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A study about the frequency of taste disorders

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Abstract Although 5% of the general population exhibit a functional anosmia, little is known about the frequency of gustatory disorders. Whenever taste function has been tested within large sociodemographic studies, so far only short test versions were applied making the interpretation difficult. Using two psychophysical taste tests, the validated "taste strips" and suprathreshold taste solutions of the four basic tastes sweet, sour, salty and bitter we investigated 761 healthy subjects within the age range of 5–89 years. Prior to testing, all subjects rated their taste function. According to testing with the taste strips, 5.3% scored below the result considered as hypogeusia. All four taste sprays were correctly identified by 82.3% of all subjects. Results of the two taste tests correlated positively ($r = 0.33$, $p < 0.001$), and there was a significant negative correlation between age and test results. However, we never observed complete ageusia. Misinterpretations of tastes were surprisingly common. In summary, hypogeusia was present in 5% while complete ageusia seems to be very rare, in contrast to misinterpretations of tastes.

Keywords Taste · Disorder · Frequency · Taste strips · Misinterpretation

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Introduction

Smell disorders are common in the general population. Various reports come to a number of approximately 5% of people with functional anosmia [2, 15, 27] increasing to almost 25% anosmic subjects between 65 and 80 years, and nearly 50% anosmic subjects in the age group over 80 years [6], with growing age olfactory impairment ranges from 24.5 [19] to over 80% [6]. This relatively large number of people with olfactory loss is also reflected in the relatively large number of people seeking professional help [4]. However, many of the affected people are not even aware of their disorder since self assessment of olfactory function is very poor [14, 25].

In contrast, there is only a small number of patients with measurable taste deficits [5, 9]. As with the olfactory function, subjective ratings of taste function do not seem to be reliable. Even specially designed questionnaires (e.g. [26]) to detect taste dysfunctions are only sensitive in detecting persons without taste problems. In this context the importance of measuring gustatory function becomes obvious.

In the literature, data concerning the rate of taste disorders usually refers to patients seen in chemosensory clinics and not to the general population. The reported data exhibit great variation. Rates for generalised ageusia range from 0.84 [22] to "below 4%" [5] in patients complaining about gustatory disorders and up to almost 20% [27] in "healthy subjects". However, direct comparison of the different studies is difficult, especially since different tests are applied and test results were interpreted differently. Typically liquid solutions were used to study the four qualities: sweet, sour, salty and bitter (umami is generally not tested due to its unfamiliarity in most Western people). Solutions are characteristically made from sucrose, citric acid, sodium chloride and quinine hydrochloride or caffeine [10, 11]. Other means to test gustatory function psychophysically are whole-mouth tests using liquids [29], tablets [1] or taste strips [16, 18], usually applied in clinics. A major difference of this study compared to the former ones relates to the idea that in the study by Landis et al. [16], subjects were brought to the laboratory for testing. In this study, however, the test was brought to the people, hoping that the current results would reflect the situation in the general population to a better degree than in the previous paper. The aim of the present study was to examine (1) the frequency of gustatory disorders in a large sample of subjects in the general population of different ages, and (2) to specifically study the number of false answers given in a forced choice testing paradigm using the "taste strips", a validated, easy to apply and commercially available test [16, 18].

Subjects and methods

The study was conducted in accordance with the Declaration of Helsinki; the protocol was approved by the Ethics committee of the University of Basel.

Subjects

Seven hundred and sixty-one subjects (mean age 35.8 years ± 19.3, range 5–89 years) took part in the study. More women [464 (61%)] than men [297 (39%)] were included. Subjects were recruited at the "Museumsnight" in Basel, in public swimming pools, in the Swiss army and within the otorhinolaryngologic department of the University Hospital Basel. In the otorhinolaryngologic department only subjects accompanying patients and not patients themselves were asked to participate.

Prior to testing, all subjects filled in a questionnaire. Sociodemographic data such as age and gender, smoking habits, general diseases, medications and ratings of taste function were recorded. Subjects rated their taste as "above average", "normal", "decreased" or "missing", corresponding to scores of 1, 2, 3 and 4. If participants rated their taste function as decreased or missing they were asked for a possible reason. Moreover, if they believed they had decreased taste function they were also asked to rate the impact of their taste deficit on their lives as none, little, a lot or very strong, corresponding again to scores of 1, 2, 3 and 4.

