

Original Article

Taste Intensity and Hedonic Responses to Simple Beverages in Gastrointestinal Cancer Patients

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Abstract

Changes in the taste of food have been implicated as a potential cause of reduced dietary intake among cancer patients. However, data on intensity and hedonic responses to the four basic tastes in cancer are scanty and contradictory. The present study aimed at evaluating taste intensity and hedonic responses to simple beverages in 47 anorectic patients affected by gastrointestinal cancer and in 55 healthy subjects. Five suprathreshold concentrations of each of the four test substances (sucrose in black current drinks, citric acid in lemonade, NaCl in unsalted tomato juice, and urea in tonic water) were used. Patients were invited to express a judgment of intensity and pleasantness ranging from 0 to 10. Mean intensity scores directly correlated with concentrations of sour, salty, bitter, and sweet stimuli, in both normals and those with cancer. Intensity judgments were higher in cancer patients with respect to sweet (for median and high concentrations, $P < 0.05$), salty (for all concentrations, $P < 0.05$), and bitter tastes (for median concentration, $P < 0.01$). Hedonic function increased with the increase of the stimuli only for the sweet taste. A negative linear correlation was found between sour, bitter, and salty concentrations and hedonic score. Both in cancer patients and in healthy subjects, hedonic judgments increased with the increase of the stimulus for the sweet taste ($r = 0.978$ and $r = 0.985$, $P = 0.004$ and $P = 0.002$, respectively), and decreased for the salty ($r = -0.827$ and $r = -0.884$, $P = 0.084$ and $P = 0.047$, respectively) and bitter tastes ($r = -0.990$ and $r = -0.962$, $P = 0.009$ and $P = 0.001$, respectively). For the sour taste, the hedonic scores remained stable with the increase of the stimulus in noncancer controls ($r = -0.785$, $P = 0.115$) and decreased in cancer patients ($r = -0.996$, $P = 0.0001$). The hedonic scores for the sweet taste and the bitter taste were similar in cancer patients and healthy subjects, and these scores were significantly higher in cancer patients than in healthy subjects for most of the concentrations of the salty taste and all the concentrations of the sour taste. The present study suggests that cancer patients, compared to healthy individuals, have a normal sensitivity, a normal liking

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for pleasant stimuli, and a decreased dislike for unpleasant stimuli. Moreover, when compared to controls, they show higher hedonic scores for middle and high concentrations of the salty taste and for all concentrations of the sour taste. Further studies are needed to evaluate whether these changes observed in cancer patients translate into any alteration in dietary behavior and/or food preferences. *J Pain Symptom Manage* 2007;34:505–512. © 2007 U.S. Cancer Pain Relief Committee. Published by Elsevier Inc. All rights reserved.

Key Words

Taste, cancer, anorexia, hedonic, intensity

Introduction

A decline in food intake is common among cancer patients and may be secondary to multiple causes.^{1,2} Among these, changes in taste and smell have been implicated.^{3,4} The frequency of taste alterations in patients with cancer is not known, probably because these kinds of alterations are rarely investigated and hardly ever reported spontaneously by the patients.³ Data on detection and recognition of threshold and suprathreshold intensity responses to the four basic tastes are controversial.^{5–15} Moreover, almost all studies in cancer patients have focused on taste acuity and sensitivity rather than on hedonic judgments.^{5–15} Hedonic judgments are a measure of acceptability or pleasantness of a given stimulus.^{16–18}

Disparities in the choice and stratification of patient populations and the use of different taste test methodologies contribute to the inconsistencies among these results. Most of the studies included patients with different diseases, who were receiving different treatments. Moreover, the inclusion of suitable control groups often has not been considered.^{6–15}

The present study aimed to evaluate suprathreshold taste intensity and hedonic responses using simple beverage systems and whole mouth stimulation in a more or less homogeneous group of anorectic gastrointestinal cancer patients and comparing the results with those of nonanorectic healthy subjects.

