging from 0.55 to 0.86 (Table 4).

Known-groups validity was investigated by dividing participants into categories of anosmia, hyposmia, and normosmia (controls) (**Figure**). All domains were discriminative by discriminating between patients and healthy participants, except social and work. The best discriminating domains were hygiene and danger. Using the danger domain with a cutoff value of 2 to discriminate healthy participants from patients (measured by Sniffin' Sticks), the sensitivity was 89.2%; specificity, 100%; positive predictive value, 100%; negative predictive value, 98.1%; and receiver operating characteristic area, 0.95.

Discussion

This survey study aimed to develop an instrument with all relevant domains concerning chemosensory dysfunction and related quality of life. Due to the study's rigorous development and validation phases, all items had suitable interitem correlations in terms of not being too low, as to not be representative of the latent trait of the domain, and in terms of not being too high, meaning all items add something unique to the domain. Furthermore, all items had high item-total correlation scores, representing that all items correlated well with total domain score. The Rasch model was not rejected for any items, providing a good overall fit while also testing monotonicity—that is, item mean scores increased with domain scores. No differential item functioning was evident, except for item 1 (distorted chemosensory domain) with sex. The study included more women than men, representing the clinical population seen in specialized smell and taste clinics,[35] and similar to other olfactory-related questionnaires.[36]

Eighteen items had floor effect, indicating that not all items had clinical relevance to all patients; however, only 7 items had

Table 1. The Final Version of the Taste And Smell Tool For Evaluation (TASTE) Including 21 Items in 8 Domains

Domain/item number	Item text				
Introductory text	Below you will find questions related to your symptoms and the consequences of your problems with your sense of smell and/or sense of taste. Please, select one option only for each question. Answer as well as you can. There are no correct or incorrect answers. Please answer all questions.				
	Assess your problems as experienced in the past 2 weeks.				
Response options for all questions					
1. Not at all	2. Slightly	3. Somewhat	4. Quite a lot	5. Very much	6. Do not know/not relevant
Distorted chemosensation domain					
Item 1	I sometimes experience an (unpleasant) smell even though the source of such smell is lacking				
Item 2	I sometimes experience an (unpleasant) taste even though the source of such taste is lacking				
Item 3	The taste of some foods is distorted				
Item 4	Some odors are distorted				
Emotional domain					
Item 5	I feel excluded				
Item 6	I am emotionally affected				
Item 7	My thoughts focus on what I'm lacking				
Food and meals domain					
Item 8	The joy of eating and drinking is reduced				
Item 9	My weight has changed				
Item 10	I have problems preparing food				
Social domain					
Item 11	I visit family, friends, and neighbors less frequently				
Hygiene domain					
Item 12	I find it difficult to sense my own body odor				
Item 13	I'm unsure how much perfume I need to wear				
Item 14	I'm worried about my body odor in social contexts				
Danger domain					
Item 15	It is difficult for me to smell if food is spoiled				
Item 16	It is difficult for me to detect dangerous situations				
Item 17	I'm worried about dangerous situations (eg, smoke, gas, spoiled food)				
Work Domain					
Item 18	I am concerned that I may experience financial problems				
Item 19	I am concerned that I may experience work-related problems				
Relationship domain					
Item 20	I experience reduced joy in intimate situations				
Item 21	I feel less attracted to my partner				

floor effect greater than 50%, and the highest floor effect was found for item 18 (work), indicating that all items had relevance to subgroups of patients. In addition, ceiling effects were found for 9 items, with the highest values for item 15 (danger) and item 12 (hygiene), indicating that most patients had problems in the latent trait of the domains.

All the latent traits of the domains correlate positively, and none of the correlations were too high, meaning they all added something unique. The questionnaire and all domains had decent and expected criterion validity with olfactory function, gustatory function, MDI, and SF-36. The Sniffin' Sticks threshold and identification subtest negatively correlated with all domains, except the distorted chemosensory domain, meaning that a better olfactory function (a higher Sniffin' Sticks score) provided a lower score on the questionnaire (less effect on quality of life and daily life functions). A positive correlation with the distorted chemosensory domain is expected because parosmia is generally experienced during recovery of olfactory dysfunction, as patients with functional anosmia mainly experience negative effects from the total absence of olfactory perceptions. A similar finding was observed in the discrimination subtest, with a positive correlation with the distorted chemosensory domain; however, the emotional, food and meals, social, work, and relationship domains were also found to have a positive correlation. The gustatory function had a negative correlation with all domains, as expected (a higher score with the Taste Sprays meaning better function). The MDI correlated positively with all domains, meaning a higher score on the MDI was associated with a higher score on TASTE. As expected, the highest correlations were found for the emotional, social, and work domains. Criterion validity with the quality-of-life questionnaire SF-36 provided satisfactory results. The mental component scores had negative correlations with all domains, ranging from slight to moderate cor-

