

Perceived impacts of stress on various food taste stimulation choices

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Abstract: The theory of food preference is important for human diet and weight control. Stress can sometimes affect people's appetite. This study investigates the impact of stress on different taste stimulation choices. We invited 24 participants (12 male and 12 female participants) to join the research. The Stroop test was employed to increase participants' stress levels, and meditation was used to relax them. We set up questionnaires, which included meditation, Stroop, and food choice tests. We asked participants to choose their favorite food when different kinds of food (unhealthy savory, unhealthy sweet, healthy sweet, and healthy savory foods) appeared on their screen. Participants were required to perform the food-choice test twice, once before the Stroop test and once after the Stroop test, to elicit changes in food preference. They were also asked to evaluate their stress levels before each food-choice test. A computer was used to record each selection and stress level and integrate both together. The results revealed that in the group with the highest stress level, women showed a significant preference towards sweet food, whereas men showed subtle preferences. However, they all exhibited a significant inclination towards unhealthy foods when they were under stress. This study had a small sample size, and future research needs to not only find precise facilities to record participants' stress levels but also improve the present research in the laboratory.

1. Introduction

1.1 Background

In recent decades, the interest in healthy lifestyles has grown, leading people to notice differences in foods, which are now classified into healthy and fried foods (high-calorie foods). High-calorie foods tend to be fried and high in fat, whereas healthy foods mainly comprise green foods such as vegetables and fruits. Owing to the pursuit of health quality and body management, people have begun to pay widespread attention to the impact of high-calorie and healthy foods on the human body, particularly on human health and physique. People will have diverse food preferences, which can be influenced by the surrounding environment and stimuli [1]. Emotional manipulations in the form of pleasantly or unpleasantly perceived real-life events can influence the intensity of the perception of taste, thereby driving the hedonics for less acceptable foods [2]. Simultaneously, people are also starting to pay attention to the impact of different food types on the body's perception system. Anxiety and stress have been shown to be significant factors influencing food preferences in the human body [3]; the level of stress will influence the intake and category of food choices that people make.[4]. Both studies show that stress not only increases consumption in certain individuals but also shifts their food choices from lower-fat to higher-fat foods [5]

1.2 Stress effect

During periods of stress, there is a general increase in reported snack consumption among all respondents, irrespective of whether they are on a diet [6]. In contrast, it has been reported that the intake of 'meal-type' foods such as fruits, vegetables, meat, and fish decreases during periods of stress [4]. Meanwhile, the effect of stress also transforms people's food preferences and mental judgment [7]. This transformation results in stress influencing people's food choices, thus confirming our study's feasibility.

1.3 Sex differences

Based on the subject matter, there is still some controversy concerning the effect of sex. However, sex differences have been confirmed to play a significant role in food preferences. In stressful situations, women tend to prefer healthy (green) foods, whereas in relaxed situations, they prefer high-calorie foods. Conversely, men show controversial preferences for food; some experiments have shown that male preferences are opposite to those of women, but recent experimental data have yielded conflicting results. Men in the non-stress group ate significantly more unhealthy foods than those in the stress group. This finding somewhat differs from that observed in women. Sex differences exist due to unequal awareness. Sex differences in food choices appear to be partly attributable to not only women's greater involvement in weight control but also their stronger beliefs in healthy eating [8].

1.4 Explanation of flaws

Based on prior results, this study identified flaws in previous experiments. One major factor affecting the experimental results was the individual preference differences between the relaxed and stressed states, which were not studied in the same group of people. Additionally, the experiment did not include different types of taste stimuli, leading to bias in exploring the influence of the stressed state on the preference for various taste stimuli.

1.5 Solution to the research gap

To address these shortcomings, this study focuses on individual changes. We invited the same persons to undertake different tests during the entire process. This experiment employed the Stroop test to increase the pressure range of participants by identifying symbolic words of different colors, which has been proven to be an effective way to create pressure. The Stroop test influences part of the human brain, the engagement of a widespread network of anterior brain regions, and the reciprocal inhibition of posterior brain regions during task performance) [9].

Leite et al. [10] stated that 'the data suggest that the Video-Recorded Stroop Color-Word test is an effective anxiety-provoking test'. Such evidence is also claimed by Renaud and Bloning [11] who noted that 'they also provided indications on how the Stroop test may act as an efficient laboratory stressor'. Hence, the Stroop test is employed to increase the stress level of the participant. At the same time, we developed a meditation procedure which can relax participants and stabilize their emotions. According to Bahrke and Morgan [12], 'the present evidence suggests that acute physical activity, non-calcic meditation, and a quiet rest session are equally effective in reducing state anxiety'.

