The Effect of Elicited Emotional States on Women's Reaction to Food Cues

Sukeltų emocinių būsenų poveikis moterų reakcijai į maisto užuominas

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SUMMARY

Purpose. This study aimed to investigate the effect of elicited emotional states on women's reaction to food cues.

Methods. 87 women (aged 20–39) participated in the study. The study used experimental design, in which reaction times to food cues were measured before and after randomly assigned experimental mood induction group (negative, positive or control). Reaction time to food cues and attention bias were measured using visual dot-probe task (stimuli exposure duration was 500 ms). Before experiment the psychological eating styles (measured by Three-Factor Eating Questionnaire-R21) and demographic characteristics were assessed. The data was analyzed using univariate and bivariate methods as well as logistic regression analysis.

Results. Logistic regression analysis showed that mood induction did not account for changes in attention bias or reaction times among study participants. Yet, the reaction time to food cues after mood induction decreased in all experimental groups, while attention bias to food cues decreased after mood induction in negative and positive mood induction groups.

Conclusions. The current study revealed that negative and positive emotional states do not affect women's reaction to food cues or attention bias to food stimuli as measured through visual dot-probe task.

Keywords. attention bias, mood induction, emotional eating, food cues, visual dot-probe task

SANTRAUKA

Tikslas. Tyrimu buvo siekiama nustatyti sukeltų emocinių būsenų poveikį moterų reakcijai į maisto užuominas.

Metodai. Tyrime dalyvavo 87 20–39 metų moterys. Atliktas eksperimentinis tyrimas, kurio metu reakcijos laikas į maisto užuominas buvo matuotas prieš ir po atsitiktiniu būdu paskirtos emocinės būsenos sukėlimo užduoties (negatyvi, pozityvi ar kontrolinė). Reakcijos laikas į maisto užuominas ir dėmesio tendencingumas matuotas vizualinio zondo užduotimi (stimulai rodomi po 500 ms). Prieš eksperimentą apklausos būdu įvertinti tiriamųjų psichologiniai mitybos stiliai (angl. *Three-Factor Eating Questionnaire-R21*) ir demografinės charakteristikos. Duomenys analizuoti naudojant vienmatę, dvimatę analizes ir logistinės regresijos modelius.

Rezultatai. Logistinės regresijos modeliai atskleidė, kad sukeltos emocinės būsenos neturėjo poveikio dėmesio tendencingumo ir reakcijos į maisto užuominas pokyčiams. Nepaisant to, reakcijos laikas į maisto užuominas po emocinės būsenos sukėlimo užduoties sumažėjo visose tyrimo grupėse, o dėmesio tendencingumas po užduoties sumažėjo negatyvaus ir pozityvaus poveikio grupėse.

Išvados. Negatyvios ir pozityvios emocinės būsenos neturėjo poveikio moterų reakcijai į maisto užuominas ir dėmesio tendencingumui į maisto stimulus, matuojant vizualinio zondo užduotimi.

Raktažodžiai. Dėmesio tendencingumas, emocinės būsenos sukėlimas, emocinis valgymas, mityba, vizualinio zondo užduotis

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INTRODUCTION

Over the last few decades, obesity has become a major global heath challenge [1]. The prevalence of overweight and obesity is quickly rising and is considered to affect up to 38 percent of adults globally [1]. Obesity negatively impacts health – it is linked to cardiometabolic diseases, type 2 diabetes, coronary artery disease [2-3], and is also involved in the majority of the leading causes of death [4]. One of the main causes of obesity is increased energy consumption [5] though other factors are also playing a role. Thus, it is important to investigate contributing factors to overeating and obesity, especially the lesser researched ones like cognitive factors, particularly attention bias (AB) [6].

AB is a selective information processing in which individuals direct their attention towards personally relevant stimuli, when neutral stimuli are also present [7]. Detecting and approaching food in the environment is considered to be one of the most essential evolutionary adaptations for survival [8], therefore elevated AB for food can be prevalent in people with normal body mass index (BMI), especially while feeling hungry [9]. However, higher AB can predict weight gain [10] and faster reaction times for food are associated with higher BMI [11, 12].

