Eye-tracking the obese: BMI-dependent gazing behavior in a food context

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Abstract

Objective: Investigating the relationship between the Body Mass Index (BMI) and gazing behavior, expecting differences in attention allocation consistent with the Incentive Sensitization model.

Participants & Methodology: 174 subjects with BMIs ranging from 17 to 69.1 were shown images of paired objects (foods of high and low caloric density in addition to neutral images of inedible objects). A Tobii T60 eye-tracker was used to record gaze movements. Based on this data, a linear regression model relating BMI to gaze metrics was constructed. Regression lines were compared between genders based on the Conditional Sum of Squares.

Results: A tendency to start examining stimuli from left to right strongly affected Time to First Fixation (TTFF); Fixation Count (FC) and Fixation Length (FL) were primarily affected by size and visual complexity. Several objects elicited BMI-dependent behavior: FC and FL had a weak but statistically significant negative correlation with BMI, regardless of caloric content. First Fixation Duration (FFD) was positively correlated with BMIs when observing high-fat savory foods, suggesting BMI-dependent attention-capturing properties. Contrary to expectations, TTFF on the potato chips was positively correlated with BMI. There were no statistically significant differences in FL and FC between genders, while FFDs from male subjects notably differed ($p<0.05$) in exhibiting a weak negative correlation on the cheeseburger and potato chips. For TTFF on the potato chips, males displayed a significantly stronger positive correlation.

Conclusion: Our study did not explicitly confirm or contradict the Incentive Sensitization model, but our observations do suggest TTFF and FFD as indicators of implicit attention or emotional significance, whereas measures of explicit attention (FL and FC) generally failed to yield the expected results. There are gender differences particularly when observing high-fat savory foods, possibly related to gender-specific dietary preferences.

Keywords: Eye-tracking; gaze; implicit measures; BMI; attention; food images

Introduction

According to the “Incentive Sensitization” model[1, 2], the dysregulated eating behaviors at the root of obesity may be understood as a form of addiction: The activity of the dopaminergic reward system in anticipation of and in response to consuming the “substance of abuse” (i.e. food) causes a sensitization to reward-related cues, increasing their salience (making them more “attention-grabbing”). The subject becomes more likely to notice these cues, which evoke feelings of “craving” and “wanting”, leading to greater food intake which promotes further priming of the brain, sending them into a vicious circle that has to be broken through strict adherence to strategies of dietary restraint (forcing them to un-learn dietary habits they had been practicing for much of their lives). These issues are often compounded by psychological factors – a sense of shame and lack of self-esteem that either prevent them from seeking help or cause them to abandon their diet plan after a relapse (an ever-present risk, considering the widespread use of food as a mood regulator [3]).

Rothemund et al.[4] used functional Magnetic Resonance Imaging (fMRI) to demonstrate that in obese women, visual stimulation with food images was enough to activate the dorsal striatum, an area of the brain involved in reward anticipation and habit learning; interestingly, the level of activation was proportional to the subject’s BMI, but independent of their actual physiological level of satiety. High-calorie foods in particular led to BMI-dependent activity in regions associated with taste processing (anterior insula, lateral orbitofrontal cortex), motivation (orbitofrontal cortex) as well as emotion and memory (posterior cingulate). As a result, obese subjects display decreased D2 receptor availability in these regions, similar to methamphetamine addicts[5]. They also reported a discrepancy between how subjects rated the palatability of the displayed food and the level of actual emotional response in the brain (low-calorie foods received higher ratings, despite eliciting less brain activity). A similar discrepancy was found with alcoholics exposed to alcohol-related stimuli[6], suggesting that verbal reports are not a reliable measure of actual liking/craving if the person is trying to project a more favorable image or is in denial about their condition.

