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Psychophysical Taste Assessment: Comparison Between Taste Strips and Cotton Taste Buds

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ABSTRACT

Background: To develop a more practical screening test for gustatory function, without losing the sensitivity of taste strips, and to evaluate the effect of a learning phase in identification of tastants.

Methods: A total of 35 participants (25 female and 10 male, mean age of 34y) were enrolled and consecutively tested with the already established "taste strips" method, the newly proposed "cotton taste buds" method, and the "cotton taste buds" method with a preceding learning phase. For all different methods, the same tastants and concentration steps were used. The GustaF algorithm was used as a tool for whole mouth testing in a computer-randomized sequence.

Results: The newly proposed "cotton taste buds" method showed significantly higher scores compared to the "taste strips" method, both for total taste scores ($P < .001$), as for lateralized taste scores ($P < .001$). Analysis of variance revealed a significant difference in the number of taste confusions made in the different dilution steps ($P < .001$) and a significant difference between the different taste confusions made ($P < .001$) in the "taste strips" method. Sweet is the only basic tastant which is rarely mistaken for a different taste. All participants preferred the "cotton taste buds" method. However, there was no difference between the "cotton taste buds" method and the "cotton taste buds" method with a preceding learning phase, showing objectively that a prelearning phase did not overcome the bias due to a lack of proper verbal descriptors of tastants.

Conclusion: "Cotton taste buds" seems a valid diagnostic tool for screening. Nevertheless, taste strips remain the golden standard for psychophysical taste assessment.

Keywords: Cotton taste buds, gustatory assessment, taste assessment, taste loss, taste strips

Introduction

Even though hypogeusia is only present in 5% of the population and ageusia seems to be very rare,[1] a reliable diagnostic test is necessary to solve the confusion of gustatory and olfactory mediated sensations due to retro-olfaction. Patients presenting at the smell and taste center frequently report both smell and taste dysfunction prior to diagnosis. Most people are not aware of the distinction between taste and flavor. Since flavor perception is largely mediated by retronasal stimulation of olfactory receptors during mastication and deglutition, patients confuse their loss of smell (and secondary loss of flavor) with loss of taste.[2]

Most current gustatory testing devices are either based on liquid dilutions,[3,4] taste tablets,[5] edible wafers,[6] or taste strips.[7] Since the opening of the Smell and Taste Centre at the hospital, assessment of taste function was performed using "taste strips." A test device based on the ideas by Mueller et al in 2003, using filter papers impregnated with tastants, was[7] proven reliable in lateralized testing,[8,9] and provided normative data on a forced choice paradigm.[10]

Based on our experience, people had rather difficulties with recognizing the tastants in the "taste strips" method, even if they had normogeusia. Furthermore, the naming of tastants in the normal tasting population was more difficult than previously assumed. Like Welge-Lüssen once wrote: "misinterpretations are much more common than true 'mis-tastes'."[1]

A prospective study is presented in which a newly presented "cotton taste buds" method with the already established "taste strips" method was compared. The first endpoint of the study was to see if the "cotton taste buds" were a more

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practical method for gustatory testing, without losing the test sensitivity of taste strips. The second endpoint was to evaluate the effect of a preceding learning phase on the identification of tastants.

Methods

In this single center prospective psychophysical taste assessment study, participants reporting a normal sense of smell and taste were enrolled. Inclusion criteria applied were healthy males and females between the ages of 18 and 55 years old. Participants who reported an olfactory and/or gustatory dysfunction, who suffered from chronic middle ear infections in the past, who had systemic diseases with xerostomia as a main feature or reported other oral diseases, who underwent a tonsillectomy in their medical history, who are current or past smokers, who reported allergies, and participants who underwent radiotherapy in the head and neck region was excluded. Subjects who met the inclusion criteria and did not meet the exclusion criteria were selected.

The Ethics committee of the hospital has acknowledged this prospective pilot study as scientifically relevant and in line with prevailing ethical standards, as confined in the Declaration of Helsinki (BUN: B049201838145 // Int. Nr. 2389). All participants included gave their written consent.