Methods

Subjects

Patients affected by gastrointestinal malignant tumors admitted to the Istituto di Clinica Chirurgica of the Università Cattolica del Sacro Cuore of Rome between June and

December 2005 who were candidates for surgery were considered eligible. Inclusion criteria were: expected survival of more than six months, performance status of grade 3 or better on the Eastern Cooperative Oncology Group (ECOG) scale, weight loss >5%, and presence of anorexia. Exclusion criteria were: evidence of distant metastases, age over 70 years, anorexia nervosa, AIDS, sepsis, endocrine or neurologic disorders known to alter taste or smell sensitivity, renal failure (serum creatinine > 1.5 mg/dl), jaundice (bilirubin > 1.5 mg/dl), alcoholism, inflammatory bowel diseases, pregnancy, assumption of drugs known to alter taste, and chemotherapy and/or radiotherapy within four months before the study. Healthy subjects matched for body, age, sex, weight, and smoking habits constituted the control group.

Current weight and weight before illness (usual body weight) were registered. Anorexia, defined as the loss of the desire to eat, was assessed by means of a questionnaire, extensively validated in cancer patients,¹⁷ in which the presence of major symptoms, namely meat aversion, taste and smell alterations, nausea and/or vomiting, and early satiety were investigated. All these symptoms interfere with eating and are likely related to a deranged central nervous system regulation of feeding behavior. Patients reporting one or more of the major symptoms were considered anorectic.

Before threshold and hedonic determination, all patients and control subjects had a thorough clinical examination of ears, nose, and throat to disclose any pathologic conditions that could affect taste. No patient was tested while having fever or anemia.

The study was approved by the local ethics committee, and written informed consent was

obtained from all patients before enrollment in the study.

Materials

Five suprathreshold concentrations of each of the four taste substances were dissolved in appropriate beverages: sucrose in a black currant drink (Germinal Italia, Cellatica-BS, Italy); citric acid in lemonade (Vismara, Segrate-MI, Italy); NaCl in unsalted tomato juice (Germinal Italia, Cellatica-BS, Italy); and urea in tonic water solvent (Schweppes Italia, Scorze-VE, Italy).

Concentrations were prepared as follows, according to Trant's modified method:¹⁶

- 1) Sweet taste: Solution "A" (1.0 M) was prepared by dissolving 340 g of sucrose in 1.0 L of Solution "B" (which represents the commercially available product diluted 1:1 in water);
- 2) Sour taste: Solution "A" (0.1 M) was prepared by dissolving 21 g of citric acid in 1.0 L of Solution "B" (which represents the commercially available product diluted 1:1 in water) and adding 85 mg of sucrose per liter (0.25 M);
- 3) Bitter taste: Solution "A" (4.0 M) was prepared by dissolving 248 g of urea in 1.0 L of Solution "B" (which represents the commercially available tonic water); and
- 4) Salty taste: Solution "A" (0.1 M) was prepared by dissolving 57.7 g of NaCl in 1.0 L of Solution "B" (which represents the commercially available product diluted 1:1 in water).

The concentrations of solutions, made by serial half dilution, were identified by a progressive number, with 1 being the lowest.

These beverages were chosen because they taste similar to the additive, and they contain a known amount of the tastant itself (approximately 0.14 M sodium in salted tomato juice, 0.33 M citric acid in lemonade, and 0.33 M sucrose in cherry drink, according to manufacturer's specifications), giving the subject a familiar framework upon which to base hedonic judgments. The five concentrations of each taste were chosen because, according to the literature, they were easily discerned by normal subjects.¹⁶ Solutions were prepared the day before the test and stored at 4°C to 5°C in glass containers. Before testing, 10 ml

samples of each solution were brought to room temperature (24°C ± 2°C) in 30 ml plastic medicine cups. The order of presentation of the five concentrations was randomized among each of the four replicate sets. The taste samples, 1 L of distilled water for rinsing, and a container for expectorating were placed on a mobile cart to allow tasting at the patient's bedside or in the clinic.

Taste Evaluations

Intensity and hedonic judgments were performed separately on two different days. All sessions were scheduled at the same time of the day, at least two hours after eating or smoking and under constant temperature and humidity conditions. Dentures were removed, and the mouth was rinsed with a sip of distilled water before tasting each of the 10 ml samples from a plastic cup. All samples and rinse water were spit before making judgments.