The effects of such neural processes have been explored in a number of attentional paradigms, such as the dot-probe task and Stroop task[7], sometimes combined with eye-tracking. Nijs et al.[8] explored several methods for detecting potential attention biases for food images versus neutral ones: In an eye-tracking paradigm, both obese and normal-weight women showed a direction bias (the first image to be fixated on) and a duration bias for food, without significant differences between groups; the P300 ERP (an EEG peak appearing ~300 ms after a stimulus), an indicator of conscious attention allocation, also revealed a bias for food in both groups. Interestingly, this bias was greater in hungry normal-weight subjects than in satiated ones, while the opposite was the case with overweight persons – possibly due to a conscious mental effort by the obese to disengage attention from the food cue in order to "prevent disinhibited food intake"[8]. Piech et al.[9] used an Emotional Blink of Attention (EBA) paradigm to demonstrate that a state of hunger significantly increases the attention-capturing effects of food cues (hungry participants were less likely to identify targets preceded by food stimuli).

Modern eye-trackers are unobtrusive and require little activity from the respondents, allowing insights into "natural" viewing behaviors, thus producing "implicit measures" ("measurement outcomes that reflect the to-be-measured construct by virtue of processes that are uncontrolled, unintentional, goal-independent, purely-stimulus-driven, autonomous, unconscious, efficient, or fast"[10]). While such methods tend to be less susceptible to manipulation than common "explicit" measures, they are nonetheless not immune to it, especially when participants are aware of the purpose of the experiment and have a general understanding of the mechanisms by which the result is produced[11]. Obese subjects, for example, are likely to guess that the goal of the experiment may be related to their body weight, prompting them to manipulate their gaze patterns to produce a more "favorable" result (avoiding high-calorie foods). However, some of the commonly analyzed gaze metrics are harder to manipulate than others, and hence more reliable indicators of implicit attitudes, while others, conversely, represent controlled, "explicit" attitudes. Specifically, the former should be more prevalent in the early stages of visual processing (e.g. the direction of the first fixation or an initial pupillary response), while the latter should become evident in the later stages (e.g. as total fixation duration).

The attentional effects of learned implicit attitudes have been investigated in several studies on restrained eating behaviors – according to Stewart & Samoluk[12], chronic dietary restraint significantly affects latencies in a Stroop task, while acute food deprivation (an induced hunger state) does not. Hoefling & Strack[13] used an Extrinsic Affective Simon Task to analyze implicit attitudes towards foods of varying caloric densities among a group of restrained eaters, reporting a clear discrepancy between implicit measures and explicit ratings with high-calorie foods, but not low-calorie ones. Combining eye-tracking with a dot-probe task, Castellanos et al.[14] reported that while both obese and normal-weight women showed increased gaze duration on food versus non-food images in the hunger condition, only the obese also exhibited this bias in the sated condition; there were no significant differences between groups in terms of reaction times, however.

Combining gaze tracking and pupillometry, Graham et al.[15] investigated the relationship between food-related gazing behavior, BMI status (normal vs overweight/obese), state of hunger, state and trait craving scores and restrained eating behaviors. Their findings seemingly contradict those of Castellanos et al.[14] – specifically, they did not find a statistically significant correlation between either state of hunger or state craving scores and average fixation durations on food images. A possible explanation for these discrepancies is provided by the Elaborated Intrusion Theory of Desire[16], which posits that the “seemingly spontaneous and intrusive thoughts that ultimately underlie cravings and subsequent consumption may be more likely to arise while cognitive resources are low and attention is divided”[15] – whereas Castellanos et al. employed a dot-probe task that required a significant attentional commitment, Graham et al. used a free-viewing paradigm which – while approximating a “natural” viewing situation – did not require a significant diversion of attention, and may thus have been more susceptible to an intentional manipulation of gaze patterns. Additionally, self-report measures including pointed questions concerning the participants’ eating habits and state of hunger and a lack of non-food images may have further exacerbated the influence of their explicit food attitudes on fixation durations. Another explanation lies in the role of highly specific learned associations in craving states, which vary wildly between individuals and demographics, leading to poor comparability between studies with small sample sizes from distinct social or ethnic demographics.