Taste testing

Two psychophysical tests were applied to evaluate gustatory function. In all subjects testing started using the well validated taste strips ("Taste Strips", Burghart, Wedel, Germany, [16]). These are impregnated filter papers of a length of 8 cm with a tip area of 2 cm^2. Each of the 16 taste strips is impregnated with one of the four tastants: sweet, sour, salty and bitter. Each quality is tested in four different concentrations as follows: sweet: 0.4, 0.2, 0.1, 0.05 g/ml sucrose; sour: 0.3, 0.165, 0.09, 0.05 g/ml citric acid; salty: 0.25, 0.1, 0.04, 0.016 g/ml sodium chloride; bitter: 0.006, 0.0024, 0.0009, 0.0004 g/ml quinine hydrochloride. Umami was not tested because most Europeans are not familiar with it. The taste strips were placed on the anterior part of the tongue. Even though taste strips can be easily used to test different areas of the mouth separately, in our study participants deliberately were allowed to close their mouth because a whole mouth testing procedure was performed. The whole mouth testing procedure was chosen because this has not been studied extensively in previous investigations. In addition, the whole mouth experience reflects general taste sensitivity to a better degree than lateralised taste function (e.g., after section of the chorda tympani).

So after closing the mouth and moving the strip slightly around, subjects had to identify the taste from a list of four descriptors – sweet, sour, salty and bitter – in a forced choice paradigm. Their answer was noted irrespective of its correctness. After each taste strip application the mouth was rinsed with water. A test score below the 10th percentile of the normal distribution (a score below 9) was considered as a sign of hypogeusia, normogeusia is defined as a test score of 9 and higher [18]. One rationale for taking the number of correctly analysed taste strips instead of the concentration used is the fact that we rely on the original papers [16, 18]. Another rationale is the fact that tastants are applied as dried substances, which need to dissolve in the mucus. While this technique seems to work fairly well, we still do not know how much of the tastant is actually dissolved in the mucus. We therefore provide the number of correct taste strips rather than concentrations.

In contrast to testing in clinical set-ups where subjects usually are asked not eat, smoke, brush their teeth or drink anything other than water 1 h prior to testing, this was not possible in the current setup, because testing was mostly performed in public areas where it's difficult to keep people for longer than 30 min. However, when people were currently eating or drinking something other than water, they were not included.

A second suprathreshold taste test was applied after completing the "Taste Strip" testing. Four sprays, containing the following substances (each diluted in 100 ml distilled water): sweet: 10 g D-saccharose; sour, 5 g citric acid; salty, 7.5 g NaCl; and bitter, 0.025 g quinine hydrochloride were used. This test was applied to examine if people tested ageusic with the taste strips were unable to identify the sprays which then would make complete ageusia likely. Each spray was only applied once. Subjects, however, after they had received all four sprays, were allowed to change their answers if they wished to do so. Subjects opened their mouth, put out their tongue and a spray (volume approximately 150 µl) was applied. They afterwards were allowed to take their tongue inside the mouth again and to move it. The taste had to be identified as either sweet, sour, salty or bitter. Again, the answer was noted irrespective of its correctness. At the end of the test subjects received feedback with regard to their results.

Statistical analysis

SPSS 17.0 (SPSS Inc, Chicago, IL, USA) was used to perform statistical analysis. Data were submitted to analyses of variance (repeated measures design); *t* tests were used for post hoc testing. The alpha-level was adjusted to 0.05. The results are depicted as means and standard error means (SEM) if not otherwise depicted.

Results

Characteristics of all subjects are presented in Tables 1 and 2.

Subjective ratings

Subjectively taste function was rated to be "above average" (labeled as 1) by 65 subjects (8.5%), "normal" (labeled as 2) by 651 subjects (85.5%), "decreased" (labeled as 3) by 43 (5.7%) and "missing" (labeled as 4) by one subject (0.1%). The mean subjective rating was 2.0 ± 0.01 (SEM). If subjects rated their taste function as decreased or missing, the most common reasons subjectively assumed (not being further evaluated) for these disorders were: no explanation ($n = 6$), smoking ($n = 5$), no practice ($n = 5$), problems with nose ($n = 4$), age ($n = 4$), congenital ($n = 3$), others ($n = 8$), or some subjects ($n = 9$) did not fill in this field.

