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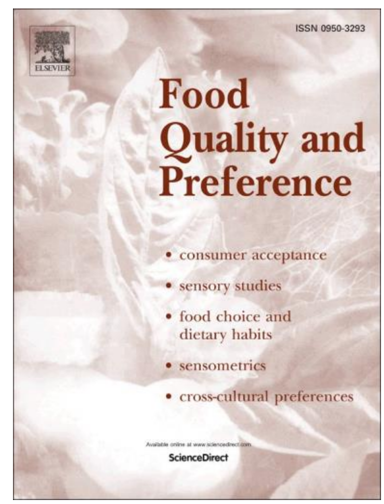

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Health body priming and food choice: an eye tracker study

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Abstract

The "gaze bias theory" suggests that people tend to look longer at items that are eventually chosen. This was not entirely confirmed for food choice, a complex phenomenon influenced by many factors. Although it has been shown that health-related primes affect both consumer attention and choice, the effect of unhealthy body shape primes on these outcomes is largely unknown. Therefore, we here investigated how body primes, namely normal weight (NW), severely overweight (OW) and severely underweight (UW) body shapes, influenced attention and choice for low-calorie food (LcFd) and high-calorie food (HcFd). We hypothesized that OW and UW primes would activate opposing health goals (weight-loss vs. weight-gain respectively). Fifty normal weight sated females completed a primed food choice task in which choices between a LcFd and HcFd, matched for subjective liking, were presented after control or human body shapes (NW, UW or OW). In each trial participants had to identify the shape (i.e., non-human, human male or human female) and then choose the food they wanted to eat at that moment. Gaze was recorded by an eye tracker. Results showed that, although primes did not influence the choice, the total dwell time on chosen HcFd was higher when preceded by an OW prime compared with chosen LcFd and chosen HcFd preceded by an UW prime. Also, both total dwell time and the number of fixations were higher for chosen food compared with non-chosen food as well as for HcFd compared with LcFd without a corresponding higher proportion of HcFd choice. Overall, these data shed light on the interactions between attention, health body priming and food choice.

Keywords: Health priming; Food Choice; Eye-Tracking; Attention; Gaze bias theory; Body shapes; Food preference

1. Introduction

Food choice is a complex phenomenon which is influenced by many physiological, psychological and social factors (Renner, Sproesser, Strohbach, & Schupp, 2012) determining which products are selected for consumption and which are rejected (Babicz-Zielińska, 2006). Several studies have suggested that people tend to look longer at items that were eventually chosen (e.g., Krajbich, Armel, & Rangel, 2010; Schotter, Berry, McKenzie, & Rayner, 2010; Van der Laan, Hooge, De Ridder, Viergever, & Smeets, 2015). Visual attention is influenced by bottom-up and top-down processes (Corbetta & Shulman, 2002). Bottom-up (stimulus-oriented) processes refer to visual characteristics (e.g., color, texture, size) or internal features of stimuli that automatically capture the attention of individuals (Lohse, 1997; Navalpakkam, Kumar, Li, & Sivakumar, 2012). For example, people look longer at food items compared with non-food items (Castellanos et al., 2009; Werthmann et al., 2013) due to the salience and rewarding nature of foods (LaBar et al., 2001; Foroni & Rumiati, 2017). Conversely, top-down (goal-oriented) processes refer to the voluntary allocation of attention on objects relevant for the currently pursued goal or task (Rayner, Miller, & Rotello, 2008). For example, consumers with specific health goals in mind, increase attention on products' nutrition labels and they make more healthy choices (van Herpen & van Trijp, 2011).