However, ”bogus” tasks or additional attentional paradigms carry their own risks. Blatantly obvious attempts at obfuscation or unnecessarily complex tasks may annoy or frustrate the test subject, negatively affecting their compliance with instructions or deterring them from participating altogether. The memory recall test is commonly used in this role, e.g. in this previous eye-tracking study at our institution[17]. While appearing plausible to participants, it also presents a situation where they feel they can “win” or “lose”, making them more likely to try and influence their gaze patterns in order to increase memory retention; some participants may also experience unnecessary stress. In addition to constituting an ethical problem, particularly when working with participants undergoing treatment for obesity-related health issues, stress is also known to increase both perceived hunger and attention bias to high-calorie snacks, making it a confounding factor to be avoided[3, 18].

We thus decided on a free-viewing paradigm (involving food images and neutral non-food images) without any additional task, instead reassuring participants by claiming to perform a test on the eye-tracking device rather than the person, and having the self-report form (which contained questions about weight and eating habits) filled out after completion of the eye-tracking recording.

The primary objective of this study was to investigate the correlations between respondents’ BMIs and a number of gaze metrics by constructing a linear regression model, rather than comparing obese and non-obese on a group basis.

Secondly, we attempted to investigate whether these gaze metrics show a preference for objects on a specific side of the screen. In contrast to previous studies in this field [14, 15, 17], our study included both male and female participants, allowing us to compare regression models between genders.

Materials & Methods

Participants

174 subjects with BMIs ranging from 17 to 69.1 took part in this study. Participants were recruited among students, employees and visitors of the University of Natural Resources and Life Sciences (“BOKU”), Vienna, and among patients of the Psychosomatisches Zentrum Waldviertel (“PSZW”) in Eggenburg, Austria and the Therapiezentrum Buchenberg in Waidhofen an der Ybbs, Austria. Participants were assigned a code, and all data was handled anonymously.

At all locations, the experiment was approved by the responsible authorities. For their participation, respondents at Buchenberg were compensated with €10; normal-weight participants at the BOKU were offered coffee and cake. Participant statistics were collected through a form filled out after the eye-tracking task. At this point, the goal of the experiment was fully disclosed to the participant, and they were asked to give informed consent to the use of their gaze recording and self-report form.

161 participants produced acceptable recordings. Grounds for exclusion were obvious manipulation of gaze patterns, duplicates, data corruption and insufficient recording quality. Among these, 43 of the participants qualified as “obese”, (BMI≥30). For participant statistics, see Table 1.

Table 1 goes ~here

Eye-Tracker

Eye-tracking readings were taken using a Tobii T60 remote eye-tracker, manufactured by Tobii Technology AB, Danderyd, Sweden. The eye-tracker was connected to a laptop computer running the Tobii Studio software (v. 1.7.3), used for planning the stimulus sequence, recording and processing gaze data, managing participant data, designating Areas of Interest (AoIs) and exporting AoI-based fixation data.

Visual stimuli

Each visual stimulus consisted of a composite image of two food items of similar appearance but significantly differing caloric density, positioned on the left and right side of the screen at approximately the same distance from the center. Source photographs were taken with a Canon EOS 400D digital camera or adapted from the department's image archive. Using Adobe Photoshop CS4, the objects were adjusted for coloration, brightness and contrast, and arranged over a uniformly blue background approximately matching the brightness of the foods in order to ensure optimum color contrast while avoiding an excessive brightness contrast that would cause the items to appear washed out and increase eye strain.

In addition to our 7 food stimulus images, we created 8 neutral images of pairs of various household and office objects in order to reduce the likelihood of participants guessing at the goal of the experiment. To ensure that all participants started out at approximately the same gaze position in each picture, a "fixation cross" (a red cross at the center of the screen in front of a blue background) was inserted before each stimulus. Food and neutral stimuli were displayed for a duration of 8 seconds, the fixation cross was displayed for 2.5 seconds (a compromise to allow "slow-gazing" participants enough time to examine the image while not enticing "fast-gazing" participants to drift off-screen out of boredom). The image sequence was preceded by an instruction (red text on blue background, visible for 5 seconds) to look at the fixation cross.

Being a "free viewing"-paradigm, participants were verbally instructed prior to the eye-tracking task to center their gaze on the fixation cross only as long as it was present on the screen (to avoid misunderstandings where participants assumed they were supposed to keep their point of gaze centered on this position throughout the experiment), then look at the following images in a "free" and "natural" manner.