The presentation order of five dilutions was randomized within each of the four sets. The washout period between the test of each taste was 15 minutes. During the first session, different tastes were administered, chosen at random, and the subject was invited to express a judgment of intensity ranging from 0 (no sweetness, sourness, saltiness, or bitterness) to 10 (extremely sweet, sour, salty, or bitter) of each sample, placing a crosshatch on a 10 cm line labeled at each end. During the second session, different tastes were administered, and the subject was invited to express a hedonic judgment ranging from 0 (dislike extremely) to 10 (like extremely) to indicate degree of liking of each sample, placing a crosshatch on a 10 cm line labeled at each end. The first of the four replications of each tastant series was used to orient the subject to the score sheet and the range of concentrations. These scores were discarded.

The response "absence of sensation" and "I don't know" were accepted. The repetition of the presentation was also allowed, provided the examiner considered the error as casual; in such cases, a positive response substituted for a previous negative one, in order to avoid cognitive errors.

Data Analysis

Scores were recorded as distance in centimeters from the left end mark on the 10 cm

scale. All analyses were performed with the CRISP package. Hedonic and intensity data were expressed as mean \pm SD. The correlation between the intensity and liking degree and the intensities of stimulation for the four main tastes were evaluated by linear regression analysis. Student's *t*-test was used to evaluate the difference of intensity and hedonic judgments at every concentration and for the same taste between control and cancer patients.

Results

One hundred-two subjects were included in the study. Forty-seven subjects constituted the cancer group, and 55 the control group. Their characteristics are shown in Table 1. Groups were comparable in terms of age, sex, and smoking habits. Cancer patients had a mean body weight loss of $9.9 \pm 1.8\%$ with respect to the usual weight.

Intensity Scores

Mean intensity scores of healthy controls and cancer patients increased directly with concentration of added stimuli (Figs. 1a–4a) for the sweet ($r^2 = 0.983$, $P = 0.0001$ and $r^2 = 0.988$, $P = 0.0001$, respectively), the salty ($r^2 = 0.998$, $P = 0.0001$ and $r^2 = 0.996$, $P = 0.0001$, respectively), the sour ($r^2 = 0.997$, $P = 0.0001$ and $r^2 = 0.979$, $P = 0.0001$, respectively), and the bitter tastes ($r^2 = 0.921$, $P = 0.026$ and $r^2 = 0.979$, $P = 0.0004$, respectively). The extremely high coefficients of determination (r^2) for these

Table 1
Patients' Characteristics

	Cancer Patients (<i>n</i> = 47)	Controls (<i>n</i> = 55)
Age (y), mean \pm SE	65.3 \pm 9.7	64.8 \pm 10.6
Male/female	25/22	29/26
Smokers/nonsmokers	0/47	0/55
Weight loss (%), mean \pm SE	9.9 \pm 1.8	1.3 \pm 0.5
Anorexia	47 (100%)	0 (0%)
Serum albumin (g/L)	3.4 \pm 0.2	4.3 \pm 0.3
Tumor site		
Stomach	25 (53%)	—
Ampullary region	10 (21.2%)	—
Colon-rectum	12 (25.5%)	—
Chemotherapy in last 6 mo	0	0
Radiotherapy in last 6 mo	0	0
Surgery in last 6 mo	0	0

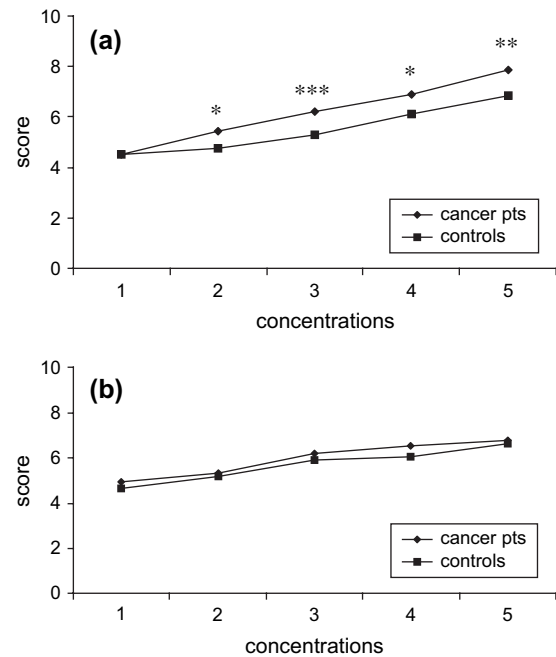


Fig. 1. (a) Sweet taste: intensity scores. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.005$; (b) sweet taste: hedonic scores.

correlations signify that cancer patients, similar to healthy individuals, were able to distinguish easily among the five concentrations of each additive.