The study of how attention mechanisms influence food choices is crucial for both marketing purposes and cognitive research. According to the "gaze bias theory" (Schotter et al., 2010) people look longer at chosen items (i.e., gaze allocation accompanies preference/choice). Although Shimojo and coworkers (Shimojo, Simion, Shimojo, & Scheier, 2003) suggested that choice was causally influenced by attention, research on food choices did not unanimously support this hypothesis: Armel, Beaumel and Rangel (2008) showed that food choices were only marginally increased for longer-viewed items compared with shorter-viewed ones. More recently, Wang, Cakmak and Peng (2018) showed that total dwell time did not predict food choice in an *ad libitum* buffet setting. Although total fixation duration was correlated with liking for high-calorie foods, this measure was a weak predictor of food selection. Further, Werthmann and coworkers (2011) have found that in overweight individuals, who generally have a goal of losing weight, it is the direction of the first gaze towards high-fat food, rather than the total dwell time, which predicts consumption. Such approach-avoidance pattern of attention may occur in response to “forbidden” but desired products (Cartwright & Stritzke, 2008) and a longer dwell time on a product could reflect health-related worries about its consumption (Werthmann, Janse, & Roefs, 2015). Therefore, it is important to consider top-down goals (e.g., personal wills and task request) when investigating the gaze bias in food choice (van der Laan et al., 2015).

The goal to self-impose restriction of food intake and weight fluctuation (Herman & Mack, 1975) is one of the main top-down processes involved in feeding behavior. Particularly, the “goal conflict model of eating” (Stroebe, Mensink, Aarts, Schut, & Kruglanski, 2008; Stroebe, Van Koningsbruggen, Papies, & Aarts, 2013) posits that individuals can have conflicting goals regarding food, namely a short-term goal of pleasurable eating and a long-term goal of weight-control. While intake of high energy foods, which are generally regarded as highly tasteful (e.g., Drewnowski, 1997a, b), is in line with the short-term goal, the intake of low energy foods, generally perceived as healthier (e.g., Charbonnier, van Meer, van der Laan, Viergever, & Smeets 2016), is in line with the long-term goal. It has been shown that specific goal-related cues can activate, also without conscious awareness, health goals thereby facilitating healthier behavior (Papies, 2016). In this field, a lot of studies demonstrated that consumers decrease their unhealthy food consumption if a healthy cue (e.g., skinny sculptures, weight-scale) was placed in the meal environment (e.g., Brunner & Siegrist, 2012; Stöckli, Stämpfli, Messner, & Brunner, 2016). Van der Laan and coworkers (van der Laan, Papies, Hooge, & Smeets, 2017) showed that a diet banner in an online supermarket task increased the attention toward and the choice of low-calorie products.

Hollands and coworkers (Hollands, Prestwich, & Marteau et al., 2011; Hollands & Marteau, 2016) employed pictures of negative overeating consequences (i.e., pictures of obesity, arterial disease and heart surgery) to activate health goals and influence choice toward healthy food (e.g., fruit). Another study (Huneke, Shams, & Gustafsson, 2015) demonstrated that exposure to an overweight waitress did not stimulate greater attention to unhealthy meal alternatives (as shown by few previous studies), whereas exposure to an underweight/unhealthy appearing servant did. Actually, both underweight and overweight bodies arouse opposite unhealthy food-related lifestyles: several reports demonstrated that weight related stigma is widespread in our society and does not involve only overweight/obese individuals, but also underweight/anorexic ones (e.g., Crisp, 2005; Puhl & Suy, 2015). In summary, by providing health-related cues or primes, it is possible to influence food choices and attention. However, the effects of realistic severely underweight and overweight body shapes on food choice and related attentional processes, are less known. To our knowledge, no earlier studies used a classical priming paradigm in which the preliminary display of a stimulus (i.e., the prime) should evoke affective states/mental representation able to influence the judgment of the subsequent stimulus (e.g., Schwarz & Clore, 1983; Manippa, Padulo, & Brancucci, 2018).