Eating is not always regulated by objective states like feelings of hunger or satiety; it can also be used as an emotion regulation strategy [13]. Emotions can direct behavior by influencing different cognitive processes [14], that can direct attention towards personally attractive incentives that could potentially change a person's mood in a positive way, either by enhancing positive affect or by reducing negative affect [15]. Several studies have studied the association between AB for food and emotion. Research shows that sad mood increases attention to unhealthy food in women with food addiction [16], increases AB after negative mood between students [17, 18]. However, some studies have found that negative emotions do not have any effect on AB [19, 20].

However, studies that examined if elicited emotions have an effect on AB are scarce [16-20] and a lot is still unknown about this relationship. Previous studies have concentrated on negative emotions and their effect on AB. There is no research about relationship between positive emotions and AB, even though it is known that positive emotions increase food consumption as much as negative emotions do [21]. Therefore, the aim of this study was to examine the effect of elicited emotional states on women's reaction to food cues. In this experiment we included negative and positive emotional states, so that we could compare how different emotional states affect the reaction times and AB for food.

METHODS

Participants

A total of 87 women were included in the study. Participants were recruited through flyers shared in public places of Kaunas city and online through various social media groups. Participants' age ranged from 20 to 39 due to the fact that they have passed puberty but not yet experienced the effects of hormonal decline [22]. The exclusion criteria were: current occurrence of severe depression and anxiety symptoms (measured by Patient Health Questionnaire-9 (PHQ-9) and General Anxiety Disorder-7 (GAD-7)) and various dietary restrictions (like vegetarian, vegan diets).

The study was conducted in accordance with ethics approval by the Lithuanian University of Health Sciences Ethics Committee (reference No. BEC-SP(M)-49).

Participants were randomly assigned to one of the three experimental groups: neutral, negative or positive mood condition (N=29 in each). The mean age of participants was 26.5±6.11 years. The sample's mean body mass index was within normal range (22.3±3.37).

Procedures

Mood induction

Video clips were used to induce a respective emotional state in different experimental groups. The video for neutral mood induction (MI) group was taken from the movie "Strangers on a Train"; negative MI group watched a scene from the movie "Hereditary"; positive MI group watcher a scene from short film "Merci!". All video clips were shown from a video-sharing website YouTube, their length varied from two to five minutes, as it is considered to successfully induce emotional states [23], making it an easy and ecologically valid method to induce emotional states [24].

Visual dot probe task

To assess reaction times and attention bias for food, manual response latencies were recorded during a visual dot probe task. During this task two pictorial stimuli appear simultaneously on the left and right sides of a computer screen, followed by a probe (a small dot) that replaces one of the stimuli. Participants are instructed to respond as quickly as possible to the location of the dot by pressing a corresponding key on the keyboard. If the attention is automatically drawn towards personally more important stimulus, the responding time to the dot that replaces the image is faster [25].

Each trial started with a fixation cross (that disappeared after 500 ms), followed by a stimulus pair (shown for 500 ms). Then the probe appeared and stayed on the screen until participants made a manual response indicating the position of the probe. The probe equally often replaced food and neutral stimuli and was equally distributed on the right and left screen locations. The task consisted of 120 trials, with 80 critical trials (photograph of sweet high-caloric food stimulus paired with a photograph of a neutral stimulus) and 40 filler trials (two neutral stimuli). All photographs were taken from "Food-pics" database [26].

Following previous research [e.g. 20], response latencies faster than 200 ms, slower than 2000 ms or more than 3 SDs above each participant's mean were excluded from the analysis. AB scores were calculated by subtracting the mean response latency on congruent trials (when the probe replaced food stimulus in critical trials) from the mean response latency on incongruent trials (when the probe replaced neutral stimulus in critical trials). A positive bias score was indicative for an AB towards food stimuli, whereas a negative bias score can be interpreted as attention avoidance from food stimuli.

Procedure

Before the experimental procedure, participants completed the questionnaire which included TFEQ-R21, demographic characteristics and exclusion criteria. Participants that were eligible for the study were invited to Lithuanian University

of Health Sciences Public Health laboratory, where the experiment took place. All the participants were tested individually by one experimenter.