Statistical analysis

Participant data was exported from Tobii Studio to be organized in Microsoft Excel 2007, and from there to Statgraphics Centurion XV.

As a simple test for directional preferences (left vs right), we calculated the quotient of the value of each eye-tracking parameter for the left AOI divided by that for the right AOI.

For our regression analysis, we used a simple linear model ($Y = a + b*X$) for each food AOI, with the gaze parameter as the dependent variable and BMI as the independent variable.

To examine gender differences, we compared linear regression models for the gaze metrics of the high-calorie AOIs based on the Conditional Sum of Squares.

Results

Left/Right-bias

Table 2 goes ~here

Direction bias scores are shown in Table 2.

First Fixation Durations (FFD) on the left side are slightly lower overall, with the exception of the "Cookie-Roll" stimulus. Fixation Length (FL) and Fixation Count (FC), both indicators of explicit attention, are approximately evenly distributed. Mean Time to First Fixation (TTFF), an indicator of initial attention allocation, is significantly lower for AOIs on the left.

BMI vs gaze parameters

Table 3 goes ~here

Linear regression models for gaze parameters as a function of BMI are shown in Table 3.

For the image "Burger-Wrap", there is a strong positive correlation between the FFD on the "Burger"-AOI and the person's BMI; a similar correlation exists for the "Chips"-AOI; although the latter relationship is relatively weak under the linear model, it becomes much stronger when applying the Double Squared model (R^2=10.67%, p=.0000). By applying the same model to the cheeseburger AOI, an R^2 of 20.29% (p=0.0000) is achieved, the highest coefficient of determination for a gaze-BMI-relationship encountered in this study.

For FL and FC, there was evidence of a statistically significant negative correlation with a person's BMI, especially noticeable for AOIs on the left side of the screen - regardless of caloric content. For TTFF, the only AOI to produce strong evidence of a correlation with participant BMIs was "Chips".

Gender differences

Table 4 goes ~here

A comparison of linear regression models between genders is shown in Table 4. FL and FC show no statistically significant differences. For TTFF, there is a significant ($p \leq 0.01$) difference between genders for the AOIs “Chips” and “Burger”, with men exhibiting a positive correlation and women exhibiting a weaker positive or even negative relationship. The positive correlation between BMI and FFD on the cheeseburger (see above) turned out to be driven by the female participants – there is a significant ($p=0.01$) difference between genders, with FFD actually being negatively correlated with BMI in men. Similar behavior is seen with the bacon ($p=0.06$) and the potato chips ($p=0.03$).

Discussion

In our free-viewing task, we analyzed key gaze parameters considered indicators of implicit or explicit attention in order to identify if and to what extent gaze patterns and attentional engagement are affected by an individual’s BMI.

In terms of initial direction bias, participants in our study showed a strong tendency to first direct their attention to the object on the left side of the screen, regardless of caloric content. This is most readily apparent in the average Time to First Fixation (TTFF), which for left-hand objects is approximately half of that for right hand objects. The exception to this is the image Burger-Wrap, in which the average TTFF for the right-side object (a chicken wrap) is only marginally lower, likely due to its oblong shape causing its edges to be closer to the center of the screen (the starting point of gaze). This direction bias may be related to the cultural background of our participants – people accustomed to left-to-right script (and left-justified software and webpage layouts) exhibit a known tendency to scan images from top-left to bottom-right[19-21], differing from individuals accustomed to a right-to-left writing system[22].

To some extent, an initial direction bias favoring the left also affects other parameters representing explicit attention allocation – by being the target of the first fixation, that object also has a “head start” in terms of total Fixation Count (FC) and Fixation Length (FL); this could be offset by increasing presentation time, albeit at the risk of causing boredom and losing the participant’s attention, especially when using stimuli of low visual complexity. As an explanation for the lower average First Fixation Durations (FFD) on the left AOI, we suggest that when confronted with a new visual stimulus, individuals will initially attempt to gain a general overview of the image through a series of quick fixations, after which they increase the time afforded to each fixation as they examine the stimulus in detail. Since initial attention is mostly directed to the left, the first fixation there is likely to be shorter. On the other hand, the higher FFD for the cookie (despite being located on the left side) may be because of its compact size, allowing a viewer to fully register it in a single, longer fixation.