Taste spray

A total of 626 subjects (82.3%) correctly identified all four sprays. Most commonly bitter was identified correctly (95.9%) followed by sweet (94.7%), sour (93.4%) and salty (90.9%). Seven subjects only identified one spray correctly and only two subjects did not identify any of the four sprays correctly. Out of these nine subjects, three were younger than 14 years and one correctly identified all 16 taste strips. Two subjects were assumed to have a reduced sense of taste. If misinterpretation took place, in most cases subjects misidentified the spray as bitter. The salty taste was most often misinterpreted as bitter; detailed results are given in Table 3.

Taste strips

Out of all 761 subjects, 40 (5.3%), scored below 9 which is considered hypogeusia; 94.7% reached a score of 9 and above, as depicted in Fig. 1. Only nine (1.2%) subjects, all men, reached a score of 6 or below; two of them were at the

Table 2 Age and gender of participating subjects

Age-group Total	Subjects $n = 761$	Women $n = 464$	Men $n = 297$
≤10 year	19	13	6
11–19 year	176	102	74
20–29 year	122	76	46
30–39 year	110	74	36
40–49 year	148	94	54
50–59 year	97	50	47
60–69 year	39	20	19
70–79 year	37	27	10
>80 year	13	8	5

Table 1 Socio-epidemiologic data of all subjects and the mean number of correct identified taste strips

	Yes (*n*%)	Mean number of correct taste strips (±SD)	No (*n*%)	Mean number of correct taste strips (±SD)		Some-times (*n*%)
Smoking	75 (10)		639 (84)			46 (6)
Medication	165 (21.7)	12.6 ± 2.2	596 (78.3)	13 ± 2.2	$t = 1.67$; $p = 0.10$	
M. Sjögren	0		761 (100)			
Epilepsy	5 (0.7)		756 (99.3)			
Hypertension	51 (6.7)	12 ± 2.4	710 (93.3)	13 ± 2.1	$t = 3.35$; $p = 0.001$	
Diabetes	4 (0.5)		757 (99.5)			
Tumor	7 (0.9)		753 (99.1)			
Head trauma	16 (2.1)	12.2 ± 2.1	745 (97.9)	13 ± 2.2	$t = 1.40$; $p = 0.16$	

Table 3 Results showing number of correct and incorrect identified taste sprays/taste strips and the misinterpretations in case of incorrect interpretation

Spray	Correct (*n*%)	Incorrect (*n*%)	If incorrect, considered as				Taste strips	If incorrect, considered as			
			Sweet	Sour	Salty	Bitter		Sweet	Sour	Salty	Bitter
Sweet	721 (94.7)	40 (5.3)		8	2	27	Sweet		78	52	71
Sour	711 (93.4)	49 (6.6)	7		10	28	Sour	187		420	361
Salty	692 (90.9)	69 (9.1)	2	10		48	Salty	62	228		153
Bitter	730 (95.9)	31 (4.1)	3	13	10		Bitter	137	230	151	

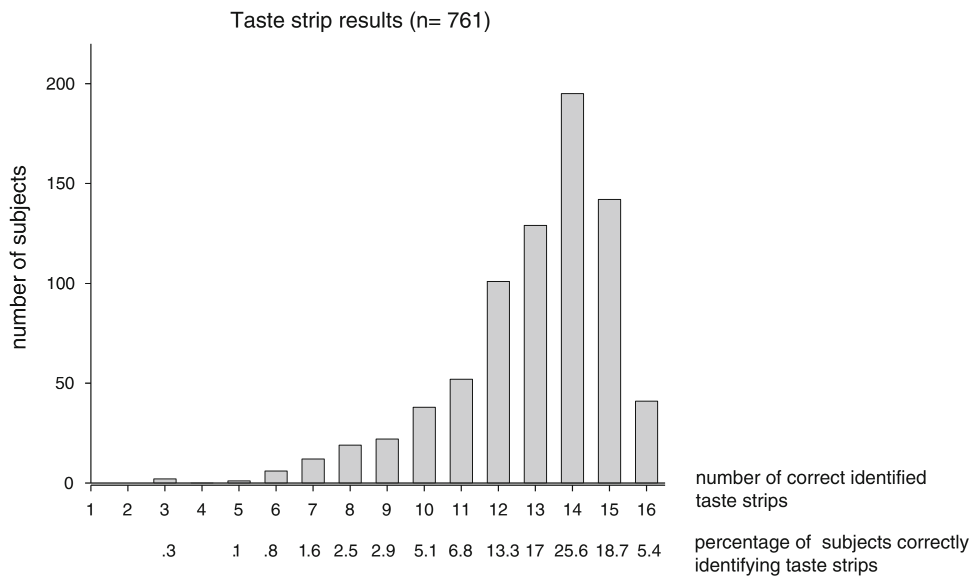

Fig. 1 The number of taste strips being correctly identified by the participating subjects (%)