Therefore, we investigated with a classical priming paradigm how body shape primes influence food choice and attention in a normal weight sated female sample. Particularly, we tested how unhealthy body shape primes (i.e., extremely underweight and overweight) can influence subsequent attention and/or food choice. Although low-calorie food (LcFd) is usually perceived as healthier compared with high energy foods (e.g., Charbonnier et al., 2016; Prada Rodrigues, Garrido, & Lopes, 2017), the exposure to underweight human body shapes may induce a more positive/healthier evaluation of high-calorie food (HcFd). Particularly, severely underweight shapes may trigger associations with starvation and anorexia nervosa and the related health risks which in turn may promote weight-gain goals. Thus, we expected that underweight primes would results in increased attention and choice for HcFd. On the contrary, severely overweight shapes could activate associations with calorie excess and obesity and their related health risks thereby increasing diet goals (lower HcFd attention/choice rate). Also, here we paired equally liked high-calorie and low-calorie foods (e.g., Charbonnier, van der Laan, Viergever, & Smeets 2015; Manippa, Padulo, van der Laan, Brancucci, 2017) to minimize the effects of pre-existing preferences on gaze and choice, in order to assess whether the total dwell time for a food is linked to its choice and/or to its calorie content. The findings regarding the relation between attentional processes, food calorie content (e.g., Doolan, Breslin, Hanna, Murphy, & Gallagher, 2014; Graham, Hoover, Ceballos, & Komogortsev, 2011; Hummel, Zerweck, Ehret, Winter, & Stroebele-Benschop, 2017) and choice, led us to hypothesize that high-calorie products would be longer viewed, regardless of the possible relationship with choice (Wang et al., 2018), because of the related health worries (Werthmann et al., 2015). In this way, we aimed to provide unbiased estimates of the relationship between health priming, visual attention and food choice.

2. Material and methods

2.1. Participants

We recruited 50 normal-weight females (BMI: *M*= 21.6 kg/m^2; *SD*= 2.5) with a *M* age of 24.1 years (± 4.3 *SD*). Four of them were left-handed. Vegetarians, individuals with food allergies, and individuals following a medically prescribed diet, were not included because they might show altered responses to some of the food stimuli. Participant selection was limited to women because they are generally more weight concerned and because of known gender differences in food preferences, dieting (Pingitore, Spring, & Garfield, 1997; Neumark-Sztainer, Sherwood, French, & Jeffery, 1999; Manippa et al., 2017) and food-related attentional processing (Hummel et al., 2017). Participants were recruited with posters, flyers, research websites and social media and we asked them to eat a complete meal within 60 minutes before the experiment in order to control their physiological state (sated). They received 5 Euro coupons for participation.

2.2. Stimulus materials and experimental task

2.2.1 Body shape primes

We used a set of 8 shapes as primes (see figure 1). Two non-human symmetric black shapes (with white background), a butterfly and a 5-points star, were used as control (CO) stimuli: these figures have been chosen because they are unrelated to human weight but, similar to human shapes, they are symmetric. We created the human shapes using MakeHuman software. We used the default setting for all the features manipulating only the muscles and the weight: 50% of muscles and 100% of weight for the normal weight shape (NW, used as human control shape), 0% of muscles and 50% of weight for the severely underweight shape (UW) and 0% of muscles and 150% of weight for the severely overweight shape (OW). For each model we created a male and a female version. From these models we obtained the 2-D frontal side of the shapes colored in black against a white background.

2.2.2 Food Stimuli

We used 160 colored food pictures (Figure 1) from the Full4Health Image Collection (University Medical Center Utrecht; http://nutritionalneuroscience.eu; Charbonnier et al., 2016). These food pictures (544 x 364 pixels) were divided in two categories: 80 high-calorie (HcFd, *M* = 452.7 Kcal/100g; *SD*= 88) and 80 low-calorie foods (LcFd, *M*= 76.6 Kcal/100g; *SD*= 52.5). Both food categories had the same number of sweet (46) and savory (34) items. We assessed the pictures' visual complexity by means of the same script used by Blechert and coworkers' (Blechert et al., 2014). There was no significant difference, but a trend (p= .05) for LcFd pictures (*M*= 0.169, *SD*= 0.028) to be more complex than HcFd pictures (*M*= 0.157, *SD*= 0.041). Each product was presented on a filled plate and with a standardized background (544x364 pixel).

