Physiology & Behavior 141 (2015) 92–96

Contents lists available at ScienceDirect

Physiology & Behavior

journal homepage: www.elsevier.com/locate/phb

Sweet taste threshold for sucrose inversely correlates with depression symptoms in female college students in the luteal phase

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HIGHLIGHTS

- Sex and menstrual cycle caused no difference in sucrose recognition thresholds.
- Sex and menstrual cycle caused no difference in depression and anxiety levels.
- Depression inversely correlated with sweet threshold only in the luteal phase—women.
- Anxiety-trait inversely correlated with sweet threshold in the luteal phase—women.

ARTICLE INFO

Article history:
Received 13 June 2014
Received in revised form 25 December 2014
Accepted 6 January 2015
Available online 7 January 2015

Keywords:
Recognition threshold
Sweet taste
Depression
Anxiety
Menstrual cycle

ABSTRACT

Influences of depression symptoms on the sweet taste threshold were investigated in healthy college students (30 males and 40 females). Depression symptoms were scored by SDS (Self-Rating Depression Scale), and anxiety levels by STAI (State- and Trait-Anxiety Inventory). Recognition thresholds for sucrose were determined. In female students, the menstrual phase on the day of the experiment was self-reported. Depression symptoms, anxiety levels, and the recognition threshold for sucrose were not different among the 3 groups, i.e. males, females in the follicular phase, and females in the luteal phase. Depression symptoms were positively correlated with state and trait anxiety in all groups. The sweet taste threshold was inversely correlated with depression symptoms ($r = -0.472$, $p = 0.031$) and trait anxiety ($r = -0.506$, $p = 0.019$) in females in the luteal phase. In males as well as females in the follicular phase, however, no correlation between sweet taste threshold and depression was found. The results show that the recognition threshold for sucrose reduces with increased depression in females with a higher anxiety trait, but only in the luteal phase. It is hypothesized that brain regions, which spatially overlap and are responsible for both aversive emotions and gustatory processing, are susceptible to periodic changes in gonadal hormones due to the menstrual cycle.

1. Introduction

A reciprocal relationship between food and mood generally exists in emotionally distressed individuals [7]. Emotional distress such as depression and fatigue evokes a craving for sweet carbohydrate- and fat-rich snacks [5]. Depressed individuals consume more sweet carbohydrates than their non-depressed counterparts [8].

On the other hand, there is no general consensus on whether or not depression affects the sensitivity to sweet taste. It has been reported that the recognition threshold for sweet taste is elevated in patients with major depression disorder (MDD) in comparison with healthy controls [4]. However, another study recently showed that sensitivity to sweet taste does not differ between MDD and non-MDD patients [13]. Furthermore, sensitivity to and preference for sucrose do not change in MDD patients responding to psychotherapy [13]. Reuptake inhibitors of serotonin (5-HT) and noradrenaline (NA) are often adopted for pharmaceutical purposes in psychiatric diseases, and these drugs significantly affect taste sensitivity. For example, the administration of paroxetine, a 5-HT-specific reuptake inhibitor (SSRI), reduces the sweet taste threshold for sucrose by 27% [17]. This also makes it difficult to identify the correlation between taste sensitivity and the emotional state in psychiatric patients.

In the present study, therefore, we investigated the correlation between the taste threshold and depression symptoms in college students without psychopathological disorders. A weak inverse correlation between the self-reported taste intensity for sucrose and depression was

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http://dx.doi.org/10.1016/j.physbeh.2015.01.003
0031-9384/

noted in a preceding study on men and women without a history of psychiatric disorders [29]. This suggests that depression symptoms affect the taste threshold in healthy humans. However, in the same study, detection thresholds determined by electrogustrography did not correlate with depression scores. Therefore, in the present study, we examined whether the recognition threshold for sucrose, instead of the self-reported taste intensity, correlates with depression symptoms. Furthermore, we evaluated sex differences between students and menstrual cycle-dependent differences between the follicular and luteal phases in female students. It was recently reported that acute stress decreases the sweet taste intensity in healthy men and women [1]. Women feeling sad show a greater likelihood of eating sweets than males [7]. Social stress tests provoke aversive emotions such as depression and anxiety more markedly in the luteal phase than in the follicular phase [9]. The consumption of and preference for sweet foods increase in the luteal phase [5]. These studies suggest that sex and menstrual cycle influence the correlation between the mental state and sweet taste threshold.

2. Methods

Participants were 70 undergraduates from Yamanashi Prefectural University who volunteered, aged 20.7 ± 0.3 years (30 males and 40 females). None of them had a habit of smoking. At least for 2 months prior to the experiment, they had been free from medication, including contraceptives for female students. A psychiatrist, one of the authors, confirmed that they were free from affective disorders requiring therapy. The experiment was carried out from 10:00 to 12:30, and participants were requested not to skip breakfast and to finish it at least 2 h before the experiment. Experimental procedures were performed in accordance with the Ethics Committee of Yamanashi Institute of Environmental Sciences on the basis of the Declaration of Helsinki, and informed consent of all participants was obtained in written form.