Upon arrival, the participants signed the informed consent form and filled in the visual analogue scale (VAS) for subjective hunger. After that all the participants completed first measure of visual dot probe task. Then, participants rated their emotional state before MI (VAS1). Depending on the experimental group that the participants were randomly assigned to, they watched a negative, positive or neutral video clip and subsequently rated their emotional state after MI (VAS2). Finally, participants completed another visual dot-probe task. At the end of the experiment participants were debriefed.

Measurements

Visual analogues scale (VAS) was used to measure subjective hunger (at baseline) and emotional states (before and after MI). Each scale consisted of a continuous line ranging from 0 ("very bad mood"; "starving") to 10 ("very good mood"; "full"). Emotional states were not labeled due to the fact that seeing emotional adjectives can change how a participant feels [27]. Participants were asked to mark a cross on each line to indicate how they were feeling.

The Three Factor Eating Questionnaire-R21 (TFEQ-R21) [28]: a 21-item questionnaire with three scales: emotional eating (6 items; α=0.939), uncontrolled eating (9 items; α=0.882), cognitive restraint (6 items; α=0.759). Items were scored on a four-point Likert scale ranging from "definitely true" to "definitely false". Possible scores range from 0 to 100 with higher scores indicating greater prevalence.

Demographic characteristics: participants were asked about their age, education, height and weight. Height and weight were used to calculate BMI, which was later grouped into three categories: low (<18.5), normal (18.5 to 24.99) and high (25.0 and more) [29].

Analyses

Statistical analyses were performed using "IBM SPSS Statistical Version 23". Statistical significance level was set at $p<0.05$.

Because data between groups was not normally distributed, non-parametric methods were used. Spearman correlation was used to compute associations between variables under study; Kruskal-Wallis test was used to compare three independent experimental groups; Wilcoxon signed-rank test was used to compare two related samples.

Multivariate logistic regressions were used to determine whether MI procedure had an effect on reaction time and AB for food. The regression method was used to determine how different factors (MI, psychological eating styles, BMI and age) associated with AB and reaction times to food cues. Odds ratios (OR) and 95% confidence intervals for each independent variable in the model were computed.

RESULTS

Group characteristics

Independent sample Kruskal-Wallis tests confirmed that there were no significant differences between different experimental groups, except for the difference in measurement of time since last meal (p=0.034; Table 1). Even though participants in different experimental groups differed from one another by the time since they last ate, the subjective hunger did not differ significantly. Thus, participants in all

Table 1. **Characteristics of study participants (n=87)**

Variables	Mean±SD or N (%)			
	Neutral	Negative	Positive	p
Education				
Secondary	9 (31)	13 (44.8)	10 (34.5)	0.269
Vocational	0 (0)	3 (10.3)	2 (6.9)	
Higher	20 (69)	13 (44.8)	17 (58.6)	
Body mass index (BMI)				
Low	1 (3.4)	1 (3.4)	3 (10.3)	0.685
Normal	20 (69)	23 (79.3)	20 (69)	
High	8 (27.6)	5 (17.2)	6 (20.7)	
Age	26.5±5.78	25.7±5.85	27.1±6.79	0.726
Hunger at baseline	7.72±2.52	6.95±2.95	7.86±2.63	0.348
Time since last meal (h)	3.64±4.62	3.71±3.38	2.03±2.00	0.034
TFEQ-R21				
Emotional eating	35.3±29.70	34.5±31.19	36.1±29.57	0.982
Uncontrolled eating	37.8±16.79	42.0±25.73	38.0±24.90	0.778
Cognitive restraint	46.6±19.47	36.2±22.87	39.3±22.2	0.156
VAS				
Mood at baseline	7.1±2.07	7.5±1.43	6.9±2.24	0.918
Mood after MI	7.3±1.75	4.6±2.18	8.2±1.77	<0.001
Reaction time pre-MI (ms)	414.0±48.54	442.9±121.75	442.8±74.96	0.428
Reaction time post MI (ms)	398.2±45.23	420.2±89.37	412.5±43.74	0.428
Attention bias pre-MI	8.3±11.85	7.5±17.23	6.7±14.46	0.851
Attention bias post MI	2.3±11.97	-2.8±13.86	-1.3±8.95	0.431

Note: TFEQ-R21 – The three-factor eating questionnaire revised 21; VAS – visual analogue scale, MI – mood induction.

the experimental groups arrived in a similar mood and hunger states for the experiment.

