



REVIEW ARTICLE

## Quantitative evaluation of taste in childhood populations: a systematic review<sup>☆,☆☆</sup>



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### KEYWORDS

Taste;  
Child;  
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### Abstract

**Introduction:** Taste is of great importance for the feeding process. Seen in this light, it is essential to investigate this sense in children as developing human beings. However, despite little variation in the use of tests that measure the gustatory capacity, there are still questions about the applicability and effective use of tools for quantitative assessment in children.

**Objective:** To search the literature on quantitative instruments used for the evaluation of taste used in studies with children.

**Methods:** A search was conducted in the PUBMED and Web of Science platforms, and subsequently, the identified articles were selected and reviewed. The descriptors and terms used were "taste," "child," "assessment," "diagnosis," and "dysgeusia". Original articles related to the theme in English, restricted to children and with no year limitation, were selected. Studies conducted in other stages of human development, exclusively or concurrently with the pediatric population; animal studies; literature review articles; dissertations and book chapters; and case studies and editorials were excluded. The data analysis was performed through a cataloging protocol created for this study, including the following points: author, research department, year, location, population/sample, age, purpose of the study, methods, and primary results.

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**PALAVRAS-CHAVE**

Paladar;  
Criança;  
Avaliação;  
Disgeusia

**Results:** 5613 items were found. 5307 were excluded based on title, 248 by abstract analysis, and 43 by full text evaluation. Fifteen articles were selected for analysis; of these, six were repeated articles, and thus nine articles were selected for review.

**Conclusion:** The tests aiming at evaluation of taste were judiciously used, ensuring reliability for future research, which may employ methods similar to previous studies.

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**Avaliação quantitativa do paladar na população infantil: revisão sistemática****Resumo**

**Introdução:** O paladar é de grande importância para o processo de alimentação. Visto dessa forma, torna-se fundamental a averiguação deste sentido junto às crianças, que são seres em desenvolvimento. Porém, apesar da pouca variação na utilização de testes que mensuram a capacidade gustatória, ainda existe questionamento acerca da aplicabilidade e do uso eficaz dos instrumentos de avaliação quantitativa, especificamente na população infantil.

**Objetivo:** Levantar na literatura os instrumentos quantitativos para a avaliação do paladar utilizados em estudos com crianças.

**Método:** Busca dos artigos realizada nas plataformas PUBMED e Web of Science, seguindo etapas de seleção e análise crítica dos periódicos encontrados. Os descritores e termos utilizados foram taste, child, assessment, diagnosis e dysgeusia. Foram selecionados artigos originais relacionados ao tema no idioma inglês, realizados somente com a população infantil e sem restrição de ano. Foram excluídos estudos realizados em outras fases do desenvolvimento humano, exclusivamente ou concomitantemente com a população infantil; estudos com animais; artigos de revisão de literatura, dissertações e capítulos de livros, artigos de estudo de caso e editoriais.

A análise dos dados foi realizada por meio de um fichamento protocolar criado para este estudo, contemplando os seguintes pontos: autor, departamento de pesquisa, ano, local, população/amostra, idade, objetivo do estudo, métodos utilizados e resultados principais.

**Resultados:** Foram encontrados 5613 artigos. Foram excluídos 5307 artigos pelo título, 248 pelo resumo e 43 pelo texto lido na íntegra. 15 manuscritos foram analisados, dos quais seis eram artigos repetidos. Assim, 9 artigos foram selecionados para esta revisão.

**Conclusão:** Foi observada a utilização criteriosa dos testes de avaliação do paladar, garantindo confiabilidade às pesquisas futuras que venham a utilizar métodos semelhantes aos estudos já realizados.

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**Introduction**

The release of chemicals during the chewing process allows the taste buds in the oral cavity, pharynx, and larynx to transmit information for the recognition of the taste of the food. Taste is a complex sensory mechanism that can be broken down into four basic sensations (salty, sweet, sour, and bitter), but always resulting from the interaction of all of them and influenced by olfactory and trigeminal nerve mediated factors (texture, consistency, temperature, etc.).<sup>1</sup>

Changes in taste can be characterized as ageusia (absence of taste); hypogeusia (decreased perception of taste); dysgeusia (distorted taste capacity); parageusia (distorted sense of taste in the presence of stimulus); and phantogeusia (distortion of taste perception, but without the presence of stimulus).<sup>2,3</sup> The gustatory disorders of some individuals are affected by changes in nasal–oral airflow<sup>4</sup> during respiration that changes the influence of smell on

taste. In other individuals, a decrease of saliva from chronic mouth breathing,<sup>5</sup> which is common in childhood alters the perception of taste. Other causes of gustatory disorders include poor hygiene and impaired oral condition<sup>6</sup> and some specific epilepsy medications.<sup>7</sup> In children, a loss of sense of taste can cause a significant decrease in food intake possibly resulting in eating disorders, which can affect physical growth and overall development, as well as reduce the pleasure and comfort associated with food and increase the danger of food poisoning or excessive exposure to harmful environmental chemicals that would otherwise be detectable by the sense of taste.<sup>8</sup>