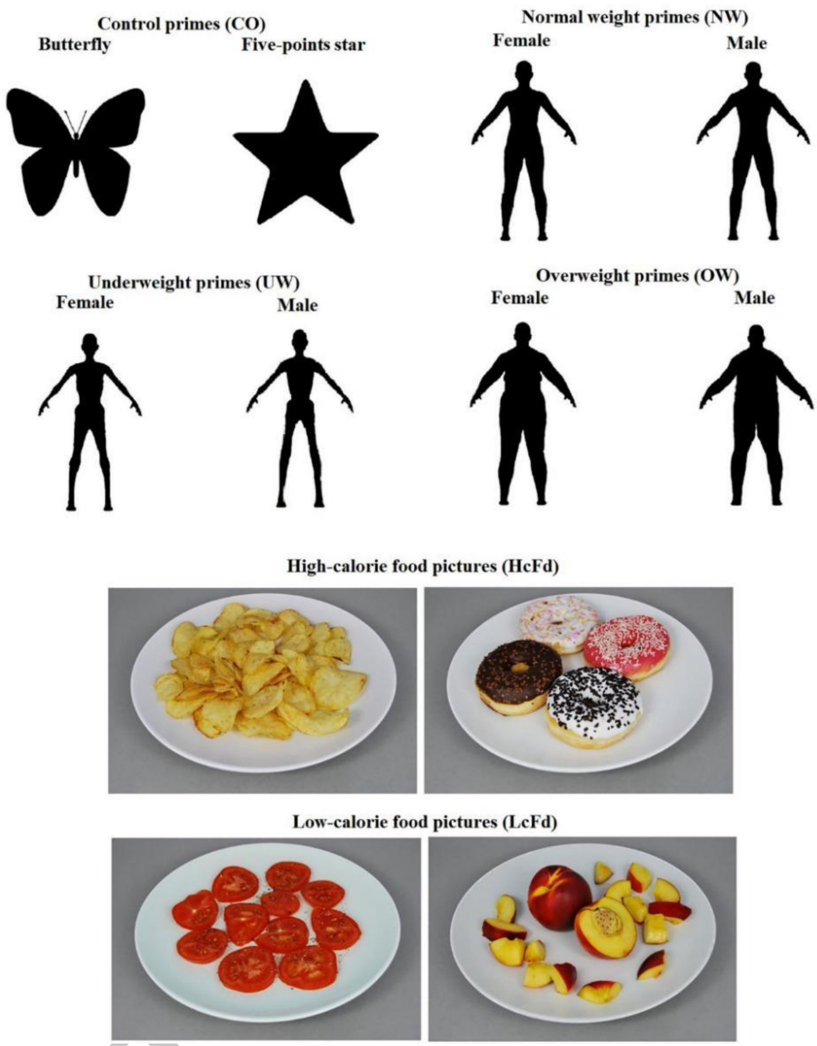

Figure 1. Stimuli used in the experiment. Above: the shapes used as primes; below: examples of high-calorie and low-calorie foods.

2.2.3 Procedure

All the procedures have been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. The experiment was implemented using Open Sesame v.3.1 (Mathot et al., 2012) on a 20-inch monitor with screen resolution 1400x1050 pixel. Participants seated at about 58 cm from the screen and a chin rest was used. The monitor and the tracker, as well as the mouse and the keyboard, were placed within a cubicle. Participants gave written consent and were tested individually. Firstly, they reported personal information about weight, height, education level, age and physiological state. This latter was assessed using two 10-point Likert scale questions (i.e., How hungry are you at this moment? 1=Not at all; 10=Very hungry; How much would you like to eat at this moment? 1=Not at all; 10=Very much). All participants resulted sated (scores < 5) since we asked to eat a complete meal not more than 60 minutes before the experiment. Then the rating task started.

The rating task was based on the Leeds Food Preference Questionnaire (LFPQ; Finlayson et al., 2007). During this task participants rated liking, perceived healthiness and calorie content of the 160 food stimuli on a 9-point Likert scale. They received the following instructions: “You will see 160 product pictures. For each product you will respond to three questions about the liking, the healthiness and the calorie of the products. There are no correct or incorrect answers, it's about your opinion. Don't think too long about the answer, the first that occurs to you is usually the best one”. Then they were left alone in the experimental room. Each trial was composed of a food picture shown for 3 seconds. After each picture, the following questions were asked: “How much do you like the taste of the product?” (1 not at all—9 very much), “How healthy do you think this product is?” (1 not healthy at all—9 very healthy) and “How many calories do you think this product contains?” (1 very few calories—9 many calories). Each question was shown until participants responded by keypress (numbers from 1 to 9). After each trial, a fixation cross of 1.5 s was showed. This session lasted about 30 min. The order of presentation of food pictures was randomized for each participant.