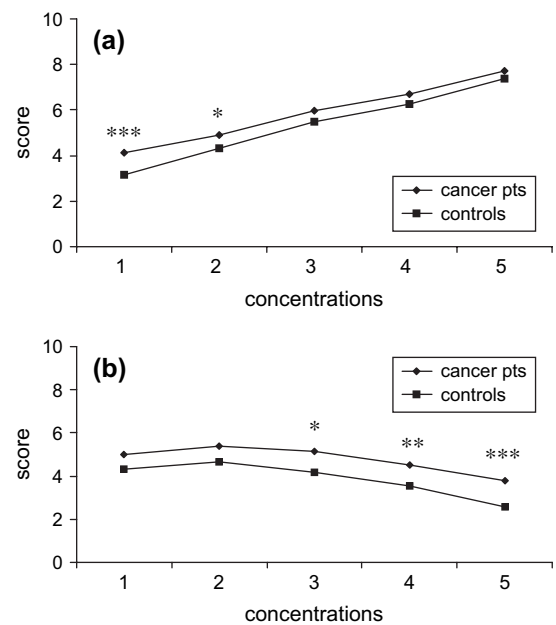


Fig. 2. (a) Salty taste: intensity scores. * $P < 0.05$, *** $P < 0.005$; (b) salty taste: hedonic scores. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.005$.

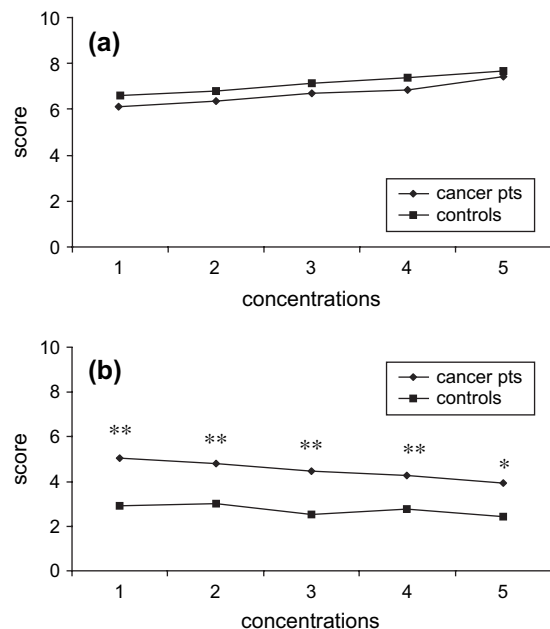


Fig. 3. (a) Sour taste: intensity scores; (b) sour taste: hedonic scores. * $P < 0.005$; ** $P < 0.001$.

Moreover, we observed that:

- Mean intensity scores for the middle and highest concentrations of the sweet taste were significantly higher in cancer patients than in healthy subjects (Fig. 1a);

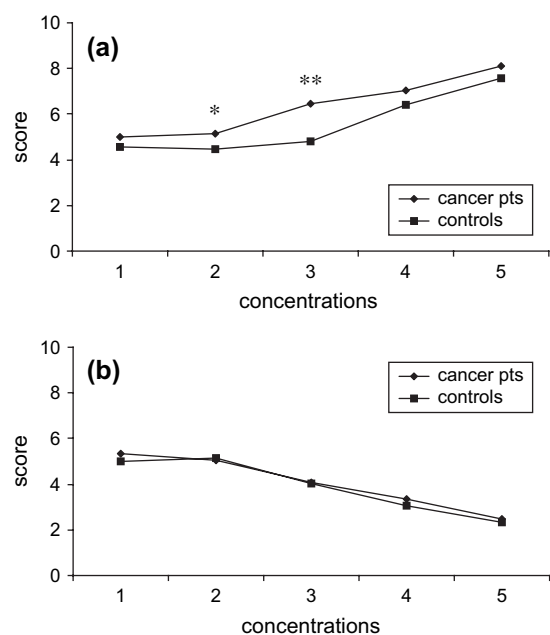


Fig. 4. (a) Bitter taste: intensity scores. * $P < 0.05$; ** $P < 0.001$; (b) bitter taste: hedonic scores.