Study Design

The newly proposed cotton taste buds method was based on previous gustatory testing devices with liquid dilutions,[3] combined with the testing paradigm of the "taste strips" method, implying lateralized testing with a forced choice testing paradigm.[10] To compare the "cotton taste buds" method with the already established "taste strips" method proposed by Mueller et al in 2003 as the first endpoint, and to see the influence of a learning phase on taste assessment as the second endpoint, subjects had to perform the following 3 gustatory tests:

1. Taste strips method - This test was based on filter paper strips ("taste strips", Burghart, Wedel, Germany), with a length of 8 cm and a tip area of 2 cm^2 being impregnated with tastant (4 concentrations each of the 4 basic taste qualities). The following concentrations were used for the taste strips: sweet (0.4, 0.2, 0.1, 0.05 g/mL saccharose); sour (0.3, 0.165, 0.09, g/mL citric acid); salty (0.25, 0.1, 0.04, 0.016 g/mL); and bitter (0.006, 0.0024, 0.0009, 0.0004 g/mL quinine hydrochloride).[10]

Taste strips were presented in a PC-randomized sequence, given by GustaF, at each of the 4 levels of concentrations. The strips were placed alternately on the left or right side of the anterior third of the extended tongue. With their tongue still extended, subjects had to identify the taste out of the 4 basic tastes: sweet, sour, bitter, and salty. Forced multiple choice was applied. After every sweep, subjects were asked to rinse the mouth with water.[10]

2. Cotton taste buds (CTB) method (Figure 1) – In this taste test cotton buds instead of taste strips were used, which were dropped in liquid solutions containing 4 different concentrations of sweet, sour, salty, and bitter, with distilled water as a solvent. Taste solutions were prepared freshly at regular intervals by the pharmacy department. As for the strips, the same concentrations were used. The cotton buds were first dropped in the solution and then subsequently wiped on the lateral side of the anterior two-thirds of the extended tongue, alternating between the left and the right side. All liquid solutions were shaken before use to obtain a homogeneous solution. Again GustaF was used to give a randomized sequence at each of the 4 levels of concentrations, and subjects were asked to rinse the mouth with water after every sweep.

3. Cotton taste buds method, with preceding learning phase (CTB + LP) – The same protocol as in the CTB method was used in this taste test, but the test was preceded by a learning phase. In this learning phase, all subjects learned the different tastes by giving them a drop of the highest concentration of each tastant, while the examiner told them what to taste.

Like Hummel, the tastant umami was not included, since this taste concept is hardly known in the European population. Subjects were instructed to abstain from eating and drinking (except still water), from eating chewing gum, and from brushing their teeth 1 hour prior to testing. Since smoking has a negative influence on gustatory sensitivity,[11] current and past smoking as an exclusion criterion was defined. All tests were performed by the same examiner.

The number of correctly identified tastes was calculated and added up to a "taste subscore" per side, and a "total taste score." These data were calculated with GustaF (downloaded at https://www.uniklinikum-dresden.de).

After performing all different taste assessment methods, participants were asked to fill in a questionnaire about their preferences. First, the volunteers were asked their preferred method for assessing their sense of taste (the taste strips method or the cotton taste buds method). Secondly, the participants were enquired if they found the preceding learning phase useful or not.

Statistical Analysis

Statistical analyses were performed using SPSS version 26 (IBM SPSS Statistics, New York). Patient demographics,

Main Points

- "Cotton taste buds" seems a valid diagnostic tool for screening. Nevertheless, taste strips remain the golden standard for psychophysical taste assessment since "cotton taste buds" is a self-made screening test, which is not validated and has a short shelf-life.
- Sweet is a basic tastant which is rarely mistaken for a different taste.
- In basic taste perception, there are some frequent confusions, such as salt-sour and sour-bitter, which appear to be present in a considerable proportion of the general population due to a similar inherent tingling and stinging feeling, the rather undeveloped concept of bitter and sour, and cultural misdescriptions.
- Overall gustatory function and its description is biased by a lack of proper verbal descriptors, leading to a mix-up of sour, salt, and bitter. Even a learning phase could not overcome this bias.

Figure 1. "Cotton taste buds" method.

taste subscores, and total taste scores were described using descriptive statistics. The different ways to assess taste function were compared using paired *t*-test.

Furthermore, the frequency of the following confusions made: sour-bitter; salt-sour; bitter-salt; and the number of mistakes in the different concentration steps were analyzed. Descriptive statistics were used, besides analysis of variance (ANOVA), to analyze the differences among group means. If ANOVA showed a significant difference, the Tukey and Scheffe tests were subsequently applied.

For all statistical analyses, significant difference was defined as a *P*-value < .05.