The current study used a 2-2-2 controlled trial to investigate the effects of stress on different food stimulus preferences, considering the sex, food type, and stress state groups as control variables.

1.6 Taste stimuli

In contrast to the various food categories (high-calorie and healthy foods), several taste stimuli influence food preferences. Combining the differences in food categories, we explore the role of taste in people's food preferences. A previous study has suggested that acute stress may alter taste perception [13]. Meanwhile, differences in taste stimulation actually have varying effects on stress, but the relationship remains ambiguous.

1.7 Hypothesis

This study's hypothesis is that stress is an influencing factor on different forms of taste stimulus preferences. Moreover, sex plays a significant role in preferences, with women being more inclined to consume green foods than men. Finally, most changes in taste stimulus preferences are from healthy savory foods in stressful states to unhealthy sweet foods.

2. Methods

2.1 Type of food

In this experiment, three control groups were established: sex (male/female), food (high calorie/healthy), and stress control groups. Considering that people generally prefer high-calorie foods in stressful situations, we selected four types of foods: high-calorie sweet (creamy chocolate cake and doughnuts), high-calorie savory (burgers, fried chicken, and pizza), healthy sweet (watermelons, bananas, and peaches), and healthy savory (various types of savory salads) (*Figure 1*).

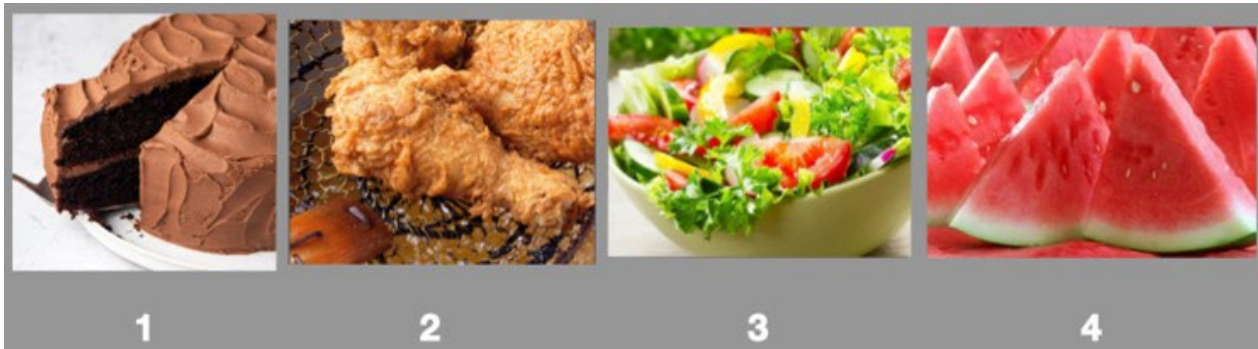


Figure 1. Food choice

2.2 Change of individuals

To eliminate the influence of individual food preferences, we conducted tests with the same participants under different stressful situations to observe their changes in food choices rather than specific food preferences. Stress was induced using the Stroop test, whereas relaxation was induced through meditation. The order of both conditions was randomly assigned before and after the experiment to ensure that the variables were balanced.

2.3 Counterbalance

Furthermore, to balance the position of different foods, we arranged them in different sequences and images (same category but different pictures). In addition, we randomly assigned participants to first join the Stroop or meditation tests to control the variable. Meanwhile, in terms of sex, we invited the same number of male and female participants (12 each).

2.4 Participants

We recruited $N = 24$ participants (12 female and 12 male participants) aged 19-90 through a university recursion and social media. All participants were fluent Chinese speakers (could handle basic English), which was required for the Stroop test part (they were required to recognize the English names of different colors: yellow, green, red, and blue).

They were all healthy and well-educated adults. We randomly assigned participants to either the Stroop test or the meditation part first. We used this assignment method so that all participants could encounter a change from either a relaxed to a stressful situation or a stressful to a relaxed situation. We gave the participants links and allowed them access to the experiment on their own computers. This avoids emotions of reluctance or the influence of unfamiliar facilities.

2.5 Defect

Owing to the facility's limitations, our judgement of the stress level could not be detected precisely by the facility. Hence, we only use general provokers and self-assessments to obtain data. This type of method is not supported by professional standards. Future studies should use professional facilities, such as heartthrob meters, to confirm the stress levels of individual participants.

3. Tasks

3.1 Procedure

We instructed participants to engage in an online test, which included several parts, as each step below clearly indicates (*Figure 2*).