These results suggest the use of counterbalanced image sequences in order to counteract this bias, either by showing each pair of objects twice (with switched positions) in the same sequence, or having one half of the participant group view the original images, and the other viewing a mirrored version. However, the former option also introduces a new element of uncertainty (“to what extent does seeing the same object for a second time affect gaze behavior?”), whereas the latter would require an even larger number of participants (studies in this field have so far been conducted with relatively small sample sites; Castellanos[14] and Graham[15] had to make do with sets of only 36 women each.)

Whereas previous studies generally calculated a bias score by relating the parameter for one AOI to that of another, we constructed linear regression models for each AOI individually. In general, we noticed that FL and FC are mostly dependent on attributes like AOI size (compare the relatively small cookie vs. the relatively large pumpkinseed roll possessing a similar visual texture) and visual complexity (e.g. the stimulus Tomato-Salami, where the AOI “tomato”, consisting of an assortment of sliced and whole tomatoes, attracts more attention than three homogenously-textured slices of sausage, despite its smaller size), with relatively little influence from a participant's BMI.

The cause for the almost universally negative relationship between FL/FC and BMI (regardless of caloric density) is still unclear – considering the higher mean age of our high-BMI participant group, it is possible that this phenomenon is not due to the BMI itself, but rather the participant's age, which is itself correlated with the BMI value. Performing a linear regression analysis relating the above gaze metrics to participant age, we found similar statistical relationships, although R^2-values were slightly lower. Age has been shown to influence dietary preferences to some degree, with younger people turning to snacks as their "comfort foods", while seniors prefer warm, hearty dishes [23]; however, since the strength of the statistical relationships do not seem to coincide with these dietary preferences, the influence of age on gaze metrics seems to be mostly due to biologically motivated[24] changes in gaze behavior (e.g. frequency of fixations or eye movement speed) rather than the actual content of the stimulus.

The strong correlation between FFD and BMI for the "Burger"-AOI is highly interesting because out of all the images chosen for this study, the cheeseburger most universally represents what one would describe as an "unhealthy", high-calorie food (we specifically selected this type of burger because it lacked lettuce, tomatoes or other "healthy" ingredients). Several participants later reported actually feeling visually drawn to this item because they found it disgusting rather than appetizing (disgust due to spoilage has been associated with increased attention-grabbing properties[25], so this explanation is somewhat plausible). An epitomization of unhealthy qualities, a burger can be a temptation, a painful reminder or even a threat to those struggling with their body weight (as is the case with the high-BMI group), so the BMI-dependent increase in FFD may be due to its greater emotional significance (which may, in turn, evoke cognitive processes that further delay attentional detachment). Another interpretation is that the increased FFD represents a positive implicit judgment due to purely *"impulsive"* (associative) processing (based on memories of its palatability) whereas explicitly describing it as "disgusting" is result of the *"reflective"* processing system (a rational consideration bringing up undesirable consequences like heartburn or weight gain). For a discussion on the role of the conflicting processing systems in overeating, see Hoefling [13]. Lastly, it is possible that the negative explicit attitude towards the cheeseburger may simply be an attempt to project a more favorable image towards the researcher.

The same interpretations can also be applied to the (somewhat weaker) correlation between BMI and FFD on the potato chips, another classic “junk food”.

FFD values also show significant gender differences for the cheeseburger and the potato chips (and to a lesser extent the bacon), with FFD being strongly positively correlated with BMIs in women, but weakly negatively correlated in men. The reason for this may be the general dietary preference obese men exhibit for savory foods high in both protein and fat (whereas obese women prefer sweet dishes rich in sugars and fat[26]). For female dieters, these types of foods are associated with exceptional circumstances, while their emotional impact in men may be somewhat attenuated due to them being part of their “normal” diet.