In order to quantify these potential difficulties and changes, different methods were developed for the evaluation of taste. The current literature<sup>9</sup> contains several articles involving all age groups using psychophysical quantitative instruments that expose the evaluated subject to the four basic tastes. There is no major variation in the tests

used to assess taste, but there are questions about their applicability in children and the effectiveness of their use specifically in that population.

Thus, this review proposes a systematic evaluation of the literature, in search of those quantitative tools used for the assessment of taste in children, documenting the frequency of use, selection criteria, and how these instruments are applied in children.

## Methods

### Research strategy

For the formulation of this literature review, the authors sought to answer the following questions: "What are the instruments used for quantitative assessment of taste in children? How are they selected? What is the frequency of use of these instruments? Are they effective and do they allow an adequate characterization of the child population regarding changes in taste?"

From these questions, a literature search was performed in PubMed and Web of Science, two international search platforms, as these databases enjoy an international recognition and reputation and address the topic investigated. The data search occurred in July of 2013.

For the conduction of this literature search in a more efficient and goal-focused configuration, descriptors were used (DeCS and MeSH), i.e., keywords for retrieving themes from the scientific literature, and free terms (FTs), which are terms not found in DeCS and MeSH, but were of relevance to this research. From them, the following combinations were searched in the English language: Taste (DeCS/MeSH) AND Child (DeCS/MeSH); Taste (DeCS/MeSH) AND Assessment (FT); Taste (DeCS/MeSH) AND Diagnosis (DeCS/MeSH); Dysgeusia (DeCS) AND Child (DeCS/MeSH); Dysgeusia (DeCS) AND Diagnosis (DeCS/MeSH); Dysgeusia (DeCS) AND Assessment (FT).

The search was conducted independently by two researchers, following the inclusion and exclusion criteria; points of conflict were resolved at a later time by a third reviewer.

### Selection criteria

The following inclusion criteria were required: original articles with quantitative methods for the evaluation of taste exclusively for a child population (0 to <12 years old, based on the article 2 of Law No. 8069 of July 13, 1990, that provides for the *Estatuto da Criança e do Adolescente do Brasil* [Brazilian Statute of Children and Adolescents]);<sup>10</sup> and articles published in the English language. No limits were set for the period of publications, and in the PubMed platform, filters related to species (humans) and age (6–12 years; birth to 18 years; birth to one month; birth to 23 months, 1–23 months, and 2–5 years) were activated.

Original articles that did not mention the subject discussed in this review in their title, abstract, or text and studies in other phases of human development (exclusively, or in studies on children that also included adolescents, adults, and/or elderly subjects) were excluded, aiming at analysis of assessment instruments used only in the child

population. Also excluded were animal studies, literature review articles, dissertations, book chapters, case study articles, and editorials, because this research was aimed to search for large population-based studies already validated for publication in scientific journals.

### Data analysis

Through the use of the descriptors and FTs defined above, the authors identified and selected articles to be analyzed in the selected database platforms.

Initially, the articles' titles were read. Then, the abstracts of articles selected due to the relevance of the title were read, and if the predetermined inclusion criteria were met, the articles were reviewed in full, following an established protocol.

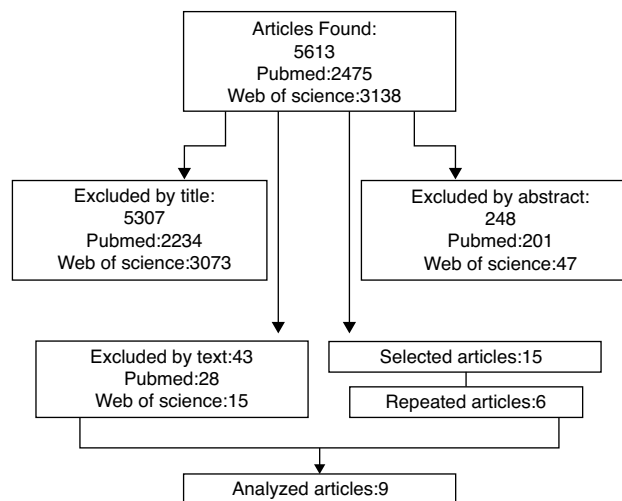
The articles finally selected were those which met all eligibility criteria set forth above, enabling to answer the questions of this review.