Table 4 Additional data from the individual subjects recognizing six or less taste strips

Patient sex/age (years)	Total men in age group	Number corrects strips	Number correct sprays	Subjective rating	Smoking	Medication	Disease
M, 61	19	3	2	Normal	No	No	No
M, 38	36	3	4	Normal	Yes	Yes	No
M, 12	74	5	3	Normal	No	No	No
M, 10	6	6	2	Normal	No	No	No
M, 33	36	6	4	Normal	No	No	No
M, 57	47	6	4	Normal	No	No	No
M, 31	36	6	4	Normal	Yes	No	No
M, 54	47	6	4	Normal	No	Yes	Diabetes, hypertension
M, 74	10	6	4	Normal	No	Yes	Hypertension

Age group were defined as depicted in Table 2

age of 12 or younger and four of them were above 50 years. Two of these were smokers and three took medications, as shown in Table 4. Mistakes were more likely at all weak concentrations, Table 5. The taste strip with the strongest concentration of all four taste qualities was correctly identified in more than 94% of all cases, most often the sweet taste was correctly identified (98.4%), followed by bitter (96.1%), salty (95.5%) and sour (94.2%). Women scored better than men (women: mean score: 13.3 ± 0.08 vs. 12.4 ± 0.14 in men, $p < 0.01$). Misinterpretations took place as well. While sweet was rarely mistaken for a different taste, sour was most commonly mistaken as salty and vice versa. Bitter was also commonly mistaken as sour. Details are depicted in Table 3.

Table 5 Depicted is the number of correct/false answers of taste strips in regard to taste and concentration

Taste	Correct (*n*)	Incorrect (*n*)	Correct (%)
Sweet 4	660	101	87
Sweet 3	694	67	91
Sweet 2	739	22	97
Sweet 1	749	12	98
Sour 4	145	616	19
Sour 3	444	317	58
Sour 2	612	149	80
Sour 1	716	45	94
Salty 4	572	189	75
Salty 3	627	134	82
Salty 2	690	71	91
Salty 1	727	34	96
Bitter 4	444	317	58
Bitter 3	654	107	86
Bitter 2	661	100	87
Bitter 1	731	30	96

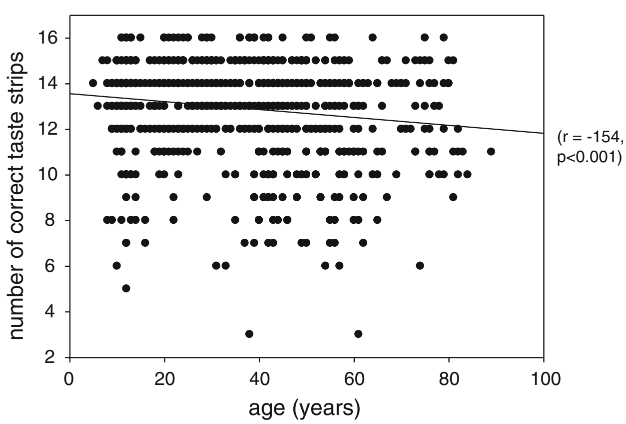

Fig. 2 The correlation between age (years) and the number of correct analyzed taste strips

There was a positive correlation between the result of the taste spray and the taste strips ($r = 0.33$, $p < 0.001$) and a negative, but rather weak correlation between the age and the taste strips results ($r = -154$, $p < 0.001$), Fig. 2. Neither results from taste strips ($r = -0.4$, $p = 28$ n.s.) nor from taste sprays ($r = -0.5$, $p = 15$, n.s.) correlated with subjective taste rating.

Discussion

The results of this study demonstrate that according to the normative data of the "taste strips" (1) hypogeusia is present in approximately 5% of a population. Complete ageusia, however, is very rare; it may occur in one or two individuals out of 1,000. Moreover, (2) women are slightly better than men in identifying different tastes and (3) misinterpretations of tastants are common, in most cases the respective taste was mistaken as bitter.

These data suggest again that complete ageusia is rare. It occurs much less than the known rates of 1–5% anosmia in the general population. The present findings are also in line with the literature, although to our knowledge this is the largest study examining the frequency of taste disorders in healthy subjects using both a suprathreshold spray test and a more detailed test based on "taste strips".