Table 2. Descriptive Statistics for All Domains and Items[a]

Domain	Item	Not relevant, No./No. (%)	No.	No./No. (%)		Mean (SD)	Range of interitem correlation	Correlation with total	*P* value
				Floor	Ceiling				
Distorted chemosensory (α = 0.79)	Item 1	12/316 (3.8)	304	146/304 (47.9)	26/304 (8.6)	2.19 (1.39)	0.47-0.53	0.76	.19
	Item 2	12/316 (3.8)	304	198/304 (65.0)	12/304 (4.0)	1.71 (1.15)	0.33-0.53	0.64	.96
	Item 3	29/316 (9.2)	287	122/287 (42.5)	44/287 (15.4)	2.40 (1.49)	0.43-0.70	0.84	.99
	Item 4	55/316 (17.4)	261	86/261 (33.1)	60/261 (23.1)	2.79 (1.57)	0.33-0.70	0.83	.12
Emotional (α = 0.83)	Item 5	13/316 (4.1)	303	138/303 (45.5)	17/303 (5.6)	2.09 (1.25)	0.52-0.61	0.79	.30
	Item 6	5/316 (1.6)	311	80/311 (25.7)	29/311 (9.3)	2.59 (1.29)	0.61-0.67	0.88	.11
	Item 7	6/316 (1.9)	310	54/310 (17.5)	34/310 (11.0)	2.87 (1.27)	0.52-0.67	0.87	.74
Food and meals (α = 0.65)	Item 8	3/316 (1.0)	313	33/313 (10.5)	86/313 (27.5)	3.45 (1.32)	0.40-0.49	0.83	.06
	Item 9	17/316 (5.4)	299	162/299 (54.2)	6/299 (2.0)	1.82 (1.06)	0.26-0.40	0.64	.22
	Item 10	9/316 (2.9)	307	69/307 (22.5)	54/307 (17.6)	2.85 (1.40)	0.26-0.49	0.79	.59
Social	Item 11	21/316 (6.7)	295	222/295 (75.2)	8/295 (2.7)	1.48 (0.97)	NA	NA	NA
Hygiene (α = 0.72)	Item 12	5/316 (1.6)	311	16/311 (5.1)	192/311 (61.7)	4.19 (1.22)	0.31-0.50	0.66	.63
	Item 13	44/316 (13.9)	272	51/272 (18.8)	104/272 (38.2)	3.45 (1.54)	0.50-0.51	0.86	.48
	Item 14	1/316 (0.3)	315	100/315 (31.7)	43/315 (13.7)	2.48 (1.38)	0.31-0.51	0.76	.99
Danger (α = 0.84)	Item 15	12/316 (3.8)	304	14/304 (4.7)	196/304 (64.6)	4.31 (1.14)	0.49-0.64	0.70	.47
	Item 16	46/316 (14.6)	270	52/270 (19.4)	105/270 (38.8)	3.43 (1.55)	0.64-0.72	0.92	.23
	Item 17	10/316 (3.2)	306	50/306 (16.3)	90/306 (29.3)	3.18 (1.47)	0.49-0.72	0.89	.79
Work (α = 0.83)	Item 18	81/316 (25.6)	235	191/235 (81.3)	5/235 (2.3)	1.33 (0.84)	0.74-0.74	0.82	.95
	Item 19	95/316 (30.1)	221	156/221 (70.6)	7/221 (3.2)	1.56 (1.03)	0.74-0.74	0.99	.95
Relationship (α = 0.86)	Item 20	65/316 (20.6)	251	154/251 (61.4)	8/251 (3.2)	1.77 (1.14)	0.70-0.70	0.96	.96
	Item 21	76/316 (24.1)	240	176/240 (73.3)	2/240 (0.8)	1.45 (0.88)	0.70-0.70	0.83	.96

Abbreviation: NA, not applicable.

[a] Details of interitem correlations, item-total correlation, and percentage of "don't know/not relevant" answers for all items. Cronbach α is provided for each domain. The interitem correlation displays the correlation between the item and the rest of the items in the domain. The *P* value was formalized using a statistical test of the null hypothesis that the item fits the Rasch model, where *P* values below .05 indicating that the item did not fit the model. N = 316.