Data from the selected articles of interest for the present review were analyzed in detail through the protocol created for this study. Through this protocol, the following items were covered: author, research department, year, place, population/sample, age, purpose of the study, methods, and main results.

Data presentation was made utilizing the relevant data from each article through tables and figures, in order to facilitate its observation and understanding during the presentation and discussion of results.

## Results

5613 studies were found with the use of the search descriptors and FTs above. Of these, 5307 were excluded by title, 248 by abstract, and 43 by full text reading. Thus, 15 articles were selected according to inclusion and exclusion criteria, but six were repeated articles, leaving nine analyzed in this review (Fig. 1).



**Figure 1** Flowchart of the number of articles found and selected after the application of inclusion and exclusion criteria.

**Table 1** Results of selected studies according to the variables analyzed.

| Author  | Department                      | Year | Country     | Population/<br>sample   | Age        | Objectives   | Methods used  | Primary results   |
|---|---------------------------------|------|-------------|---|------------|--|---|---|
| Laing, DG;<br>Wilkes, FJ;<br>Underwood,<br>N; Tran, L <sup>11</sup>     | Medicine                        | 2011 | Australia   | 432 Aboriginal (166) and non-Aboriginal (266) children from public schools: 186 boys and 246 girls                            | 8–12 years | To determine the level of existing taste disorders in Aboriginal and non-Aboriginal children, matched for age and gender and living in the same social and educational environment | Five increasing concentrations of sweet, salty, sour and bitter tastes, and corresponding chemical substances (sucrose, sodium chloride, citric acid and quinine hydrochloride); five samples of water; mouth rinsing with water provided at every offered taste; 20–30 s between tastes; representative figures; classification of taste disorder (three errors in five solutions of each taste)   | 41 children with disorders of taste; higher prevalence in Aboriginal children and in girls; greater difficulty in sweet taste, followed by bitter, sour, and salty tastes   |
| Shin, IH; Park, DC; Kwon, C; Yes, SG <sup>12</sup>                      | Medicine (Otorrhinolaryngology) | 2011 | South Korea | 42 children (24 boys and 18 girls) with chronic otitis media with effusion and 42 control children matched for gender and age | 3–7 years  | To evaluate the changes in taste thresholds in children with chronic otitis media with effusion and to correlate with body mass index  | Electrogustometer; record the minimum voltage with gustatory detection. Chemical test of the taste; application throughout the oral cavity; four concentrations for taste (sweet-sucrose, sour-citric acid, salty-sodium chloride, and bitter-quinine hydrochloride); threshold set by the minimum concentration identified by taste  | Average of taste thresholds in electrogustometry significantly higher in the left and right sides of the tongue in subjects. Chemical taste test, with medium thresholds to sweet and salty tastes significantly higher in the study group; chronic otitis media with effusion can cause changes in taste, and this may be related to pediatric obesity |
| Knof, K; Lanfer, A; Bildstein, MO; Buchecker, K; Hiltz, H <sup>17</sup> | Food Technology                 | 2011 | Germany     | 191 children (54% boys and 46% girls) from North of Germany   | 3–10 years | To present a new model for evaluation of taste sensitivity and preference in children  | Non-quantitative test of taste preference and sensitivity test. Five concentrations, in ascending order, of sweet, sour, salty, and bitter tastes presented in small cups with a volume of 20 ml; the indication of presence or absence of a taste, and preference should be requested; duration of 15 min; distilled water offered between each taste test; chemical agents used: sucrose, monosodium glutamate, sodium chloride, and caffeine | Possibility of evaluation of the sensitivity of, and preference in, taste in young children, provided that the procedure applied is adapted to this population  |

Table 1 (Continued)