Results

Participants Demographics

Thirty-five normal healthy volunteers who met the inclusion criteria were enrolled. Twenty-five of them (71.43%) were female and 10 were male (28.57%). The mean age was 34, ranging from 18 to 55 years (SD = 10.62).

Taste Scores

The taste strips method was employed as a reference test to the new CTB method. The taste scores of the 3 different taste assessment methods were compared using the paired *t*-test. Participants obtained a significantly lower score if taste strips were used, compared with CTB or CTB + LP, both for total taste scores (Figure 2) and lateralized taste scores (Figure 3). No statistical difference was found between the CTB method and the CTB + LP.

Comparing the taste subscores of the 4 basic tastants between the 3 different taste assessment methods revealed a significantly lower subscore if the taste strips method was used, but only for the tastants sour, bitter, and salt (Figure 4). No significant difference was found in the taste subscores for sweet.

Taste Confusions

First, the number of taste confusions between the different dilution steps were considered. ANOVA revealed a significant difference in the number of taste confusions between the different dilution steps ($F = 43.180$; $P = .001$) in the taste strips testing method. No significant difference was found in the CTB method ($F = 3.899$; $P = .010$) and in the CTB + LP method ($F = 0.521$; $P = .668$).

According to the Tukey and Scheffe test, which is only of value on the data of the taste strips testing method, since

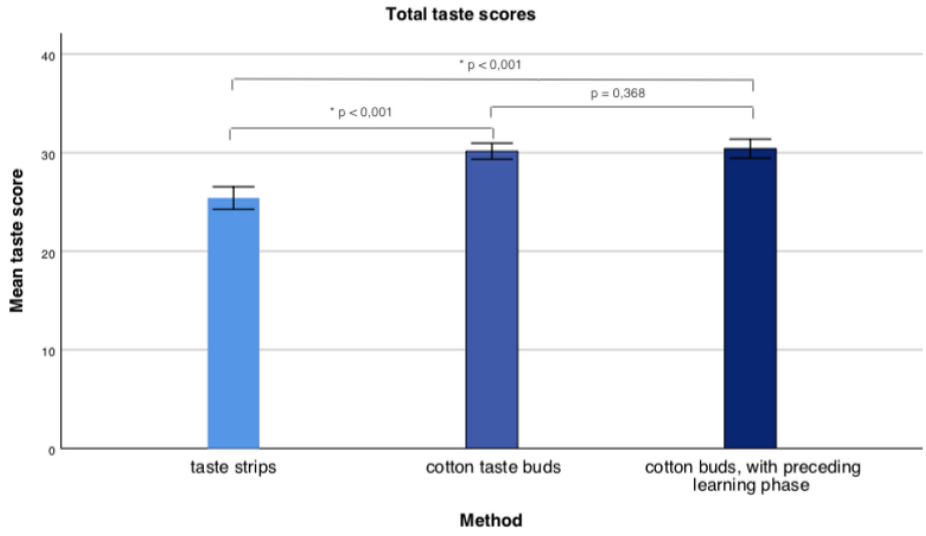

Figure 2. Results of paired *t*-test for total taste scores.

this test showed a significant difference with ANOVA, significantly more taste confusions were made in dilution step 4, corresponding with the lowest concentration. The number of taste confusions in dilution step 1 did not differ significantly from the number of taste confusions in dilution step 2, but both showed significantly fewer errors than dilution step 3. At the same time, dilution step 3 showed significantly fewer faults than dilution step 4.

Secondly, the types of taste confusions were analyzed. In the taste strips testing method, a significant difference between the different taste confusions made (bitter-sour, salt-sour, bitter-salt, sweet-salt, sweet-sour, sweet-bitter) was noticed, according to ANOVA, ($F = 20.702$; $P = .001$). No significant difference was found in the CTB method ($F = 1.839$; $P = .107$) and in the CTB + LP ($F = 0.890$; $P = .488$).

Subsequently, the Tukey and Scheffe test were performed, which was again only of value on the data of the taste strips testing method, since this test showed a significant difference between the different taste confusions with ANOVA. There is no statistically significant difference between the taste confusions salt-sour and bitter-sour, and these 2 taste confusions were more frequently made than the taste confusions bitter-salt, sweet-salt, sweet-sour, and sweet-bitter. The taste confusions sweet-salt, sweet-sour, and sweet-bitter were the least frequently made; between them, no statistical difference was found.