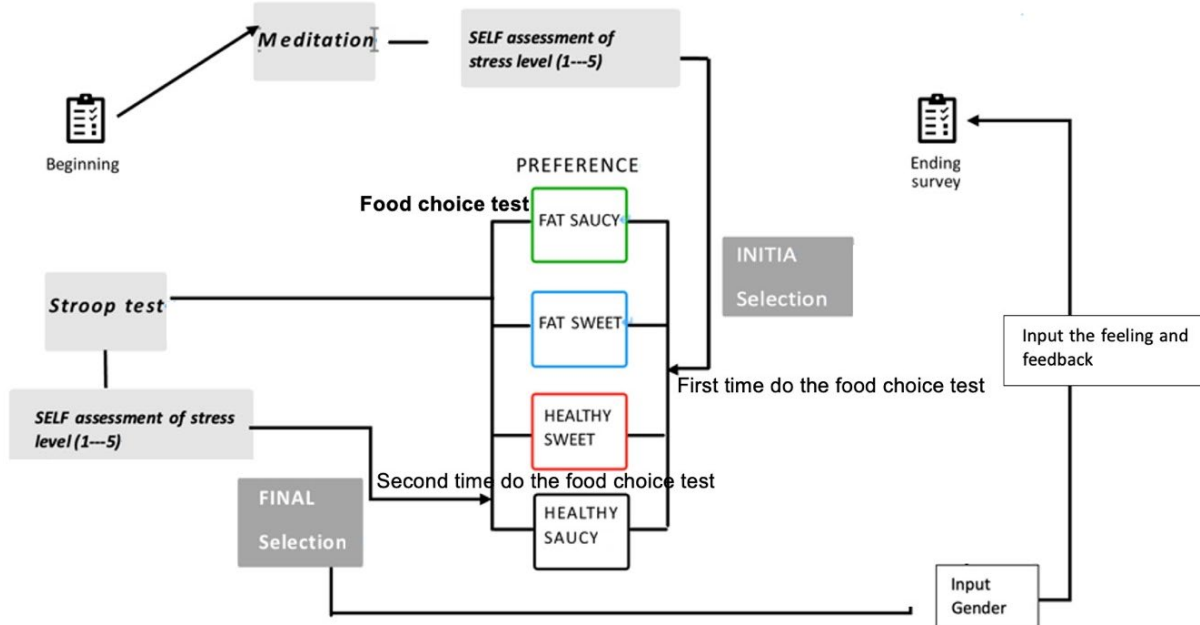


Figure 2. Steps of the experiment

3.2 Meditation test

We instructed participants to perform a meditation experiment, which required them to meditate for 2 min, during which a cross would constantly appear on the screen (to counterbalance the Stroop test part). The cross is the same as that which appears during the Stroop test.

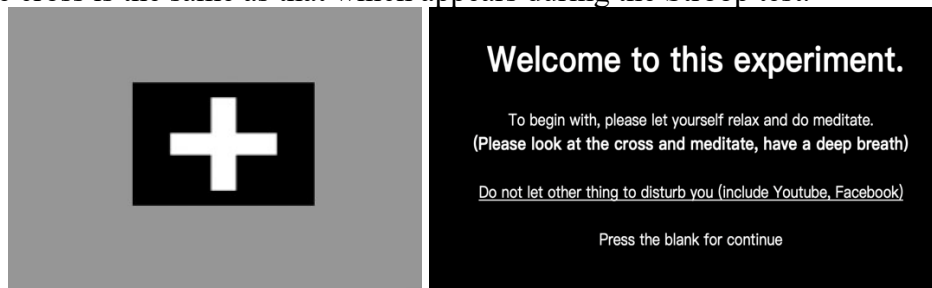


Figure 3. meditation experiment example

3.3 Stroop test

Participants are required to judge their stress levels when they complete the meditation part (from 1 to 5) and proceed to the next step.

The online Stroop test requires participants to click the first letter of the color's English word on a keyboard when they recognize the color of the word (*Figure 3*).

Another self-assessment is done when the Stroop test is concluded; this part aims to ensure that their stress level is relatively high enough.

3.4 Food selection phase

In the selection phase, participants are presented with four different types of food, each offering various taste stimuli, including sweet and salty options (as mentioned in *Figure 1*). The goal was to allow participants to choose their favorite food from the available options. To ensure unbiased results, we conducted a total of 10 trials, with a different sequence of food presentation for each group of

participants. This approach helps eliminate potential biases caused by the order of food presentation and minimizes any influence they may have on food preference outcomes.

3.5 Measures

We measured the data from the experiment and collected responses to both self-assessment and self-awareness surveys. Each data source required a separate analytical method. At the beginning of the survey, we recorded the stress level of each participant (“what do you feel about your stress level now?”).