| Author   | Department | Year | Country     | Population/<br>sample  | Age   | Objectives   | Methods used  | Primary results  |
|--|------------|------|-------------|--|---|--|---|--|
| Furquim, TRD; Poli-Frederico, RC; Maciel, SM; Gonini-Júnior, A; Walter, LRF <sup>6</sup> | Odontology | 2010 | Brazil      | 181 children from rural and urban areas of Londrina (106 girls and 75 boys)  | Children who have completed 12 years by the end of 2005 | To evaluate if the sensitivity to bitter taste and the perception of sweet taste have an influence on dental caries in urban and rural areas | Method of “whole mouth” described by Nilsson and Holm (1983) for sweet taste; drip method (simplified) described by Harris and Kalmus (1949) for bitter taste; in both, increasing serial concentrations of sweet (sucrose) and bitter (phenylthiocarbamide) solutions applied repeatedly; an initial familiarization with solutions; mouth rinsing at every tasting procedure; the first concentration perceived of the exposed taste should be recorded | Statistically significant higher value in sensitivity, only for bitter taste in students from rural areas, compared to students from urban areas; females with higher scores of gustatory sensation; statistically significant association between the presence of dental caries and the greater perception of sweet taste, both in urban and rural areas; greater severity of dental caries among children with less sensitivity to bitter taste, with a statistically significant association only in children of the urban area |
| Baik, J; Lee, H <sup>14</sup>  | Nutrition  | 2009 | South Korea | 407 children (199 boys and 208 girls) recruited, but 91 students from five elementary schools located in a rural area of Kyeonggi Province, South Korea, were included in the study analysis | 6–9 years   | To compare the physical growth, taste acuity, food behaviors, and preferences among groups, divided by level of presence of residual plaque  | The acuity of sweet (sucrose) and salty (sodium chloride) tastes punctuated by the minimum detection threshold of solutions; Previous guidance given to participants. Six concentrations of each taste provided in ascending order; exposure to the solution with the taste and to two other samples with water, asking to identify the taste solution  | Detection for the solution of sodium chloride and sucrose in 5.13 and 6.61 mmol/L, respectively; the presence of residual dental plaque does not seem to result in a lower acuity of taste   |

Table 1 (Continued)

| Author   | Department | Year | Country   | Population/<br>sample   | Age       | Objectives   | Methods used  | Primary results   |
|--|------------|------|-----------|---|-----------|--|---|---|
| Armstrong, JE; Hutchinson, I; Laing, DG et al. <sup>13</sup> | Medicine   | 2007 | Australia | 34 children (13 boys and 21 girls) recruited from a local school  | 6–9 years | To determine whether facial electromyography can provide reliable answers about different smell and taste stimuli and whether, through the use of electromyography, it is possible to discriminate olfactory and gustatory stimuli as pleasant or unpleasant | Eight concentrations of two tastes (pleasant – sweet/sucrose – and unpleasant – bitter/quinine hydrochloride); facial control of the activity of zygomatic muscles and levator labii by EMG; mouth rinsing with water between each taste test; inclusion of two distractor tastes (citric acid – sour, and sodium chloride – salty) | Over 90% zygomatic muscle response to eight offered tastes; 97.1% for bitter taste and 100% for sweet taste. For levator labii muscle, 67.6% of responses to sweet taste and 90% to bitter taste. Electromyographic activity in both muscles chosen allowed the assessment of discrimination among pleasant and unpleasant tastes and odors, indicating that the children perceived the hedonic qualities of the stimuli, suggesting that the facial expression measured by electromyography can provide objective data, adequate to the evaluation of smell and taste senses in children |
| Rogers, SJ; Hepburn, S; Wehner, E <sup>18</sup>              | Psychiatry | 2003 | USA       | 102 children divided into four groups: classic autism ( <i>n</i> = 26), fragile X syndrome ( <i>n</i> = 20), developmental delay of unknown etiology ( <i>n</i> = 32), and children with typical development ( <i>n</i> = 24) | 1–4 years | To assess the presence of sensory symptoms in autistic children, related to parents' reports, intellectual ability, age, severity of autism, and specific symptoms and maladaptive behaviors   | Short Sensory Profile (questionnaire with scores, in which parents of children score on the sensory profile of their children with regard to tactile, gustatory and olfactory, visual, auditory, and motion sensibility). Scale of 0–4; the greater the number, the greater the involvement   | Significant differences in taste and smell sensitivity between groups compared by mental and chronological age were detected. However, children with autism showed a more abnormal sensitivity to smell and taste when compared to children from other groups   |

Table 1 (Continued)