- Mean intensity scores for the salty taste were similar in cancer patients and healthy subjects, except for the lowest concentration (Fig. 2a);
- Mean intensity scores for the sour taste were similar in cancer patients and healthy subjects (Fig. 3a); and
- Mean intensity scores for the middle concentrations of the bitter taste were significantly higher in cancer patients than in healthy subjects (Fig. 4a).

Hedonic Scores

Both in cancer patients and in healthy subjects, hedonic judgments increased with the increase of the stimulus for the sweet taste (Fig. 1a), while decreasing for the salty (Fig. 2b) and bitter (Fig. 4b) tastes. For the sour taste, the hedonic scores remained stable with the increase of the stimulus in controls ($r = -0.785$, $P = 0.115$), while decreasing in cancer patients ($r = -0.996$, $P = 0.0001$) (Fig. 3b). Moreover, the study demonstrated that:

- The hedonic scores for the sweet taste and the bitter taste were similar in cancer patients and healthy subjects (Fig. 1b and Fig. 4b);
- The hedonic scores for all the concentrations of the salty taste (with the exception of the concentration number 2) were significantly higher in cancer patients than in healthy subjects (Fig. 2b); and
- The hedonic scores for all the concentrations of the sour taste were significantly higher in cancer patients than in healthy subjects (Fig. 3b).

Discussion

In the present study, mean intensity scores directly correlated with concentrations of sour, salty, bitter, and sweet stimuli, both in cancer patients and in controls. These data suggest that cancer patients, similar to healthy individuals, were able to distinguish easily among the five concentrations of each additive in the beverages and that their taste sensitivity was not reduced. Interestingly, the sweet intensity function increased more consistently with high concentrations of added taste stimuli.

Similar results have been reported by Trant et al. in a heterogeneous group of cancer patients.¹⁶

The intensity scores for the lower concentrations of the salty taste and for the low-intermediate concentrations of the bitter taste were higher in cancer patients than in controls. A lower bitter detection threshold has been reported by Pattison et al. in a heterogeneous group of patients with advanced cancer without being associated with a reduced dietary intake.¹⁷ In the general population, detection thresholds for bitter taste are extremely low.^{18–20} Bitter compounds, including extremely toxic bitter poisons, are detected by humans in micromolar amounts. Sensitivity to bitter taste is a heritable trait.²¹ Crystals and solutions of phenylthiocarbonate and 6-n-propylthiouracil (PROP) that taste bitter to some people are tasteless to others. It was recently demonstrated on the basis of thresholds and intensity ratings of PROP solutions relative to NaCl solutions that people can be distinguished as nontasters, regular tasters, and supertasters.

The hedonic scores for sweet taste, both in cancer patients and in controls, increased with the increase of the concentration. Our data are in perfect agreement with those of the study of Trant et al.,¹⁶ in which the distribution of hedonic responses relative to increasing sucrose concentrations for patients categorized according to therapy and appetite indicated that patients on chemotherapy exhibited a greater percentage of flat functions whereas those not on chemotherapy a greater percentage of direct functions. A flat response for sweet stimuli was indicative of no distinct preference for any of the five concentrations of sucrose in cherry drink. Inversely, other authors have observed that anorectic cancer patients as a group were more likely to prefer lower sweetness levels than nonanorectics.^{11,16} In the general population, in lean and obese subjects, hedonic response profiles for sweet taste are highly diverse, ranging from a monotonic rise, to an inverse U shape, to a sharp decline with increasing sweetness.^{22–24} This extreme high range of results is probably due to the difference in the population of healthy subjects and patients included in the studies.

In the past, on the bases of some of these results, some authors have suggested that

increasing the number of mildly or highly sweet food items might improve the palatability of diet of anorectic cancer patients.^{11,16} Indeed, it is generally assumed that taste preferences predict food preferences. This is not necessarily true.¹¹ In fact, it is well known that preferences for sweet solutions in the general population do not necessarily predict self-reported liking for, or the likely consumption of, sweet foods.^{25–30} If this occurs in cancer patients remains to be defined.