In the taste strips method, sour was 37.5% of the times incorrectly identified, whereas in the CTB method, normal healthy volunteers identified sour incorrectly 5% of the time and in the CTB LP method 3.57%. Sour was commonly mixed up as salt, and vice versa. The bitter tastant was also often referred to as sour. Sweet was the tastant that was identified correctly most of the time. Details are depicted in Tables 1-3, respectively, for the taste strips method, the CTB method, and the CTB LP.

Questionnaire in Preferences

All of the 35 participants (100%) preferred the cotton taste buds method as a method for taste assessment. Furthermore,

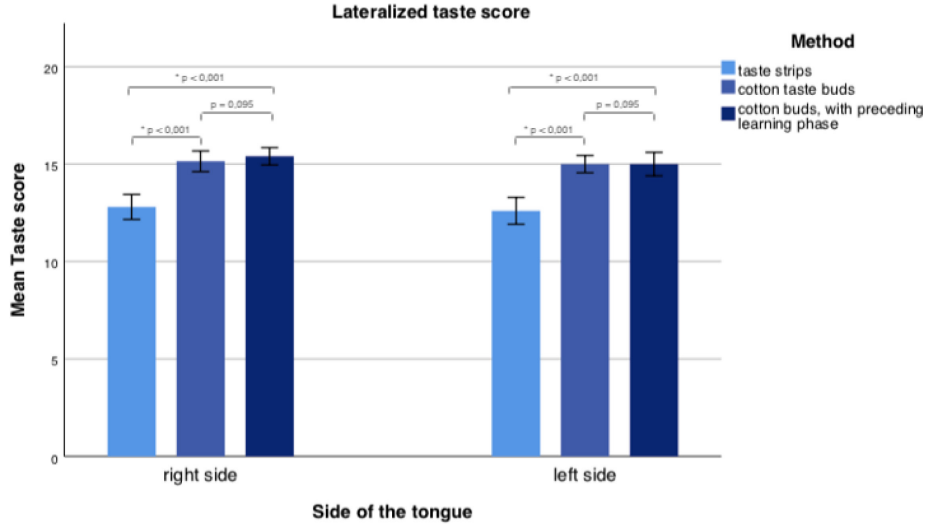

Figure 3. Results of paired *t*-test for lateralized taste scores.

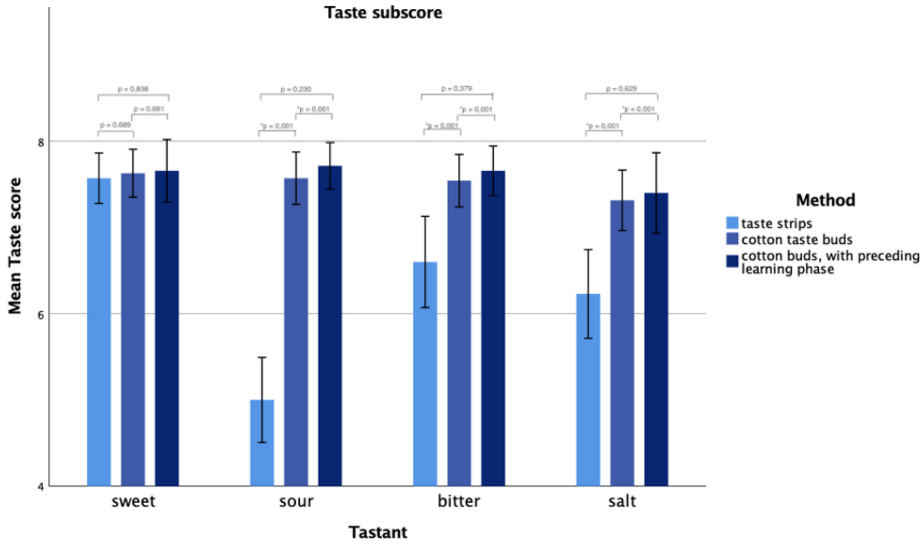

Figure 4. Results of paired *t*-test for taste subscores for each of the tastants.

it was asked whether the participants thought the preceding learning phase had added value in taste screening. Twelve participants found the preceding learning phase useful, 15 found it useful if they would have a taste disturbance, and 8 subjects found the learning phase not useful.

