Development and validation of a Taste Sensitivity Test in a group of healthy children

ABSTRACT

Aim This was to validate a taste test on healthy school children. A cross-sectional study was designed to perform a standardised clinical evaluation of the gustatory sensitivity. Materials and Method Forty (18 males and 22 females) children were selected. Inclusion criteria were age between 5 and 12 years, absence of systemic disease and no antibiotic treatment in the last six months. The taste assessment tests were performed following a standardised protocol, repeated at two different intervals: a) tested at time 0; b) tested after 20-30 days. Tests were performed using a pipette with the sample solution: sucrose, sodium chloride, citric acid and quinine hydrochloride at different concentrations. The examiner reported in a grid the flavour perceived by the subject. A placebo (tap water) was administered in between the flavours. Results The majority of the subjects detected the bitter taste at the lowest concentration (mean=1.83). The sour taste was detected with the second concentration (mean=2.56). The sweet solution was detected with the most diluted concentration (mean=1.56). The salty taste has a threshold of 2 (mean=2.04), which means that the majority of subjects detected the salty solution with the second concentration. Regarding the perceived intensity, it increases with the increasing concentrations and it reaches maximum values that are inversely proportional to the threshold, corresponding to the second concentration. Moreover, no statistically significant gender differences were detected regarding the threshold values or the perceived intensity.

Conclusion The proposed test allows for a controlled, reliable and standardised evaluation of the gustatory modality.

Keywords Children; Taste disturbance; Test.

Introduction

Taste sensitivity provides information about the chemical characteristics of the substances coming into contact with the oral mucosa. The gustatory receptors or gustatory primary cells interact with the molecules dissolved in saliva and convert chemical stimulations in nervous signals [Migirov et al., 2008].

Taste is related to the composition of foods and beverages. It is believed that hundreds of perceptible flavours result from the combination of some primary qualities: sweet, salty, bitter and sour. Taste disorders are generally difficult to diagnose and treat. The most important clinical factors able to induce taste disorders are impairment of the turnover of taste receptors, such as stomatitis and mucositis, drugs or ionising radiations [Di Liberto et al., 2007; Márton et al., 2008].

The oral cavity is frequently associated with the typical side effects of antiblastic therapy, i.e. radiotherapy, chemotherapy and conditioning regimens used for Bone Marrow Transplantation (BMT) [Majorana et al., 2000; Pavlatos and Gilliam, 2008]. To fight those complications scientists are working hard trying to find new effective strategies for prevention and cure. Many studies have addressed xerostomy and oral mucositis while very few papers have been published on dysgeusia. Moreover, in children dysgeusia is even more important than in adults, since they often refuse the oral intake of drugs and food [Hong and da Fonseca, 2008; Skolin et al., 2006].

Diagnosis and management of this particular alteration depend on knowledge of taste sensitivity among healthy children, even if today the literature is still very poor [Majorana et al., 2000].

Taste sensitivity releases information about the chemical characteristics of the substances that enter in contact with the mucous membranes of the oropharynx. The taste receptors, also called primary gustatory cells, interact with the molecules dissolved in the saliva and transduce the chemical stimulus in nerve signals [Migirov et al., 2008]. The International literature on dysgeusia in children is very poor and usually it is simply listed among the side
effects of the antineoplastic therapy. Dysgeusia may cause anxiety, depression and nutritional deficiencies that are extremely important especially in the growing individuals [Majorana et al., 2000].

Taste alteration related to drugs assumption, may be continuous, discontinuous and with a variable intensity over time [Bågesund et al., 2000]. The cause of this side effect is complex and not completely known. Taste dysfunction induced by drugs may involve the gustatory system at every level: transportation, sensory system and different neuronal levels [Migirov et al., 2008].

Furthermore, the absence of a standardised method to assess taste dysfunction, and especially the absence of standards in the healthy child population, makes it impossible to compare the data collected in young subjects during radio-chemotherapy [Sung et al., 2007; Tomlinson et al., 2007]. The assessment of dysgeusia could be extremely useful to outline modifications in the diet regimen and promote a healthier and balanced food intake that plays a main role in the quality life of the young subject, but it can also strongly influence the prognosis of the main disease [Majorana et al., 2000].

The aim of this paper was, therefore, to develop and perform a clinical standardised evaluation of the gustatory sensitivity on a sample of healthy children, through the “validation of the test sensitivity test” procedure.

Materials and Methods

Sample selection

A convenience sample of 40 (18 males and 22 females) healthy children was selected among the child population attending the Paediatric Dentistry Department of the University of Brescia, Italy. Inclusion criteria were children of both genders with an age range between 5 and 12 years, with no systemic disease, and no antibiotic treatment in the last six months. Parents and/or caregivers were informed about the aim of the research and a signed informed consent was obtained.

Methods

The taste sensitivity tests were performed following a standardised protocol, repeated at two different intervals:

a) at baseline (T0);

b) after 20-30 days (T1).

Two trained and calibrated examiners performed the test at baseline on the same subject in two different moments. Tests were performed using a pipette with the different sample solutions: sucrose, sodium chloride, citric acid and quinine hydrochloride at two different concentrations (Table 1).

The subjects tasted the solutions at the two concentrations and were asked to identify their taste threshold, which is the lowest concentration at which each flavour can be identified from water.

The test was performed using 8 solutions with the 4 flavours at different concentrations, each administered once by each examiner, plus the placebo solution (deionised water), which was administered four times in between the flavours. The samples to be tasted were in total 12 solutions at the temperature of 24° Celsius (75,2° Fahrenheit).

The test was performed in a quiet room. Samples were given in 2 ml solution, measured with specific pipettes. After each test, the subjects were asked to rinse their mouth for 10 seconds with water.