Mood induction

First, we measured the effectiveness of completed MI procedure, using Wilcoxon signed-rank test. Results showed significant interactions between MI and time: after the MI procedure, subjective mood in negative experimental condition significantly decreased ($p<0.001$), in positive condition significantly increased ($p<0.001$), and did not significantly change in neutral condition ($p=0.109$) (Fig. 1). The differences between groups after MI were statistically significant ($p<0.001$; Table 1).

Reaction time to food and attention bias

We tested changes in reaction times and AB for food stimuli after MI in different experimental conditions. Results suggest that reaction time in all experimental conditions significantly decreased (neutral condition $p=0.007$; negative condition $p=0.005$; positive condition $p<0.001$; Fig. 2). Results for AB score showed statistically significant decrease after MI in negative and positive experimental conditions ($p=0.024$, $p=0.005$ respectively). AB also decreased in neutral condition but the result was not significant ($p=0.071$; Fig. 3). There were no significant differences between the experimental groups in reaction time and AB before or after MI (Table 1).

The effect of mood induction on reaction time and attention bias

We conducted and analysis to see if elicited emotional states had an effect on reaction time and AB.

First, we examined correlations between reaction time, AB and psychosocial variables under study (Table 2). The results showed that reaction time moderately correlated with age ($\rho=0.49$), weakly correlated with body mass index ($\rho=0.33$) and uncontrolled eating ($\rho=0.29$). We did not find any significant correlations between AB and psychosocial variables under study.

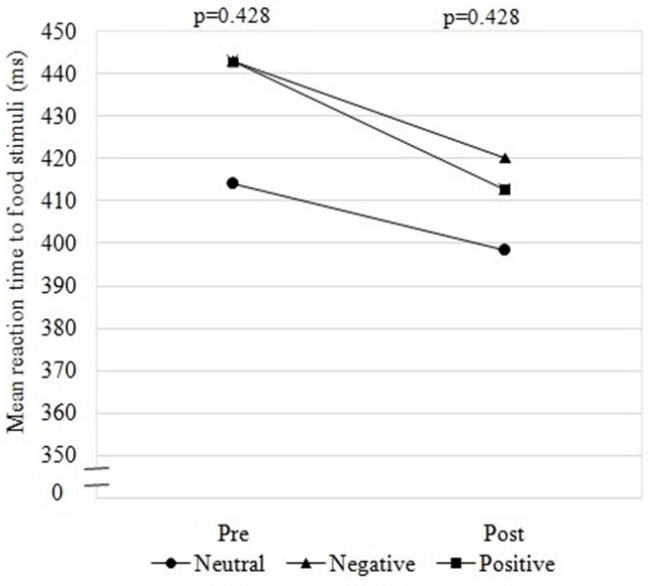

Figure 2. **Mean reaction time to food stimuli (ms) per experimental condition before and after MI**

Next, we conducted two multivariate logistic regression analyses in order to identify factors that could affect reaction time and AB for food (dependent variables). Independent variables were chosen by significance level $p\leq0.2$ [30].

While analyzing what factors influenced reaction time to food after MI, dependent variable (reaction time after MI) was split using median value (50 percentile; 394.9) as a cut off point for dichotomization. Independent variables included in the model were experimental condition, reaction time before MI, uncontrolled eating, BMI and age. Multivariate logistic regression showed that reaction time before MI was significantly predicted by reaction time before MI (OR=1.06) controlled by experimental condition, uncontrolled eating, BMI and age (Table 3).