Discussion

In this prospective study design, a new screening method for gustatory function was investigated. The already established "taste strips" method was employed as a reference test to

Table 1. Results Showing Number of Correct and Incorrect Identified Tastants in the Taste Strips Method, and Their Misinterpretations

		Correct Identified		Incorrect Identified		If Incorrect, Considered as			
		n	%	n	%	Sweet	Salt	Sour	Bitter
Sweet	Dilution step 1	61	87.14	9	12.86	-	5 (7.14%)	1 (1.43%)	3 (4.29%)
	Dilution step 2	65	92.86	5	7.14	-	3 (4.29%)	2 (2.86%)	0
	Dilution step 3	69	98.57	1	1.43	-	0	0	1 (1.43%)
	Dilution step 4	70	100	0	0	-	0	0	0
	Total	265	94.64	15	5.36	-	8 (2.86%)	3 (1.07%)	4 (1.43%)
Sour	Dilution step 1	12	17.14	58	82.86	12 (17.14%)	25 (35.71%)	-	21 (30%)
	Dilution step 2	37	52.86	33	47.14	4 (5.71%)	20 (28.57%)	-	9 (12.86%)
	Dilution step 3	59	84.29	11	15.71	0	9 (12.86%)	-	2 (2.86%)
	Dilution step 4	67	95.71	3	4.29	0	1 (1.43%)	-	2 (2.86%)
	Total	175	62.5	105	37.5	16 (5.71%)	**55 (19.64%)**	-	34 (12.14%)
Bitter	Dilution step 1	45	64.29	25	35.71	0	10 (14.29%)	15 (21.43%)	-
	Dilution step 2	57	81.43	13	18.57	1 (1.43%)	6 (8.57%)	6 (8.57%)	-
	Dilution step 3	63	90	7	10	0	1 (1.43%)	6 (8.57%)	-
	Dilution step 4	66	94.29	4	5.71	1 (1.43%)	1 (1.43%)	2 (2.86%)	-
	Total	231	82.5	49	17.5	2 (0.71%)	18 (6.43%)	**29 (10.36%)**	-
Salt	Dilution step 1	45	64.29	25	35.71	3 (4.29%)	-	12 (17.14%)	10 (14.29%)
	Dilution step 2	52	74.29	18	25.71	5 (7.14%)	-	12 (17.14%)	1 (1.43%)
	Dilution step 3	58	82.86	12	17.14	0	-	7 (10%)	5 (7.14%)
	Dilution step 4	63	90	7	10	0	-	6 (8.57%)	1 (1.43%)
	Total	218	77.86	62	22.14	8 (2.86%)	-	**37 (13.21%)**	17 (6.07%)

Table 2. Results Showing Number of Correct and Incorrect Identified Tastants in Cotton Taste Buds Method, and Their Misinterpretations

		Correct Identified		Incorrect Identified		If Incorrect, Considered as			
		n	%	n	%	Sweet	Salt	Sour	Bitter
Sweet	Dilution step 1	64	91.43	6	8.57	-	1 (1.43%)	2 (2.86%)	3 (4.29%)
	Dilution step 2	68	97.14	2	2.86	-	2 (2.86%)	0	0
	Dilution step 3	66	94.29	4	5.71	-	4 (5.71%)	0	0
	Dilution step 4	70	100	0	0	-	0	0	0
	Total	268	95.71	12	4.29	-	7 (2.5%)	2 (0.71%)	3 (1.07%)
Sour	Dilution step 1	68	97.14	2	2.86	0	1 (1.43%)	-	1 (1.43%)
	Dilution step 2	68	97.14	2	2.86	0	0	-	2 (2.86%)
	Dilution step 3	65	92.86	5	7.14	0	1 (1.43%)	-	4 (5.71%)
	Dilution step 4	65	92.86	5	7.14	0	0	-	5 (7.14%)
	Total	266	95	14	5	0	2 (0.71%)	-	12 (4.29%)
Bitter	Dilution step 1	62	88.57	8	11.43	3 (4.29%)	3 (4.29%)	2 (2.86%)	-
	Dilution step 2	65	92.86	5	7.14	0	1 (1.43%)	4 (5.71%)	-
	Dilution step 3	69	98.57	1	1.43	0	0	1 (1.43%)	-
	Dilution step 4	68	97.14	2	2.86	0	1 (1.43%)	1 (1.43%)	-
	Total	264	94.29	16	5.71	3 (1.07%)	5 (1.79%)	8 (2.86%)	-
Salt	Dilution step 1	58	82.86	12	17.14	3 (4.29%)	-	7 (10%)	2 (2.86%)
	Dilution step 2	65	92.86	5	7.14	0	-	2 (2.86%)	3 (4.29%)
	Dilution step 3	66	94.29	4	5.71	1 (1.43%)	-	1 (1.43%)	2 (2.86%)
	Dilution step 4	68	97.14	2	2.86	0	-	2 (2.86%)	0
	Total	257	91.79	23	8.21	4 (1.43%)	-	12 (4.29%)	7 (2.5%)