On the day of the experiment, depression symptoms of participants were scored by means of the Zung Self-rating Depression Scale (SDS). SDS consists of 20 questions with 4 point-scales, and greater scores in total mean that depression symptoms are greater. Anxiety levels were also scored by the State- and Trait-Anxiety Inventory (STAI). Trait anxiety is defined as a relatively stable personality characteristic, and state anxiety as transient manifest feelings of insecurity [23]. STAI consists of 40 questions with 4 point-scales, 20 questions for state anxiety and 20 for trait anxiety, and greater scores in total mean the state anxiety and trait anxiety of participants are greater. Japanese versions of SDS and STAI were purchased from Sankyo-bou, Kyoto, Japan. Among physiological parameters generally associated with psychological stress and mental health, the body temperature and saliva secretion rate were measured prior to the experiment [22,25,32]. The axillary temperature as an index for the body temperature was measured with a mercury thermometer. After rinsing the mouth with distilled water at room temperature, participants were asked to hold a piece of cylinder-shaped cotton (Salivett, Sarstedt, Nünbrecht-Rommersdorf, Germany) under the tongue for 5 min in order to collect saliva. The cotton was then centrifuged at 1,200 rpm for 5 min, and the volume of saliva was recorded. The saliva secretion rate was determined as the salivary volume in 1 min.

Sucrose, $C_{12}H_{22}O_{11,}$ was diluted with distilled water, and the recognition threshold for the sweet taste of sucrose was determined as the weight to volume ratio expressed as a percentage. Sucrose was purchased from Wako Pure Chemical Industries, Osaka, Japan. Participants were requested to rinse their mouths with distilled water every time before testing sucrose solutions with different concentrations. The volume of taste solutions for testing threshold was 20 mL. The recognition threshold was tested downward from a higher concentration to a lower concentration in decrements of 0.1%. The participants were asked to report whether or not they felt that a given test solution was sweet. When they felt that a test solution was not sweet, a concentration of the test solution one increment higher was regarded as the recognition threshold. Distilled water for rinsing and the taste solutions were 24.0–26.0 °C as the room temperature varied.

In female participants, the day the latest menstruation started was self-reported, and the menstrual phase on the day of the experiment was determined. Twenty-two of the female participants were in the luteal phase and 18 were in the follicular phase. One student in the luteal phase had an oral ulcer on the day of the experiment; therefore, her data were eliminated from further analyses.

For the statistical analysis of differences among groups, mean values of recognition thresholds for sucrose and depression or anxiety were tested by one way-ANOVA. When significant differences were confirmed, those between mean values were further examined with Fisher's PLSD. The correlation between the taste threshold and depression or anxiety was examined with Pearson's test. The hypothesis rejection level was $p < 0.05$.

3. Results

3.1. Depression and anxiety in college students

The SDS score was 39.7 ± 1.2 (mean ± SEM) in male students, 41.1 ± 1.9 in females in the follicular phase, and 39.9 ± 1.4 in females in the luteal phase. According to the defined categories of SDS [38], scores in the present experiment were distributed around the border between normal and minimum depression levels. In Japanese undergraduates, average scores of SDS were reported to vary from 37.5 to 44.9 [18,30]. Scores of SDS in the present experiment remained within the average range of Japanese college students. One way-ANOVA showed that there was no difference in ratings for depression symptoms ($F(2, 66) = 0.253$, $p = 0.777$).

Trait anxiety was 47.3 ± 1.6 in males, 46.3 ± 2.7 in the follicular-phase—females, and 49.2 ± 1.5 in the luteal phase—females. One way-ANOVA showed no difference in scores for trait anxiety among the 3 experimental groups ($F = 0.555$, $p = 0.577$). State anxiety was 39.3 ± 1.2 in males, 43.3 ± 2.3 in the follicular phase, and 43.4 ± 1.3 in the luteal phase. There was no difference in scores for state anxiety among the groups ($F = 2.642$, $p = 0.079$). According to the classification by STAI, average scores for trait and state anxiety in participants revealed a high anxiety level (class IV) but it was within the average range of Japanese college students [24].

3.2. Correlations between SDS and STAI

SDS scores were significantly correlated with both trait and state anxiety in men and women (Table 1). There was also a significant correlation between trait anxiety and state anxiety (Tables 2,3).

3.3. Body temperature and saliva secretion rate

The axillary temperature was 36.4 ± 0.1 °C in males, 36.5 ± 0.1 °C in females in the follicular phase, and 36.6 ± 0.1 °C in females in the luteal phase. There was no significant difference in the axillary temperature among the groups ($F = 0.754$, $p = 0.474$). The saliva secretion rate

Table 1
Correlation of depression with trait and state anxiety and sweet taste threshold.

		Males	Females in the luteal phase	Females in the follicular phase
Trait anxiety	r	0.771	0.642	0.805
	p	0.000*	0.002*	0.000*
State anxiety	r	0.724	0.656	0.772
	p	0.000*	0.001*	0.000*
Sweet taste threshold	r	0.040	−0.472	0.004
	p	0.853	0.031*	0.988

Asterisk (*) shows significant correlation.
r: correlation coefficient.