Hedonic scores decreased with the increase of the stimulus for the salty taste both in healthy controls and in cancer patients. Interestingly, hedonic scores of cancer patients were higher than those in healthy individuals at the middle and high concentrations. It seems that cancer subjects have a higher sense of pleasantness when a very salty beverage is administered. It remains to be defined if liking a higher concentration of the salty taste translates to a higher preferred frequency of consumption of foods with such a taste. In healthy individuals, preferences for salty solutions do not necessarily predict liking or likely consumption of salty foods.^{27–30}

With the increase of the stimuli, the hedonic scores for the sour taste decreased in cancer patients whereas it remained stable in controls. However, hedonic judgments for sour taste were significantly higher in cancer patients than in healthy individuals at all concentrations, with highest scores observed at low concentrations. These data would suggest that cancer patients do not dislike sour tastes as healthy individuals do, and have the highest pleasantness at low concentrations. Similar to the sweet and salty tastes, if this translates to a higher preferred consumption of foods with such taste characteristics remains to be defined.

With regard to the bitter taste, hedonic scores were similar in cancer patients and healthy individuals. Both normal subjects and cancer patients preferred lower concentrations of bitter taste, the pleasantness decreasing with the increase of the stimulus. These results are similar to those described as typical functions for normal European and North American populations^{28–30} and with those reported in a heterogeneous group of cancer patients.¹⁶

Several factors are responsible for the loss of appetite in cancer,^{1,2} and among these, abnormalities of taste have been implicated.^{3,4} It is

well known that taste can affect food preference in healthy animals and humans.^{4,5} Taste alterations comprise a reduction in taste sensitivity (hypogeusia), an absence of taste sensation (ageusia), or a distortion of normal taste (dysgeusia).³⁻⁷

Chemical gustometry has frequently been used to test taste threshold in patients with different cancer diseases, with contradictory results.^{8-17,31-33} Thus, the question persists whether and how taste abnormalities exist in cancer patients.

Henkin's drop method has been extensively criticized.^{16,35} Taste threshold measured by this method has been shown to change in the desired direction after administration of a placebo.¹⁶ Use of forced-choice methods eliminates some response biases, but the time required for these procedures reduces their desirability as a chemical test.³⁵ Studies using these techniques have given inconsistent results due to the inclusion of patients with different types and stages of cancer, different antineoplastic therapies, and poorly matched controls.³¹⁻³³ Moreover, using the forced-choice three-stimulus drop technique, the threshold will vary depending on the volume and the location of the drop applied.

Model systems of pure taste chemicals in distilled water also have been used, but the extrapolation of the results obtained from a single aqueous medium to complex food has been showed to be tenuous.^{34,35} In 1982, Trant et al.¹⁶ proposed to characterize supra-threshold taste intensity and hedonic responses using real food systems and whole mouth stimulation. Comparing anorectic and nonanorectic cancer patients, they concluded that no abnormalities of taste perception were observed, while hedonic functions differed among individuals and groups. However, a control group of noncancer patients was lacking, and patients who had chemotherapy within the month before testing were included. Therefore, using the above-mentioned method, we tried to compare a group of anorectic cancer patients (gastrointestinal tumors) without evidence of distant metastases and without treatments such as chemotherapy or radiotherapy with a well-matched group of nonanorectic healthy subjects.

We are aware that some investigators have argued that, in fact, there are more than four

types of taste (e.g., umami and taste for free fatty acids). Umami applies to the sensation of savoriness, specifically to the detection of glutamates that are especially common in meats, cheese, and other protein-heavy foods. New evidence is emerging that supports the inclusion of a sixth taste category for free fatty acids, the chemical components of dietary fat. However, during the design of the study, we realized that it was not easy to create simple beverages for umami and free fatty acids. Hopefully, further studies including these two tastes will be conducted in the near future.

In conclusion, the present study suggests that cancer patients, compared to healthy individuals, have a normal taste sensitivity, a normal liking for pleasant stimuli, and a decreased dislike for unpleasant stimuli. Moreover, when compared to controls, they show higher hedonic scores for middle and high concentrations of the salty taste and for all concentrations of the sour taste. Further studies are needed to evaluate whether these changes observed in cancer patients translate into any alteration in dietary behavior and/or food preferences.

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