Finally, we analyzed what factors influenced AB after MI. Dependent variable (AB after MI) was split into two groups

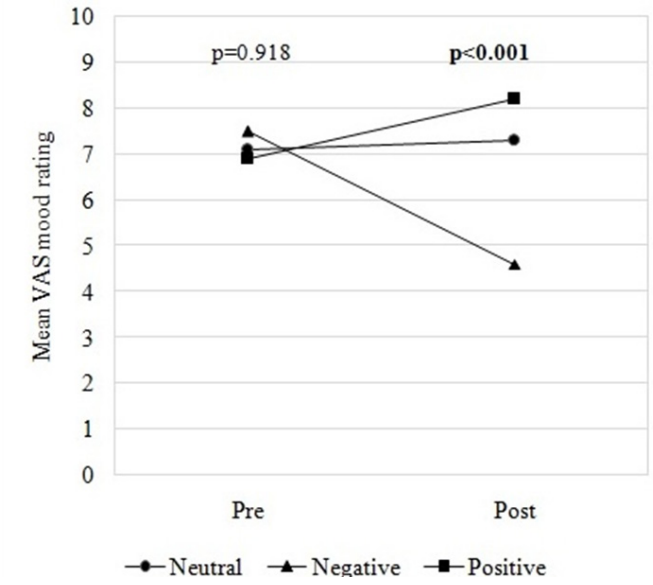

Figure 1. **Mean mood ratings per experimental condition before and after MI**

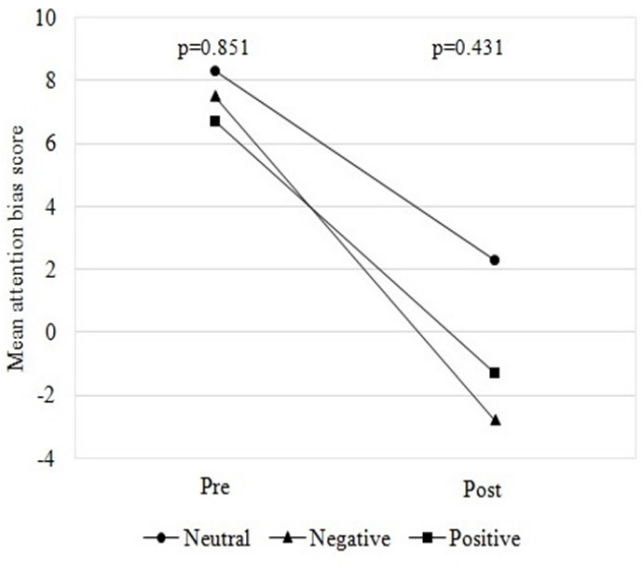

Figure 3. **Mean attention bias to food stimuli score per experimental condition before and after MI**

Table 2. **Spearman correlations between reaction time, attention bias and dietary and demographic indicators**

	Reaction time post MI	Attention bias post MI
Uncontrolled eating	0.29*	-0.09
Cognitive restraint	0.10	0.08
Emotional eating	0.11	-0.05
Subjective hunger	0.06	0.09
BMI	0.33*	0.03
Age	0.49**	0.08

Note: *p<0.05, **p<0.001; MI – mood induction, BMI – body mass index

for dichotomization: negative AB (<0) and positive AB (>0). Independent variables included in the model were experimental condition and AB before MI. Multivariate logistic regression model showed no significant factors predicting AB after MI (Table 4).

DISCUSSION

This experimental study has been conducted and the results indicate that emotional states, either positive or negative, did not affect reaction times to food cues or attention bias to food in the current sample as measured by dot-probe task.

Despite the fact that emotional states did not affect the reaction times or AB, these indicators did significantly change after mood induction. After MI, reaction time decreased in all experimental conditions, while AB decreased in negative and positive experimental groups. After MI, participants in negative and positive experimental conditions reacted faster to neutral stimuli compared to food stimuli, showing attentional avoidance to food [25]. As the stimuli in the dot-probe task were shown for 500 ms, they reflect conscious aspects of attention. It can be hypothesized that people after MI consciously relocated their attention from food to neutral stimuli. Avoidance helps when a person does not have adequate resources to process information [25]. In negative experimental group that could have happened because negative emotions tend to reduce reward value, leaving people less motivated to search their surroundings for motivational stimuli [31]. Positive emotions could leave people less motivated to search for salient stimuli because they already feel content with their emotional state and do not feel the need to make it better.