At completion of the tasting phase the results on the gustatory function were reported on a table with two columns and 12 rows. In the first column the taste perceived by the child was reported: bitter, sour, salty, sweet, water; in the second column was reported the intensity of the taste according an analogical scale from 0 to 10 (where 0 is a neutral stimulus, i.e. water, and 10 is the maximum intensity of a flavour).

The results were then analysed starting from the lowest concentration of the substance and proceeding towards the highest, to define the threshold, represented by the lowest concentration detected by the subjects.

To avoid bias due to the modality, the sequence of the solutions administered was switched with every child following a predetermined way: bitter, sour, sweet, salty; sour, sweet, bitter, salty; sweet, salty, bitter, sour; salty, sour, bitter, sweet and so on. The subjects did not know in advance the type of solution administered or its progressively increasing concentration. Each test was repeated after two days at baseline and again after 20-30 days.

Statistical methods and data analysis

Data were imputed in an ad hoc prepared Excel® worksheet. The different concentrations of the flavours were coded between 1 and 2 following the threshold, which is the lowest concentration detected by the subjects.

The results were then analysed starting from the lowest concentration of the substance and proceeding towards the highest, to define the threshold.

Intensity of the stimulus is linked to the perception referred by the subject for each of the four flavours, from the more diluted (solution 1) to the most concentrated (solution 2), according to the analogical

<table>
<thead>
<tr>
<th>Taste</th>
<th>Flavour</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitter</td>
<td>Quinine Hydrochloride</td>
<td>0.000032 M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.00032 M</td>
</tr>
<tr>
<td>Salty</td>
<td>Sodium Chloride</td>
<td>0.032 M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.32 M</td>
</tr>
<tr>
<td>Sweet</td>
<td>Sucrose</td>
<td>0.032 M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.32 M</td>
</tr>
<tr>
<td>Sour</td>
<td>Citric Acid</td>
<td>0.001 M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.01 M</td>
</tr>
</tbody>
</table>

TABLE 1 Flavours and concentrations used for the test.
scale 0 to 10.

Instrument reliability (test-retest reliability) was measured by assessing the intraclass correlation coefficient (ICC) based on the two repeated measurements in order to ensure reproducibility. Validity tests were carried out. Data from the first baseline measurement were used to assess the validity of the instrument. Because there was no ‘gold standard’, construct validity was assessed. Cohen Kappa statistics was also calculated. Statistical analysis was performed with Stata 10 for Mac. A p-value of < 0.05 was considered statistically significant.

Results

The taste test on the sample of healthy subjects allowed four fundamental evaluations about the validity of the test itself, the gustatory threshold, the intensity perceived and a possible influence of the gender on these aspects and consequently on the taste function.

The data collected are shown in Figure 1, where it can be seen that the mean of the threshold is 1.83 for bitter, which means that the bitter taste was detected with the first solution; 2.56 for sour, meaning that the sour taste was detected with the second solution; 1.56 for the sweet, which means that the sweet taste was detected with the first solution; 2.04 for the salty taste, meaning that the salty flavour was detected in the large majority of the cases with the second solution; for the placebo, the threshold was not defined, but we can state that it was generally recognised.

Regarding the perceived intensity, it increases with the increasing concentrations and it reaches maximum values that are inversely proportional to the threshold, corresponding to the second concentration (Fig. 2): in fact the maximum values reached correspond to the bitter (9.61) and to the sweet tastes (9.59), which show the lowest threshold if compared to the salty and sour, that reach the lowest intensity (respectively 9.09 and 8.49), at a higher threshold. Moreover, no statistically significant gender differences were found regarding the threshold values or the perceived intensity.

Intraclass correlation coefficients of taste perception weighted for the number of problems scoring methods, between the two test evaluations were 0.74 (data not in table).

Discussion

The purpose of this work was to perform a clinical standardised evaluation of the gustatory sensitivity on a sample of healthy children between 5 and 12 years, obtaining, at the same time, the validation of the test performed. It has been quite easy to find, from the answers of each subject, the mean of the threshold (Fig. 1) and the perceived intensity (Fig. 2).
Regarding the threshold, the majority of the subjects detected the bitter taste at the first concentration administered (mean=1.83). The sour was detected with the second concentration (mean=2.56).

The sweet solution was detected with the most diluted concentration (mean=1.56). The salty taste has a threshold of 2, and the majority of the subjects recognised the salty solution with the second concentration.

Regarding the intensity of the bitter taste, they swing between 0 and 1 for the most diluted solution and between 7 and 8 for the solution at the highest concentration. For the sour taste the threshold was detected with the second concentration, the intensity of the most diluted acid solution is around zero (solution 1 = 0.33), while the most concentrated solution has an intensity value between 5 and 6 (solution 2 = 5.53). The intensity of the more diluted sweet solution swings between 1 and 2 (solution 1 = 1.42), while the intensity of the most concentrated solution swings between 7 and 8 (solution 2 = 7.22).

The salty taste in the solution with the lowest concentration has intensity close to the neutral stimulus (solution 1 = 0.55), and the threshold value is 2. The intensity of the second concentration, the less diluted, is between 6 and 7 (solution 2 = 6.78). Moreover, the test emphasised that the perceptive intensity increases with a linear trend from the first to the second solution, together with the increase of the concentrations.

From the analysis of the thresholds and intensity values of the sapid solutions in the two increasing concentrations we can infer that to the lower thresholds correspond the higher perceptive intensity values and vice versa (see sweet and acid).

All subjects identified the placebo as water with an intensity of zero (neutral stimulus), except for one subject, which is statistically negligible.

Lastly it can be said that the this study validated the test and that therefore it can be used as a reliable standardised evaluation of the gustatory modality.

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References