The presents study was conducted to examine individual performance during the Stroop test and food selection phase. Throughout the study, the time taken by each participant to complete both tasks were measured. Additionally, we observe any changes in their food preferences as they select food images during the food selection phase. Participants' responses regarding their self-awareness of these changes were also collected.



Figure 4. Stroop test example

4. Results

The total sample (n = 92) included 68 incomplete and 24 available samples. This study did not include controversial sample sizes.

Figure 4 shows the relationship between the changes in stress and food choice.

4.1 Relationship between stress and food choice

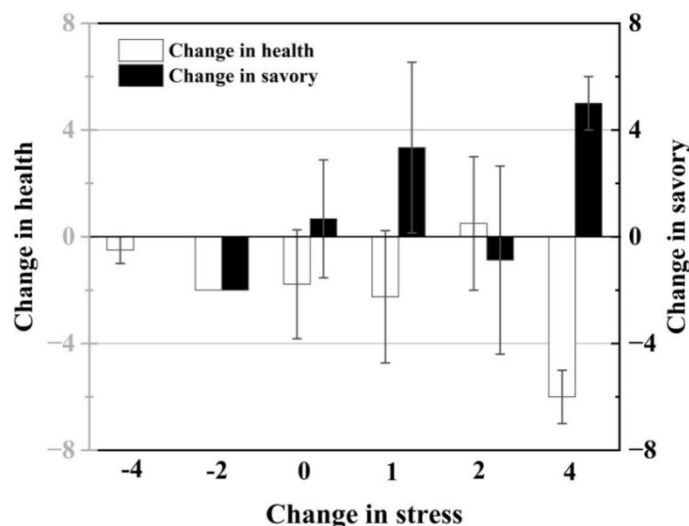


Figure 5. Relationship between stress and food choice

Table 1. Data on the Relationship Between Stress and Food Choices

CHANGE OF STRESS (K)	CHANGE OF HEALTH(H)		CHANGE OF SAVORY(S)	
	Average	R	Average	R
-4	-0.5	0.5	0	0
-2	-2	0	-2	0
0	-1.778	2.04	0.67	2.21
1	-2.25	2.45	3.34	3.197
2	0.5	2.5	-0.875	3.522
4	-6	1	5	1

As shown in Figure 5 and Table 1, Using the average number of total choices of healthy food minus that of unhealthy food, we calculate H (change in healthy), which indicates the degree of preference change towards either healthy or unhealthy food. The range of H is [-8, +8], where +8 signifies a participant's preference shift from unhealthy to healthy food, whereas values in the range of (0, +8) represent a preference change from healthy to unhealthy food.

Notably, K (change in stress) illustrates the differences in stress levels before and after the Stroop test. Owing to limitations in the sample, stress changes of -3, -1, and 3 are unavailable. A change of -4 represents a shift in the stress level from 5 (highest stress level) to 1 (lowest stress level), while a change of +4 represents a shift from 1 (lowest stress level) to 5 (highest stress level). Moreover, S (change in savory) represents the average preference change from sweet to savory foods. Negative data in the range of (0, -8) indicate a preference shift from sweet to savory foods, whereas positive data in the range of (0, +8) indicate a preference shift from savory to sweet foods. The magnitude of this number reflects the extent of the preference shift.

As a result, we find that the variance of the previous four datasets is larger than the average value, indicating that the data may not conform to the normal distribution. Consequently, the reliability of the results may be compromised, and they can neither be fully considered nor relied upon. However, the last column is valuable as the data reveal a notable pattern: when the pressure changes value (K=4) reached its highest point, there was a significant shift in the participants' food preferences (S=5). Specifically, the preference change leaned significantly from savoury food towards sweet food. This coincides with our hypothesis.

These data also support the feasibility of using the Stroop test to induce stress and effectively increase people's stress levels. To address these concerns and enhance the validity of future studies, it is essential to have experts conduct face-to-face meditation sessions with participants and carefully control and monitor their adherence to the instructions. This would ensure a more reliable assessment of the true impact of meditation on stress reduction.

4.2 Sex differences

As shown in Figure 6 and Table 2, No significant difference was found between the preferences for healthy and unhealthy foods (female participants = -3.45, N = 12; male participants = -3.23, N=12). Both groups displayed a shift towards unhealthy foods, indicating a similar pattern of food preference changes. However, there was a notable sex difference in food taste (female participants = 3.27, N = 12; male participants = 0.31, N = 12). The female group exhibited a clear preference for sweet foods, whereas the male group's sweetness preference (S=0.31) was relatively small. Nevertheless, the male group still demonstrated a subtle inclination towards sweet stimuli.