| Author   | Department | Year | Country     | Population/<br>sample   | Age        | Objectives  | Methods used   | Primary results  |
|--|------------|------|-------------|---|------------|---|--|--|
| Vissera, J;<br>Kroezeb,<br>JHA;<br>Kampsa,<br>WA;<br>Bijleveld,<br>CMA <sup>16</sup> | Psychology | 2000 | Netherlands | 45 children<br>(25 boys and<br>20 girls) from<br>primary<br>schools | 3–6 years  | To develop an<br>evaluation test of<br>taste to the child<br>population, by<br>studying the<br>perception of<br>taste in young<br>children  | Thirteen concentrations of sweet taste and 13 of bitter taste tested in isolated rooms with a child's story contextualizing the moment. Detection thresholds for sucrose and urea measured during the increasing presentation of the concentrations, and aversion to urea hedonistically evaluated with the aid of drawings of facial expressions. Three solutions (two with distilled water and the other with the taste solution) presented. Mouth rinsing with water at every tasting   | All children understood the task, performing it on the first and second times with stabilizing responses. Only on the third time did the scores related to bitter taste test decrease, probably due to the degree of distraction of children, demonstrating that it is possible to study the perception of taste in very young children, if the age is taken into account in the development of the test. Valid data can be obtained if the procedures are of short duration, easy to understand, and intrinsically motivating |
| Buzina, R;<br>Jusic, M;<br>Sapunar,<br>J;<br>Milanovic,<br>N <sup>15</sup>           | Nutrition  | 1980 | Yugoslavia  | 110 children<br>(78 boys and<br>32 girls)                           | 9–12 years | To investigate<br>whether the<br>nutritional status<br>of zinc is<br>associated with<br>functional<br>disorders, such as<br>physical<br>development,<br>anorexia, and<br>hypogeusia | “Taste acuity kit,” prepared for the study according to Henkin (1969, 1971). Recognition and detection threshold measured during the presentation and selection of the four tastes - sodium chloride (salty), sucrose (sweet), urea (bitter), and hydrochloric acid (sour). Presentation of sequences of three drops of solutions on the surface of the tongue (two drops of water + one drop of solute dissolved in water). 13 different solutions. For every taste, 3 concentrations. Results obtained by detection and recognition threshold (lowest concentration perceived and discriminated by the child). Hypogeusia considered, with failure in the detection or recognition of three concentrations of the same taste | The results showed that the occurrence of moderate to severe degree hypogeusia was statistically significant, when associated with reduced zinc content of hair. Children with moderate to severe hypogeusia belonged to the most malnourished group in the studied population   |



Analyzing the selected articles (Table 1), a great diversity of studies were found. This did not allow for statistical analysis (meta-analysis), especially because the sample, the age of the population, and the objectives of the studies were varied. However, despite these differences, important insights and conclusions can be drawn from this review.

Authors belonging to the departments of medicine<sup>11-13</sup> and nutrition<sup>14,15</sup> are primarily responsible for the production of taste-related studies conducted on children. It is possible that the interest in these areas stems from the need to identify and determine the influence of taste in the food process, considering the impact of the gustatory discrimination and perception on feed intake – which can lead to eating disorders, which may in turn affect the physical growth and overall development of the child. Clearly, there is a lack of studies performed by phonoaudiologists, even with the considerable importance of this sense for the development of the stomatognathic functions, e.g., mastication. In this context, the need arises for an exploration of the subject by a multidisciplinary team, enabling early diagnoses and interventions in individuals who, for various reasons, present taste changes.

Studies related to the quantification of taste that focused exclusively on the pediatric population emerged in the 1980s,<sup>15</sup> but a break occurred during a period of 10 years. From the year 2000 onwards,<sup>16</sup> studies on this subject began to be published more frequently.<sup>6,11-14,17,18</sup> Despite the large time lag between the moments of publication of these studies, few changes have occurred. The assessment procedures remained similar, as studies continued to be conducted with a subjective approach, showing little technological advancement in this line of research for the pediatric population. Only in 2007,<sup>13</sup> electromyography started to be used as an adjunct tool for evaluation of the ability for perception and discrimination of tastes, demonstrating efficacy for such purpose. And recently,<sup>12</sup> electrogustometry was used to evaluate the gustatory detection. The findings show that the chemosensory function of taste has begun to gain ground among studies of the various areas of the health sciences. However, one should bear in mind the need for greater emphasis on the development of assessment methodologies, aiming at validation and the coherent use of resources, especially in countries such as Brazil that exhibit high indices of eating problems in the pediatric population.

Australia<sup>11,13</sup> and South Korea<sup>12,14</sup> lead those studies related to taste in children. However, the authors also note a study<sup>6</sup> conducted in Londrina, Paraná, Brazil. Thus, the importance given to this chemosensory function that for so long was neglected in favor of studies of other human senses is now evident. We emphasize the importance of that study which sought to establish relationships between the presence of dental caries and the perception of sweet and bitter tastes by children from different regions of that Brazilian state. Perhaps this serves as a warning that care must be taken in the provision of food to children, and the importance of oral health. According to Felicio,<sup>19</sup> children with caries and tooth loss can decrease the intake and mastication of foods that require cutting and grinding movements, thus influencing the activity of the orofacial muscles and also exposing the indirect influence of taste in the development of the stomatognathic system and its vital functions, such as chewing, swallowing, and speaking. When he showed

that quantitative tools exist to assess taste and their cost for preparation and use is reasonable, Furquim et al.<sup>6</sup> raised questions about the low level of concern in Brazil for conducting research aimed at chemosensory functions.