the new "cotton taste buds" method. Testing normal healthy volunteers' ability to taste with "cotton taste buds" objectively showed significantly higher taste scores than the "taste strips" method (P = .001), except for the tastant sweet. Not only objectively, but also subjectively all participants preferred the "cotton taste buds" method. As already explained by Ahne et al[5] with their drop method, the "cotton taste buds" method allows the delivery of the tastant already dissolved in water, which immediately leads to taste perception. In the "taste strip" method, on the other hand, the strip requires saliva or water for the tastant to dissolve before a subject is able to have taste perception. Even though the same concentrations were used, the concentrations in the taste strip method may be lower due to dissolving, compared to the administration of drops with the "cotton taste" buds. If the higher taste scores would only be attributed to the fact that one is liquid and the other has to be dissolved on the tongue, it is rather surprising that this difference is not present for the tastants sweet.

Using liquid solutions raises the question of whether the normative data for the "taste strips" method published by Hummel et al[10] can be extrapolated to this method or whether there is a need for new normative data to distinguish normo- from hypogeusia. Nor the normative values for the assessment of gustatory function using liquid tastants, presented by Gudziol and Hummel in 2007, can be used, since they used another test paradigm (i.e., "three-drop test").[4]

In the "taste strips" method, an increase in the number of taste confusions with higher dilution steps was noticed (i.e., with lower concentrations of the tastants). A finding that could not be found in the "cotton taste buds" method. It makes sense that it is more difficult to detect and distinguish flavors as the taste sensation thresholds are reached. Both for the "taste strips" method as well as for the "taste tablets" method, it is already proven that the percentage of correct identifications decreased with higher dilution steps.[5,7] The fact that there's no difference in the number of taste confusions in the different dilution steps in the CTB and CTB+LP method might as well be attributed to the taste applicator. The CTB delivers an already dissolved tastant. Since there's no oral dissolving process needed, the subject is exposed to subjectively higher concentrations of the tastants, making them easier to distinguish from each other. This points out that there might be a need for new normative data, or that the concentrations in the CTB method have to be adapted (to lower concentrations around the taste threshold) to use the same normative data as for the "taste strips" method.

As Welge-Lüssen already described in 2011, it was found that sweet was rarely mistaken for a different taste (< 5%) in all 3 taste assessment methods,[1] a finding that can be attributed to basic biology. Although there is an age-related decline in sweet preference between childhood and adulthood, the liking for sweet is inborn and largely driven by basic biology.[12] The

Table 3. Results Showing Number of Correct and Incorrect Identified Tastants in the Cotton Taste Buds Method, With Preceding Learning Phase, and Their Misinterpretations

		Correct Identified		Incorrect Identified		If Incorrect, Considered as			
		n	%	n	%	Sweet	Salt	Sour	Bitter
Sweet	Dilution step 1	65	92.86	5	7.14	-	2 (2.86%)	0	3 (4.29%)
	Dilution step 2	66	94.29	4	5.71	-	3 (4.29%)	0	1 (1.43%)
	Dilution step 3	68	97.14	2	2.86	-	2 (2.86%)	0	0
	Dilution step 4	69	98.57	1	1.43	-	1 (1.43%)	0	0
	Total	268	95.71	12	4.29	-	8 (2.86%)	0	4 (1.43%)
Sour	Dilution step 1	67	95.71	3	4.29	0	1 (1.43%)	-	1 (1.43%)
	Dilution step 2	68	97.14	2	2.86	0	1 (1.43%)	-	1 (1.43%)
	Dilution step 3	67	95.71	3	4.29	0	2 (2.86%)	-	1 (1.43%)
	Dilution step 4	68	97.14	2	2.86	0	0	-	2 (2.86%)
	Total	266	96.43	10	3.57	0	4 (1.43%)	-	5 (1.79%)
Bitter	Dilution step 1	66	94.29	4	5.71	0	4 (5.71%)	0	-
	Dilution step 2	67	95.71	3	4.29	1 (1.43%)	0	2 (2.86%)	-
	Dilution step 3	68	97.14	2	2.86	0	0	2 (2.86%)	-
	Dilution step 4	67	95.71	3	4.29	1 (1.43%)	0	2 (2.86%)	-
	Total	268	95.71	12	4.29	2 (0.71%)	4 (1.43%)	6 (2.14%)	-
Salt	Dilution step 1	63	90	7	10	0	-	3 (4.29%)	4 (5.71%)
	Dilution step 2	66	94.29	4	5.71	1 (1.43%)	-	3 (4.29%)	0
	Dilution step 3	64	91.43	6	8.57	0	-	1 (1.43%)	5 (1.79%)
	Dilution step 4	65	92.86	5	7.14	0	-	2 (2.86%)	3 (4.29%)
	Total	258	92.14	22	22.14	1 (0.36%)	-	9 (3.21%)	12 (4.29%)