Table 2. Data on Gender Differences in Preference Changes

	AVERAGE H (CHANGE IN HEALTH FOOD)	AVERAGE S (CHANGE IN SAVORY)
FEMALE	-3.45	3.27
MALE	-3.23	0.31

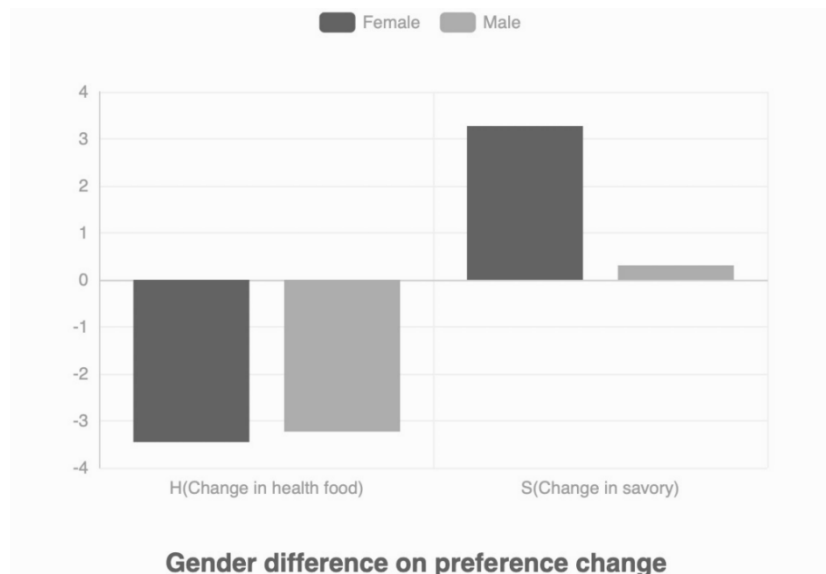


Figure 6. Gender difference on preference change

We also find that in the sweet food group, people prefer to choose fruit, most of which are fruits containing water; therefore, we infer that compared with salty foods, people prefer to eat healthy foods under pressure, especially water-containing fruit substances. Such results are influenced by sex, and women have changed their food preferences more than men. These findings are similar to those of previous women studies [4].

5. Discussion

5.1 Preference

The present study's findings are identical to our initial assumptions, indicating a shift from healthy foods to high-calorie options under stress, similar to prior research. Additionally, the study revealed a preference for sweet taste stimulation over savory foods among the participants. Male participants did not exhibit significant changes in their taste preferences. However, female participants showed a distinctive preference transfer from savory to sweet foods. Nevertheless, they demonstrated a preference for sweet and unhealthy foods compared to savory and healthy options, further supporting the notion that people tend to favor sweet foods under pressure.

Moreover, the effectiveness of the Stroop test was unsubstantiated, as most participants reported a subtle or even opposite increase in their stress levels following the administration of the test. In addition to stress, taste preferences were found to be influenced by various factors, including the surrounding environment and established eating habits. Furthermore, the study indicated that sex differences in food preferences were linked to physical health considerations. For instance, a female participant explained that she tended to be more inclined towards healthy food options during moments of anxiety owing to the impact of physical health. This finding was consistent with those of previous studies that highlighted sex-specific characteristics of food preferences.

5.2 Limitations and future research

1) This experiment took the form of an online questionnaire, which does not guarantee that the participants will conduct the experiment in full accordance with the expected norm. Future research needs to use an offline form.

2) The meditation part of this experiment was not set up with music or video assistance because of the needs of the control group, so the degree of relaxation for the participants was low.

3) For food taste preference, the experiment only gave participants pictures of food but did not let them feel the taste experience first-hand; thus, the taste preference would be biased. Future studies should provide participants with a comparison of real foods.

4) Owing to equipment limitations, pressure state monitoring took the form of asking the

participants themselves; thus, there are subjective differences. In future research, professional pressure detection equipment should be used for testing.

5) The number of samples is small, and future studies should increase the number of samples.

6. Conclusion

This study investigated the impact of stress on people's preferences towards different taste stimuli. Under a state of stress, people's preferences for taste stimuli mostly change and tend to be inclined towards unhealthy foods, specifically unhealthy sweet foods, rather than savory unhealthy foods. However, the participants showed a greater preference for sweet foods than for savoury foods. Meanwhile, taste preference is affected by sex. Women prefer to receive sweet stimuli compared to men. Additionally, food preferences are influenced by eating habits formed over time. People particularly prefer sweet and healthy foods, especially water-containing fruits.

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