Table 3. Correlations Between the TASTE Domain Scores

Domain	Distorted chemosensory	Emotional	Food and meals	Social	Hygiene	Danger	Work
Emotional	0.20						
Food and meals	0.26	0.42					
Social	0.27	0.60	0.49				
Hygiene	0.13	0.45	0.24	0.29			
Danger	0.09	0.42	0.36	0.32	0.84		
Work	0.15	0.43	0.26	0.56	0.20	0.23	
Relationship	0.11	0.32	0.29	0.48	0.17	0.37	0.31

Abbreviation: TASTE, Taste And Smell Tool for Evaluation.

relations, and the physical component score had lower but negative correlations with most domains, except the work and relationship domains. Internal consistency was excellent for 4 domains and acceptable for the rest, except for food and meals, with α just below threshold, potentially indicating problems with consistency.

Retest reliability was good for all domains but should be interpreted with the possibility of recovery between measurements. The TASTE questionnaire was found to have good discriminative properties, primarily in hygiene and danger, but also in distorted chemosensory, emotional, food and meals, and relationship domains.

The 8-dimensional CFA model showed a better fit than the bifactor CFA model, with good CFI and close to acceptable RMSEA values. However, due to the χ^2 *P* value, we suggest using the domain scores as separate indicators of latent traits instead of using a summed score for clinical interpretation.

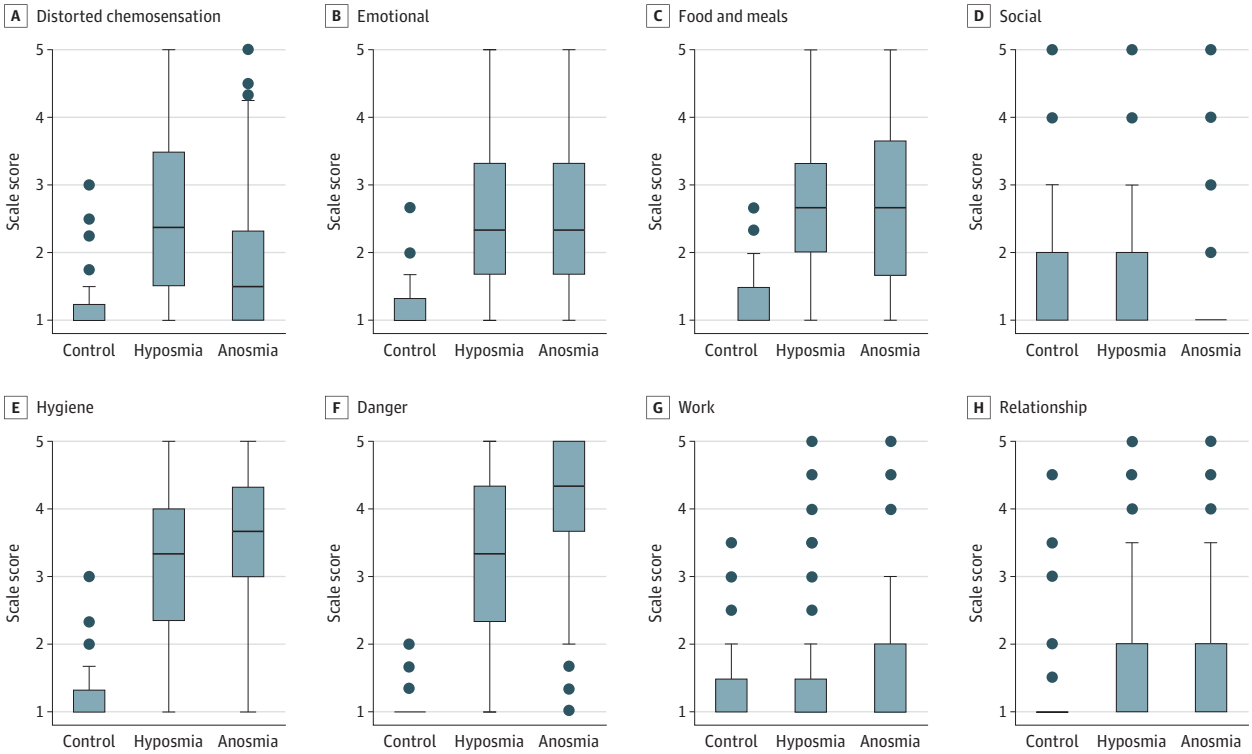
Several other studies have developed questionnaires concerning olfaction. Several are aimed at affection and emotional experiences of odors, such as the Affective Impact of Odor scale,[37] Body Odor Disgust Scale,[38] Chemical Sensitivity Scale,[39] and others.[40-42] Other types of questionnaires include awareness toward odors: Odor Awareness Scale,[43] Odours in Everyday Life Questionnaire,[44] and others.[45-49] In relation to the present study, other questionnaires have been developed to assess olfactory function and dysfunction: Questionnaire of Olfactory Disorders,[36] The Scandinavian Adaptation of the Multi-Clinic Smell and Taste Questionnaire,[50] Assess-