Most reported data are about patients complaining about either a smell disorder, a taste disorder, or a combined smell and taste disorder. Out of 750 patients presenting themselves with complaints concerning smell and taste to a medical center, only 8.7% complained about taste loss while 57.7% complained about smell and taste disorder [5]. Upon testing, <1% were found to have an isolated taste deficit. Similarly, another study examining 1,176 patients with chemosensory complaints found generalised taste disorders for all four taste qualities in only 10 (0.85%) patients. Half of these patients were classified as severe hypogeusic and half as ageusic [22], even though 8.1% were found to exhibit quality specific elevations in taste thresholds [22]. In the "Beaver Dam Offspring Study" taste discs of the qualities salty, sweet, sour, bitter and PROP were used to test taste function in 2,733 healthy subjects. Correct identifications ranged from 56.3% (PROP), 63.6% (sour), 88.5% (bitter), 89.7% (salt) up to 90.7% (sweet) [3]. However, although a large number of subjects had been tested, a critical weakness in this study is that subjects did not have to answer in a forced multiple choice paradigm but were allowed to answer: "no taste" or "unknown" after taste administration. Furthermore, there are no normative data for the "taste discs" technique which renders interpretation of these data more than difficult.

Schumm et al. [24] examined taste function in a social life, health and aging project in the USA in 2,928 subjects using only four taste strips, each strip of the strongest concentration. Correct identification ranged from 39.0% (sour), 67.2% (salty), 69.9% (bitter) to 86.3% for the sweet taste strip. In both large demographic studies obviously between 10 (regarding sweet) and 60% (sour) of the presented tastants' were not correctly identified.

A rather high percentage of possible hypogeusia rate of 19.8% was observed in an epidemiological study examining 1,312 healthy subjects with four suprathreshold taste sprays [27]. The authors applied these sprays only once and defined an incorrect identification of all four tastes as "hypogeusia". Regarding taste sprays alone, a similar rate of "hypogeusia" is found in our study. Only 82% of the four taste sprays were correctly identified during the first trial. However, when applying another psychophysical taste test to the participants, as it was done in the present study, the high percentage of "hypogeusia" could not be confirmed.

Thus, although impressive numbers of subjects have been tested in each of the studies mentioned above, typically only short taste tests have been applied, which are limited to the differentiation between "healthy" and "non-healthy". Liquid taste tests have been used for years [11]; normative data have only recently been published [10]. Examining a group of 230 healthy volunteers these authors also observed nine subjects not being able to recognize one of the four tastants sweet, sour, salty, or bitter, even at the highest concentration. They concluded that these subjects exhibit a selective hypo/ageusia [10]. Such selective ageusia has also been described for sweet [12], umami (monosodium L-glutamate), [17], and sour [13] as well as the bitter compound phenylthiocarbamide (PTC), and its chemical relative 6-*n*-propylthiouracil (PROP) [7].

Using our experimental set-up and applying each taste spray only once it became obvious that the non-identification of one spray cannot necessarily be equated with a selective ageusia since many of these subjects correctly identified the taste strips of the corresponding tastant. Such incorrect naming may indicate that naming a taste might be more difficult than generally thought. In our present study sweet has been the taste most often correctly identified in both tests, sprays and taste strips. This goes along with data from Pilková et al. [21], demonstrating that sweet taste was best identified while subjects were less successful in naming the other tastes. When applied as a spray to the entire oral cavity, bitter was identified correctly in most cases, in contrast to administration of bitter taste strips, which were very often misinterpreted. This difference indicates that administration of taste strips produced a more local stimulation of taste receptors. Thus, the method of administration also matters when it comes to comparison of taste tests. However, it is also very clear that results between different taste tests correlate, e.g. liquid drops and taste strips [18].

With increasing age, gustatory function is known to decrease. Many, but not all studies report an age related decrease of taste function. Some studies showed a more general loss in all taste qualities [8, 23], while others have shown a quality-specific loss of function [20].

There are also data showing that sweet taste might be more robust against age decline [28, 30]. Thus, the results of this study showing a weak negative correlation between taste function and increasing age is in line with the literature.

To summarize, the present investigation is the largest study to examine healthy subjects using two taste tests. (1) We were able to demonstrate that complete ageusia is very rare and was not observed within our sample of 761 subjects, and (2) hypogeusia was observed within 5% of all subjects according to the taste strips normative values. However, naming of tastants seems be more difficult than previously assumed and misinterpretations are much more common than true "mis-tastes".

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