tastant sweet has an innately rewarding feature,[13] favoring consumption of high energy, and may therefore be recognized with ease even in lower concentrations.

Furthermore, in the "taste strips" method, it was observed that the tastant sour was most commonly mistaken for salt, and vice versa. This salt-sour confusion was first stated by Gilmore and Green in 1913. They ascribed this confusion to the fact that both salt and sour give a slight tingling and stinging feeling on the tongue, due to a certain degree of irritation inherent to the tastant. Both tastants are frequently used in combination in foods with rich flavor, e.g., in dressings such as vinegar.[7,14]

A frequent confusion between bitter and sour was also noted in the "taste strips" method. In 1977 O'Mahony reported a sour-bitter blindness in a considerable proportion of the individuals in the general population, with a greater tendency to call citric acid bitter. They hypothesized that subjects have more experience in their culture of salty and sweet foods than sour or bitter ones, leading to less experience to develop the concepts of "sour" or "bitter". In addition, sour and bitter are rarely, if ever, eaten in pure form. Thirdly, Western habits reinforce this sour-bitter blindness by describing lemons as bitter and naming soft drinks as "bitter lemon."[15]

These taste confusions ("salt-sour" and "bitter-sour") were significantly more frequently present in the "taste strips" method, whereas in the "cotton taste buds" method, with or without a preceding learning phase, none of the taste confusions occurred significantly more.

Pilkova stated in 1991 that difficulties in taste identification may be caused by a lack of proper term and by a lack of experience in using it.[16] Assessing gustatory function showed that test results were biased by a lack of a proper verbal descriptor of taste, leading to mixing up sour, salt, and bitter, and to a lesser extent sweet, even in normal tasting subjects. Results other than sweet therefore need to be interpreted with some caution due to the potential bias in the test results. To overcome these problems, the study looked at the effect of a preceding learning phase on the number of taste confusions made and on the type of taste confusions made. However, although subjectively 27 (77%) participants experienced the learning phase as of additional value, objectively, the preceding learning phase did not affect the number of taste confusions made, nor the type of taste confusions. A pre-learning phase will not overcome the bias due to a lack of proper verbal descriptors of tastants. It seems as if the learning phase only puts the normal healthy volunteers at ease, rather than influencing their answers. Subconsciously, these confusions are consistently present, and further studies are needed to investigate their impact on test results, as well as the impact of the pre-learning phase.

Nevertheless, the shortcomings of the proposed "cotton taste buds" method as a new screening method must be addressed. To date, it is a self-made screening test, which is not validated. Further studies are needed to address its ability to reliably distinguish normal from impaired taste function. Secondly, the liquid solutions must be prepared weekly to avoid the risk of bacterial contamination of the solutions. In contrast, the taste strips were created to overcome the permanent need to reproduce the liquid solutions. They have a long shelf life and are currently sent around to multiple international centers, promoting multicentered studies. It is a validated test with normative data. Notwithstanding these advantages of the taste strips over the cotton taste buds, the cotton taste buds may be of value in patients with reduced saliva production, for example, the elderly or patients with a history of irradiation. Furthermore, in settings with no reimbursement for psychophysical taste assessment, the cotton taste buds may be financially more favorable. Last, leverage may be lacked, since only 35 participants were included in this study.

Conclusion

In summary, the "cotton taste buds" method seems a valid diagnostic tool. It is a lateralized testing method, with a force multiple choice paradigm. The fact that it is readily available and made by the pharmacy department makes it a cheap method for taste assessment; and thus, favorable for screening of patients' ability to taste. Adding a pre-learning phase to the test paradigm was helpful for the patient in recognizing the tastants but did not overcome the bias due to a lack of proper verbal descriptors of tastants. The verbal confusion seems to be quite robust.