Table 4. Criterion Validity and Test-Retest Correlations

Domain	Sniffin' Sticks					Taste sprays		MDI		SF-36			Test-retest correlation	
	No.	Threshold	Discrimination	Identification	TDI	No.	Correlation	No.	Correlation	No.	PCS	MCS	No.	Correlation
Distorted chemosensory	251	0.16	0.32	0.27	0.32	251	−0.09	244	0.34	59	−0.25	−0.26	51	0.55
Emotional	253	−0.11	0.04	−0.11	−0.07	254	−0.02	246	0.58	59	−0.21	−0.56	51	0.77
Food and meals	254	−0.11	0.13	−0.03	0.01	255	−0.18	247	0.30	59	−0.13	−0.36	51	0.67
Social	240	−0.01	0.07	−0.08	−0.02	240	−0.03	233	0.54	54	−0.06	−0.46	41	0.86
Hygiene	254	−0.27	−0.10	−0.29	−0.26	255	−0.09	247	0.17	59	−0.07	−0.29	51	0.84
Danger	249	−0.33	−0.25	−0.42	−0.41	251	−0.09	242	0.13	59	−0.15	−0.18	50	0.69
Work	192	−0.12	0.11	−0.10	−0.03	192	−0.05	178	0.59	51	0.05	−0.18	36	0.61
Relationship	207	−0.07	0.06	−0.01	0.01	203	−0.21	200	0.37	49	0.00	−0.26	39	0.63

Abbreviations: MCS, mental component score; MDI, Major Depression Inventory; PCS, physical component score; SF-36, 36-Item Short Form Health Survey; TDI, combined score of threshold, discrimination, and identification.

Figure. Known-Groups Validity



Scale scores for patient groups of controls (normosmia), hyposmia (reduced olfactory function), and anosmia (no olfactory function) for all domains. The box plots include the median (line inside the box) and the upper and lower quartiles (upper and lower ends of the box). The whiskers show the lower and upper adjacent values (following the 1.5 IQR rule), and outliers are plotted as dots. Note that there was no variability in the middle 50% of the data for the anosmia group in the social domain, or the control group in the danger and relationship domains.

ment of Self-reported Olfactory Functioning and Olfaction-related Quality of Life,[51] and Self-reported Mini Olfactory Questionnaire,[52] among others.[53,54]

The present study fills a gap because it uses modern psychometrics, which to our knowledge has not previously been used for olfactory dysfunction questionnaires. This allows for direct comparison of results from different populations and includes both olfactory-related and gustatory-related items.

Limitations

A limitation to the study was the low number of healthy participants (n = 39); however, the amount is comparable with the development of other questionnaires, as Frasnelli et al[36] included 25 healthy participants, Millar Vernetti et al[53] included 25, while Nordin et al[50] and Zou et al[52] did not include any healthy participants. Other limitations were that not all domains were found to be discriminative; however, most were

found to be moderately discriminative, and 2 domains were found to be highly discriminative. Only a subgroup of participants filled out SF-36, and the study shows good criterion validity, but this could have led to greater variability. A strength of the study was the broad range of causes included; however, it is possible that more patients from the postinfectious group could have been COVID-19 related, which were not tested or verified. A second strength was the sample size, which should include at least 5 to 7 experts, and 5 to 15 target population interviews.[55] In the study, 12 target population interviews and 11 expert interviews were conducted. The population included 316 patient responses with chemosensory dysfunction. Sample size for CFA is a challenge, and applications often use outdated rules of thumb. Focus has recently shifted from observations per variable toward consideration of model quality.[56] The CFA model requires a sample size between 100 and 400.[57] For item response theory and Rasch models, a sample size between 250 and 500 has been suggested to provide a good balance for interpreting fit statistics.[58]

The sample size was comparable to 205 included in Frasnelli et al,[36] 35 included by Pusswald et al,[51] 72 by Millar Vernetti et al,[53] 285 by Zou et al,[52] and 571 by Takebayashi et al.[54] Another strength of the study is the vigorous development and validation process using the criterion standard of modern psychometrics.

The TASTE questionnaire has fulfilled the primary purpose of development and discrimination. The next step will be to investigate the secondary purposes of evaluation and responsiveness to evaluate the effect of treatment and measure changes over time.

Conclusions

In this survey study, results show that the TASTE instrument has been rigorously developed and validated with 8 domains related to chemosensory dysfunction and quality of life. All items had good internal consistency, test-retest reliability, interitem correlations, and item-total correlations, and the Rasch model provided a good overall fit of the model. These findings support that the questionnaire is now ready for use in clinical and research settings.

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