The vast majority of studies we analyzed<sup>6,11,13-17</sup> reported on populations of healthy children, possibly because there are no regulatory normative standards that allow comparisons between populations with normal development and groups of sick children. However, two studies<sup>12,18</sup> sought to compare groups based on the presence of a taste-limiting condition. The study by Shin et al.<sup>12</sup> highlighted the possible influence of chronic otitis media with effusion in children; and Rogers et al.<sup>18</sup> sought to establish comparisons among children with different types of invasive developmental disorders. As to the sample size of the studies, a balance between >100 and <100 subjects evaluated was found, with a minimum of 34<sup>13</sup> and a maximum of 432<sup>11</sup> children. Similarly, a balance between the prevalence in the number of female<sup>6,11,13,14</sup> and male<sup>12,15-17</sup> children was noted in the studies analyzed. Only one study does not mention gender.<sup>18</sup>

The age range for the reviewed studies ranged from 1<sup>18</sup> to 12<sup>6,11,15</sup> years, comprising a large part of the age group defined as children by art. 2 of Law No. 8069 of July 13, 1990, which provides for the Statute of Children and Adolescents in Brazil<sup>10</sup> that was adopted in this review. Possibly, the difference in this respect was due to the need for evidence on different aspects of child development, such as the influence of gustatory responsiveness in the process of nutrition and the consequent overall development of the child, as well as the proper establishment of oral health of children with disordered diets and exposure to foods with high levels of sugar.

The authors noted that the diversity of the populations surveyed demonstrates the importance of studies on gustation, to consider the possible negative implication of this factor on the quality of life of individuals living with complete or partial loss of their ability of gustatory discrimination. This also brings about the need to perform adjustments in the methodology employed for different population groups in terms of age, language, and cognitive and attention level, so that the instruments used are effective and efficient in determining the gustatory difficulties in children with widely varied clinical and developmental presentations. These precautions will mandate that the researcher adheres to the needs of the target audience, and thus obtain consistent results in the data presented. Also, this will allow the evaluation techniques to be reproduced for the same conditions, or with minor changes by other researchers for different situational contexts.

The selected studies had several objectives, among them: to characterize a population by means of the association among variables,<sup>6,12,14,15,18</sup> e.g., physical growth, taste acuity, and food behaviors and preferences with the presence of dental caries;<sup>14</sup> to compare the gustatory ability among distinct populations,<sup>6,11,12,18</sup> e.g., Aboriginal and non-Aboriginal children<sup>11</sup>; to develop a framework for the establishment of an assessment instrument for taste<sup>16,17</sup>; and to prove the effectiveness of an electrophysiological evaluation (EMG) method as a complementary tool for identifying olfactory and gustatory changes in children.<sup>13</sup> Despite the variety of goals, it was necessary for all studies to utilize a quantitative assessment of taste, in order to obtain results.



This facilitated the establishment of standards for quantitative assessment for use with children, but with attention given to the various methods of using these patterns, as a possible strategy of adaptation of the population assessed.

In most cases, the tests and instruments used in the selected studies followed the same evaluation criteria for taste. Six studies<sup>11,14-17</sup> used exclusively psychophysical evaluation methods composed of a standardized physical stimulus and a standardized psychological response; the children were exposed to various types of taste diluted in water and, thus, based on their gustatory perception, responses were elicited. Some studies sought answers regarding the detection of taste,<sup>6,14-17</sup> as to the pleasantness<sup>13,16</sup> and preference;<sup>17</sup> others sought information about gustatory discrimination.<sup>11,12,15</sup> This reveals a possible method to be developed in pursuit of the standardization of quantitative instruments for taste assessment in children aged from zero to 12 years.

However, three studies used different methodologies.<sup>12,13,18</sup> The electrogustometer, a device that provides quantitative gustatory detection thresholds by means of the application of an electric current in four areas of the tongue (tip, base, and sides), registering the minimum voltage that allows the individual being evaluated to perceive a metallic or sour taste, was used with the aim of evaluating the changes in taste thresholds in children with chronic otitis media with effusion, relating these findings to body mass index.<sup>12</sup> Electromyography, besides representing a psychophysical test, was used as an accessory and as a computerized control for the movement of specific facial muscles of individuals exposed to pleasant (sweet) and unpleasant (bitter) tastes.<sup>13</sup> Finally, one study established scores from zero to 4 points through a sensory profile questionnaire of patients with autistic spectrum disorders, through the responses of the children's parents.<sup>18</sup>