In terms of TTFF, only the potato chips showed a significant correlation with participant BMIs. It is also noteworthy that this correlation is positive and stronger in male participants, which is at odds with the incentive salience model, which predicts increased salience and thus lower TTFF for this object in high-BMI individuals, especially in men who are more likely to consume savory snacks. An alternative explanation is that obese individuals avert their gaze from the object before a fixation can be recorded in an attempt to prevent unnecessary food intake, similar to what was reported by Nijs et al.[8]. In this case, TTFF shows promise as an implicit measure of learned aversion strategies.

Also employing eye-tracking, Graham et al.[15] compared normal-weight and overweight/obese women in terms of duration bias for high-calorie foods, initial direction biases and changes in pupil size. Their findings indicated negative implicit attitudes towards high-calorie foods in high-BMI individuals, especially those engaging in restrained eating behaviors, as evidenced by a decreased direction bias (there were, however, no between-group differences in gaze duration bias). Pupil dilation was greatest in low-BMI individuals confronted with high-calorie savory food (implying intense arousal of either positive or negative valence). These findings partially contradict those of Castellanos et al.[14], whose combined eye-tracking /visual probe task revealed both a duration and direction bias for high-calorie foods in both obese and normal-weight subjects when hungry, which only persisted in the obese group in the sated condition. One explanation for this discrepancy may be the presence of a concurrent attention-related task in Castellanos' experiment. While such a task may cause participants to adjust their gaze patterns to optimize performance in the given task, a task-less free-viewing paradigm may allow them to "optimize" their gaze patterns in terms of social desirability, for example by averting their gaze from high-calorie foods, especially during the later, explicitly controlled phase of visual attention. Despite also using a free-viewing paradigm, our results differ from those of Graham in that we observed higher TTFFs in high-BMI women looking at high-calorie savory foods, suggesting a positive implicit attitude, as well as increased FFDs, suggesting greater emotional arousal.

The availability of more accessible, less intrusive eye-tracking devices has greatly expanded their usefulness in nutritional psychology. Still, researchers have to cope with a lack of standardized paradigms. Results are therefore hard to compare between studies, as the nature and display times of stimuli and selection of self-report measures are largely left to the discretion of the individual researcher. However, an in-depth discussion and systematic inquiry into the reasons for inconsistencies between studies is a necessary groundwork for establishing a robust methodology in this field. Furthermore, eye-tracking as a stand-alone technique is inherently limited by the often ambiguous emotional valence of attention allocation. Combining eye-tracking with emotion measurement technology (such as EEG or facial expression analysis) promises to increase the validity of studies in this field, especially when employing implicit measures.

Conflict of Interest

None of the authors has any conflict of interest arising from publishing this manuscript.

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Tables

Table 1. Participant statistics (only counting usable data sets)

	Women	Men
N	92	69
Mean Age	30.4 (12.3)	27.6 (11.2)
Mean BMI	27.4 (10.2)	26.6 (8.1)

Table 2. Direction bias scores (left AOI value divided by right AOI value)

Image pair[a]	First Fixation Duration	Fixation Count	Fixation Length	Time to First Fixation
Tomato-Salami	0.840	1.398	1.379	0.512
Avocado-Cucumber	0.783	1.101	1.081	0.506
Bacon-Loin	0.942	0.909	0.850	0.494
Grapes-Candy	0.863	1.234	1.188	0.494
Burger-Wrap	0.580	1.056	0.773	0.935
Cookie-Roll	1.247	0.568	0.661	0.558
Chips-Banana	0.942	0.616	0.628	0.630
Means[b]	0.885 (0.21)	0.983 (0.307)	0.937 (0.284)	0.590 (0.160)

[a] Image names are always “*left object-right object*“

[b] Standard deviations in parentheses

Table 3. Simple linear regression describing the relationship between gaze parameters and participant BMI (by AOI)

	slope	R-squared[%]	p-value
First Fixation Duration			
Tomato	0.000	0.039	0.804
Salami	0.000	0.048	0.783
Avocado	0.000	0.063	0.752
Cucumber	0.000	0.060	0.759