Table 3. **Factors predicting attention bias after MI: multivariate logistic regression**

Indicator	Group	Attention bias after MI	
		OR (95% CI)	p
Experimental condition	Neutral	1.00	
	Negative	0.88 (0.31–2.50)	0.810
	Positive	0.78 (0.27–2.22)	0.640
Attention bias before MI		1.02 (0.99–1.05)	0.169

Note: MI – mood induction, OR – odds ratio, CI – confidence intervals

Table 4. **Factors predicting reaction time to food cues after MI: multivariate logistic regression**

Indicator	Group	Reaction time after MI	
		OR (95% CI)	p
Experimental condition	Neutral	1.00	
	Negative	0.51 (0.08–3.35)	0.480
	Positive	1.14 (0.20–6.55)	0.886
Reaction time before MI		1.06 (1.03–1.09)	<0.001
Uncontrolled eating		1.03 (0.99–1.07)	0.096
BMI		0.95 (0.73–1.22)	0.666
Age		1.04 (0.88–1.24)	0.643

Note: MI – mood induction, BMI – body mass index, OR – odds ratio, CI – confidence intervals

Prior research on this topic has found mixed results. In study conducted by Werthmann and colleagues [20] negative mood induction decreased initial orientation towards food. Hepworth and colleagues [17] aimed to examine the effect of negative mood on attentional bias between women students. They found that negative mood increased AB, meaning that women reacted faster to food stimuli compared to neutral stimuli. These mixed results could come from different assessment of attention bias: our study used visual dot-probe task with stimuli present for 500 ms. Similarly, Hepworth and colleagues used a visual dot-probe, but stimuli were present for 500 ms and 2000 ms, analyzing different components of attention; while Werthmann and colleagues measured the AB with eye movement recordings.

Our study did not find prognostic variables for attention bias or reaction times to food cues. Previous research also did not provide consistent results. Some researchers find correlations between AB and external eating [32, 33], or trait impulsivity [32]. In the above-mentioned study by Werthmann [20], emotional eating did not predict changes in attention allocation for food. It can be hypothesized that emotional states are not sufficient for changes in reaction to food to occur. It is thought that emotion regulation strategies, impulsivity or self-control levels could have a bigger impact in this relationship. For example, Pollert and Veilleux [34] found that AB predicted eating behavior after self-control exertion. Other study by Schepers and Markus [18] has found that both genetic and cognitive stress vulnerability increased AB for high palatable food during acute stress.

Our study also had some limitations. First, the question concerning the visual dot-probe task and its validity needs to be addressed. Even though this technique has been widely used to measure AB in different populations [7, 35], studies on its validity are very rare. Some researchers find the task to be reliable [36], while other studies report low reliability [37, 38].There are also some questions about the tasks' ecological validity. The participant's in our experiment reported feeling bored and finding it hard to concentrate while completing the task for the second time at retest. The second limitation would be the fact that sweet high calorie food images were chosen as food cues in the experiment. While these stimuli are more

likely to catch attention [39], they could have been personally irrelevant for some of the participants.

Despite these potential limitations, one of the biggest strengths of our study includes its experimental design, involving negative, positive emotional states and a neutral control group. This experimental design enabled us to draw implications about the effect that study variables had on AB. Finally, our research concentrated on a wider population, not limiting itself on students as other previous studies in this field usually practiced [17, 20].

These strengths and limitations raise some recommendations for future studies. First, it raises the need for a new and ecologically valid measure of AB. Finding a way to measure AB in real life situations would show the real impact of AB on eating behavior. One of more successful methods to do that is eye tracking technology [20]. Another important thing to investigate would be how AB impacts the feeling of hunger and consequently eating behavior.

To conclude, we can state that the current study revealed that negative and positive emotional states do not affect women's reaction to food cues or attention bias to food stimuli as measured by visual dot-probe test.

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