To facilitate standardization of the instruments used, exposure to water immediately after each taste sample offered, a procedure known as rinsing was used in all the studies that adopted a psychophysical test methodology.<sup>6,11-17</sup> In these same studies, the number of samples varied between 3<sup>15</sup> and 13<sup>16</sup> for each evaluated taste. However, the number of samples increased proportionally to the decrease in tastes evaluated. Thus, there was a trend for the presentation of three,<sup>15</sup> four,<sup>12</sup> or five<sup>11,17</sup> samples when assessing the four basic tastes (sweet, salty, sour, and bitter), and an increase in the number of samples when only two distinct tastes were tested.<sup>13,14,16</sup> Some studies<sup>6,11,14,16,17</sup> reported that these samples were increasingly concentrated, representing a method to establish a score for the test through the minimum threshold of detection of the solution.

In addition, there was an agreement on the choice of the evaluated tastes, considering that the studies used two<sup>6,13,14,16</sup> or more<sup>11,12,15,17</sup> psychophysical tests for the four basic tastes, and some studies<sup>15,16</sup> have chosen to provide alternatives, such as solutions with water and a specific taste. One study<sup>17</sup> reported that the application time for the entire test was approximately 15 min; another study<sup>11</sup> related that the interval between the exposure of one taste sample to the subsequent taste was 20–30 s. The method of application of the solutions ranged from the application of

the solution on the surface of the tongue<sup>6</sup> to drinking the food solution.<sup>17</sup>

In most of the studies we analyzed,<sup>6,11-16</sup> the scoring process was based on the minimum threshold of detection<sup>6,12,14-16</sup> and discrimination<sup>13,15,16</sup> of concentration. For a study<sup>11</sup> that evaluated only the gustatory discrimination, the authors considered the presence of a "taste disorder" when three errors occurred after the subject was exposed to five concentrations of each taste in the evaluation; and Horn, Jusic, Sapunar, and Milanovic (1980)<sup>15</sup> found hypogeusia (decreased gustatory acuity) when detection or discrimination errors occurred in three concentrations of the same taste.

As for the child population, some studies adopted representative figures to aid in taste identification<sup>11</sup> and pleasantness;<sup>16</sup> other investigations adopted a children's story to contextualize the test conducted,<sup>16</sup> a time prior to the test to familiarize with solutions,<sup>6</sup> and guidelines prior to individual evaluation.<sup>14</sup> These performed adaptations possibly involve the particularities presented by the child population, such as cognitive, linguistic, and emotional development, and different levels of attention and concentration that should be factors addressed when designing evaluative instruments specific to this age group. Thus, some changes possibly occur to adapt the conditions of an evaluative methodology to the age of the population.

In the description of the evaluative methodologies used, it was noted that there are already several common points in the instruments used for taste evaluation, and a few points were referred as disagreements or not clarified by research. Still, the various techniques may generate questions about their effectiveness, considering the existence of some discrepancies. But it must be considered that, for each population group, some adjustments always will need to be made.

Thus, it is pretentious to make comparisons or judgments of techniques, classifying them as better or worse, for use in children. Each technique must have a globally established foundation. However, modifications should be made, in an attempt to consider the specific needs of each sample population. This premise will be decisive in the choice of the test(s) used and in modifications to be made, but it is also necessary to consider that, for different systems and health facilities in countries and states with sometimes conflicting conditions, some choices made or changes desired may not be implemented. But possibly, this will not be detrimental for localities with less favored socioeconomic status, since both instruments easily reproduced in compounding pharmacies at low cost and high-tech equipment are now used.

Finally, as to the results, most of them had their hypotheses confirmed.<sup>6,11-13,15-18</sup> Only one study did not confirm the initial hypothesis, finding no statistically significant association between the presence of dental plaque and the acuity of taste, but another study<sup>14</sup> established the relationship between the presence of dental caries and the high level of perception of sweet taste.<sup>6</sup> In addition, greater difficulty of children in the perception of sweet taste was noted in some studies<sup>11,12</sup> who performed this survey by offering such stimulus. Attention must be drawn to the results of two studies<sup>16,17</sup> that proposed to develop quantitative taste assessments. These studies confirmed that it is possible

and feasible to conduct these tests in children, provided that they are relevant to the conditions and needs required by the specific age group. Therefore, the importance of early investigation of gustatory conditions through reliable means of diagnosis should be emphasized. The authors suggest conducting studies for validation of quantitative taste assessment tools to use in pediatric populations with typical and atypical development.

## Conclusion

With the advancement of research and the interest of many professionals involved in the function of taste (speech therapists, nutritionists, otorhinolaryngologists, neurologists, occupational therapists, and dentists), we are achieving good results – especially regarding standardization of quantitative tests that are appropriate and age-specific.