Bacon	0.001	0.191	0.582
Lean Loin	0.001	0.410	0.420
Grapes	-0.002	0.594	0.331
Candy	0.000	0.021	0.855
Burger	0.006	7.521	0.000
Wrap	0.005	1.082	0.189
Cookie	0.000	0.011	0.894
Roll	0.000	0.043	0.795
Chips	0.003	1.772	0.092
Banana	0.000	0.001	0.964
Fixation Count			
Tomato	-0.083	4.000	0.011
Salami	-0.001	0.000	0.969
Avocado	-0.091	5.490	0.003
Cucumber	-0.053	2.329	0.053
Bacon	-0.122	8.705	0.000
Lean Loin	-0.022	0.348	0.456
Grapes	-0.089	4.893	0.005
Candy	-0.010	0.110	0.676
Burger	-0.066	2.846	0.032
Wrap	-0.045	1.905	0.081
Cookie	-0.018	0.306	0.486
Roll	-0.090	4.262	0.009
Chips	-0.057	2.665	0.039
Banana	-0.087	3.906	0.012
Fixation Length			
Tomato	-0.032	5.082	0.004
Salami	0.012	1.003	0.206
Avocado	-0.036	7.117	0.000
Cucumber	0.000	0.001	0.964
Bacon	-0.032	5.891	0.002
Lean Loin	0.000	0.004	0.938
Grapes	-0.023	3.140	0.025
Candy	0.015	1.796	0.090

Burger	-0.009	0.467	0.389
Wrap	-0.011	0.824	0.252
Cookie	0.010	0.693	0.294
Roll	-0.026	4.256	0.009
Chips	-0.013	1.165	0.173
Banana	-0.006	0.222	0.552
Time to First Fixation			
Tomato	-0.002	0.081	0.722
Salami	-0.002	0.027	0.836
Avocado	0.003	0.154	0.624
Cucumber	0.000	0.004	0.935
Bacon	-0.004	0.246	0.535
Lean Loin	0.011	1.118	0.182
Grapes	-0.008	0.884	0.236
Candy	0.011	1.311	0.148
Burger	0.008	0.460	0.396
Wrap	0.001	0.008	0.913
Cookie	0.003	0.142	0.638
Roll	0.005	0.314	0.481
Chips	0.021	4.673	0.006
Banana	-0.001	0.018	0.868

Table 4. Gender differences in statistical relationships between BMI and gaze parameters for the high-calorie stimuli

	slope(women)	slope(men)	R-squared [%]	p-value (slopes)
First Fixation Duration				
Salami	0.000	0.001	0.386	0.913
Avocado	0.001	0.000	0.078	0.899
Bacon	0.003	-0.004	2.441	0.059
Candy	0.001	-0.003	0.785	0.420
Burger	0.010	-0.002	14.709	0.001
Cookie	0.002	-0.003	0.409	0.430
Chips	0.006	-0.003	4.704	0.031
Fixation Count				

Salami	0.009	-0.019	0.483	0.635
Avocado	-0.099	-0.074	5.610	0.696
Bacon	-0.116	-0.134	8.773	0.788
Candy	-0.013	-0.007	0.338	0.916
Burger	-0.062	-0.066	5.469	0.962
Cookie	-0.009	-0.042	2.180	0.556
Chips	-0.043	-0.089	3.257	0.435
Fixation Length				
Salami	0.020	-0.003	5.713	0.246
Avocado	-0.036	-0.035	7.126	0.935
Bacon	-0.026	-0.043	6.994	0.439
Candy	0.018	0.007	2.058	0.546
Burger	0.000	-0.024	4.835	0.245
Cookie	0.012	0.002	1.601	0.601
Chips	-0.005	-0.031	2.221	0.205
Time to First Fixation				
Salami	0.002	-0.011	0.589	0.542
Avocado	0.003	0.002	0.774	0.906
Bacon	-0.010	0.013	2.633	0.062
Candy	0.014	0.004	2.180	0.540
Burger	-0.007	0.044	4.653	0.010
Cookie	0.004	-0.001	0.522	0.691
Chips	0.006	0.061	14.565	0.001