Nevertheless, its shortcomings must be addressed. In patients, particularly with hypogeusia or ageusia, the "cotton taste buds" method misses the above-mentioned test characteristics. The fact that the percentage of correct identifications does not decrease with higher dilution steps and that the already known taste confusions were not significantly more frequent raises the question if this taste assessment method is reliable enough to distinguish healthy from impaired taste function, and if there's a need for new normative data.

Furthermore, it must be addressed that the shelf life of the "taste strips" is much longer than that of the liquid solution. Since this study only included 35 participants, leverage may be lacked, and thus further research is necessary to conclude if this newly proposed "cotton taste buds" method is equal to the "taste strips" method.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Artificial Intelligence Usage Statement: The authors declared that no Artificial Intelligence Tool was used in the preparation of the manuscript.

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Informed Consent: Written informed consent was obtained from the patients/patient who agreed to take part in the study.

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References

1. Welge-Lüssen A, Dörig P, Wolfensberger M, Krone F, Hummel T. A study about the frequency of taste disorders. *J Neurol*. 2011;258(3):386-392. [CrossRef]
2. Deems DA, Doty RL, Settle RG, et al. Smell and taste disorders, a study of 750 patients from the University of Pennsylvania Smell and Taste Center. *Arch Otolaryngol Head Neck Surg*. 1991;117(5):519-528. [CrossRef]
3. Krarup B. Electro-gustometry: a method for clinical taste examinations. Acta Otolaryngol. 1958;49(4):294-305. [CrossRef]
4. Gudziol H, Hummel T. Normative values for the assessment of gustatory function using liquid tastants. *Acta Otolaryngoll*. 2007;127(6):658-661. [CrossRef]
5. Ahne G, Erras A, Hummel T, Kobal G. Assessment of gustatory function by means of tasting tablets. *Laryngoscope*. 2000;110(8):1396-1401. [CrossRef]
6. Hummel T, Erras A, Kobal G. A test for the screening of taste function. *Rhinology*. 1997;35(4):146-148.
7. Mueller C, Kallert S, Renner B, et al. Quantitative assessment of gustatory function in a clinical context using impregnated "taste strips". *Rhinology*. 2003;41(1):2-6.
8. Just T, Pau HW, Bombor I, Guthoff RF, Fietkau R, Hummel T. Confocal microscopy of the peripheral gustatory system: comparison between healthy subjects and patients suffering from taste disorders during radiochemotherapy. *Laryngoscope*. 2005;115(12):2178-2182. [CrossRef]
9. Landis BN, Beutner D, Frasnelli J, Hüttenbrink KB, Hummel T. Gustatory function in chronic inflammatory middle ear diseases. *Laryngoscope*. 2005;115(6):1124-1127. [CrossRef]
10. Landis BN, Welge-Luessen A, Brämerson A, et al. "Taste Strips" – A rapid, lateralized, gustatory bedside identification test based on impregnated filter papers. *J Neurol*. 2009;256(2):242-248. [CrossRef]
11. Chéruel F, Jarlier M, Sancho-Garnier H. Effect of cigarette smoke on gustatory sensitivity, evaluation of the deficit and of the recovery time-course after smoking cessation. *Tob Induced Dis*. 2017;15(15):15. [CrossRef]
12. Mennella JA, Bobowski NK. The sweetness and bitterness of childhood: insights from basic research on taste preferences. *Physiol Behav*. 2015;152(B):502-507. [CrossRef]
13. Appleton KM, Tuorila H, Bertenshaw EJ, de Graaf C, Mela DJ. Sweet taste exposure and the subsequent acceptance and preference for sweet taste in the diet: systematic review of the published literature. *Am J Clin Nutr*. 2018;107(3):405-419. [CrossRef]
14. Gilmore MM, Green BG. Sensory irritation and taste produced by NaCl and citric acid: effects of capsaicin desensitization. *Chem Senses*. 1993;18(3):257-272. [CrossRef]
15. O'Mahony M, Goldenberg M, Stedmon J, Alford J. Confusion in the use of the taste adjectives 'sour' and 'bitter'. *Chem Senses*. 1979;4(4):301-318. [CrossRef]
16. Pilková L, Nováková M, Pokorný J. Naming and identification of tastes in aqueous solutions. *Nahrung*. 1991;35(9):999-1002. [CrossRef]