This review showed that, although there are still some differences and little information on some specific points (such as the duration of the test and the time between each sample) and some technological increments in the evaluation of taste, the psychophysical tests for quantitative evaluation of this function already follow the standard criteria of choice regarding the methodology applied (presentation and chosen gustatory stimuli, presentation and quantity of samples by taste, use of the rinsing method) and the scoring modality adopted.

Therefore, the findings in this study enable greater reliability for future research, employing similar methodologies and based on published studies for assessment of gustatory function. Furthermore, this methodology can be applied with reliability in the phonoaudiological rehabilitation of children with disorders of taste.

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## Conflicts of interest

The authors declare no conflicts of interest.

## References

1. Esbérard CA. Sensibilidade especial. In: Aires MM, editor. *Fisiologia*. 12th ed. Rio de Janeiro: Guanabara Koogan; 1991. p. 240–8.
2. Félix F. Avaliação do paladar: um recurso importante na semiologia otorrinolaringológica. *Rev Bras Med*. 2009;4:35–40.
3. Leopold D, Holbrook EH. Disorders of taste and smell; 2014. Available at: <http://www.emedicine.com/ent/topic333.htm> [accessed 09.07.13].
4. Hilgers FJM, Dam FSAM, Keyzers S, Koster MN, As CJ, Muller MJ. Rehabilitation of olfaction after laryngectomy by means of a nasal airflow-inducing maneuver: the polite yawning technique. *Arch Otolaryngol Head Neck Surg*. 2000;126:726–32.
5. Lopes FF, Silva LFG, Carvalho FL, Oliveira AEF. Estudo sobre xerostomia, fluxo salivar e enfermidades sistêmicas em mulheres na pós-menopausa. *Rev Gauch Odontol*. 2008;56:127–30.
6. Furquim TRD, Poli-Frederico RC, Maciel SM, Gonini-Júnior A, Walter LRF. Sensitivity to bitter and sweet taste perception in schoolchildren and their relation to dental caries. *Oral Health Prev Dent*. 2010;8:253–9.
7. Ghanizadeh A. Loss of taste and smell during treatment with topiramate. *Eat Weight Disord*. 2009;14:137–8.
8. de Oliveira GM, Menezes HS, Schuh A, Urnesbach CB, Kilpp DO. Estado nutricional do idoso institucionalizado no lar Moria. *Arq Med*. 2006;9:7–18.
9. Muller C, Kallert S, Renner B, Stiassny K, Temmel AFP, Hummel T, et al. Quantitative assessment of gustatory function in a clinical context impregnated taste strips. *Rhinology*. 2003;41:2–6.
10. Brasil. Lei nº 8.069, de 13 de julho de 1990; 1990. Available at: <http://www.planalto.gov.br/ccivil.03/leis/l8069.htm> [accessed 09.05.13].
11. Laing DG, Wilkes FJ, Underwood N, Tran L. Taste disorders in Australian Aboriginal and non-Aboriginal children. *Acta Paediatr*. 2011;100:1267–71.
12. Shin IH, Park DC, Kwon C, Yeo SG. Changes in taste function related to obesity and chronic otitis media with effusion. *Arch Otolaryngol Head Neck Surg*. 2011;137:242–6.
13. Armstrong JE, Hutchinson I, Laing DG, Jinks AL. Facial electromyography: responses of children to odor and taste stimuli. *Chem Sens*. 2007;32:611–21.
14. Baik J, Lee H. Habitual plate-waste of 6- to 9-year-olds may not be associated with lower nutritional needs or taste acuity, but undesirable dietary factors. *Nutr Res*. 2009;29:831–8.
15. Buzina R, Jusic M, Sapunar J, Milanovic N. Zinc nutrition and taste acuity in school children with impaired growth. *Am J Clin Nutr*. 1980;33:2262–7.
16. Vissera J, Kroezeb JHA, Kamps WA, Bijleveld CMA. Testing taste sensitivity and aversion in very young children: development of a procedure. *Appetite*. 2000;34:169–76.
17. Knoff K, Lanfer A, Bildstein MO, Buchecker K, Hilz H. Development of a method to measure sensory perception in children at the European level. *Int J Obes*. 2011;35:131–6.
18. Rogers SJ, Hepburn S, Wehner E. Parent reports of sensory symptoms in toddlers with autism and those with other developmental disorders. *J Autism Dev Disord*. 2003;33:6.
19. Felício CN. Sistema estomatognático e funções. In: Fonoaudiologia aplicada a casos odontológicos matricidade oral e audiológica. São Paulo: Pancast; 1999. p. 23–35.