Subsequently, after a break of 10 minutes, they engaged in the primed choice task (described below). At the end of the experiment, participants completed the following questionnaires: the Body Uneasiness Test part A (Cuzzolaro et al., 2006), the Dutch Eating Behavioral Questionnaire (van Strien et al., 1986), Perception of Teasing Scale (scale 1: weight teasing), both overweight

(Thompson et al., 1995) and underweight version (Lundgren et al., 2004). This was done to control for participants' eating patterns and body-weight issues and exclude individuals with outlier scores (+ 2 *SD* over the normative mean) of each questionnaire/subscale.

2.2.4 Primed food choice task

Based on the rating, 80 food pairs were created for each subject: each pair was made-up by a HcFd and a LcFd matched on liking (i.e., equal liking evaluation ± 1 on a 9-points scale) in order to minimize the effect of pre-existing preferences. Several studies (e.g., Foroni, Pergola, Argiris, & Rumiati, 2013; Prada et al., 2017) showed that people are able to recognize if a food is low or high in calories, and studies showed that the perceived amount of calories is negatively related to the perceived healthiness of the food (e.g., Charbonnier et al., 2016; Manippa et al., 2017). As expected, this negative relation was also found in our food stimuli (HcFd vs. LcFd; see Table 1). Regarding the taste (sweet-savory) foods were randomly paired and there was no significant difference (X^2_1= 9.504, p= .002) between the number of trials (2098) of taste-matched pairs (i.e., sweet vs. sweet or savory vs. savory) and the number of trials (1903) of no taste-matched pairs (i.e., sweet vs. savory). In the primed food choice task participants had to subsequently perform two tasks during each trial (see Fig. 2). After the eye tracker calibration, the experimenter gave the following instruction: "In this session you have to perform 2 different tasks. In each trial, two screens will be shown sequentially. The first screen will show a shape. You have to indicate (by a left-hand key press) if it is a human male shape (pressing "Z" key), a non-human shape (pressing "X" key) or a human female shape (pressing "C" key). After that, a food pair will be presented on the screen. You have to choose which of the two products you most want to eat at this moment (by a right-hand key press): for left food press left arrow, for right food press right arrow. You have 3 s to evaluate the shape as well as to choose a food after which the next trial will start". Then they were left alone in the experimental room. We asked participants to judge a non-weight related feature of the primes to make it covert that we were interested in the effects of underweight and overweight body shapes. Thus, individuals had a 3 s maximum from the onset of the prime to indicate the kind of shape, and then they had a 3 s maximum from the onset of the food pair to choose which food they wanted to eat. As soon as a key was pressed, the next screen appeared. If they did not answer within 3 s the trial was considered as missed and the next screen appeared. Such fixed decision times (van der Laan, de Ridder, Charbonnier, Viergever, Smeets, 2014; Charbonnier et al., 2015; Manippa et al., 2017) are routinely used in eye-tracking studies involving forced food choices (e.g., Hare, Camerer, & Ranger, 2010; van Meer, van der Laan, Viergever, Adan, & Smeets, 2017). Particularly we used a 3 s time limit to make choice more impulsive and in order to maximize the influence of the primes (e.g., Hermans, De Houwer & Eelen, 2001). Also, as shown by van der Laan and coworkers' study (2015) in which participants had no limit on their reaction time, on average binary food choices were made in 2.6 sec which suggests that a 3 s choice period is naturalistic. In each prime condition (CO, NW, UW, OW) 20 food pairs were presented. The order of presentation of the shapes was randomized as (right-left) of the high- and low-calorie foods. Each pair was unique although each food could be combined with several other foods. This session lasted about 15 min. At the end of experiment, through a brief interview, we ensured that participants did not understand the real aim of the task.

	High-calorie foods		Low-calorie foods	
	Mean	*SD*	*Mean*	*SD*
Liking	6.07	2.18	6.22	2.11
Perceived calories*	7.06	1.62	4.02	1.91
Perceived healthiness*	2.97	1.75	6.92	2.02

Table 1. **Liking, Perceived Calories and Healthiness of study stimuli, distinguished by food type.** Mean and Standard Deviation *(SD)* for the variable scores of high- and low-calorie choice options. All the variables ranged from 1 to 9 on a Likert scale. *= p < .05 (High-calorie foods vs. Low-calorie foods)

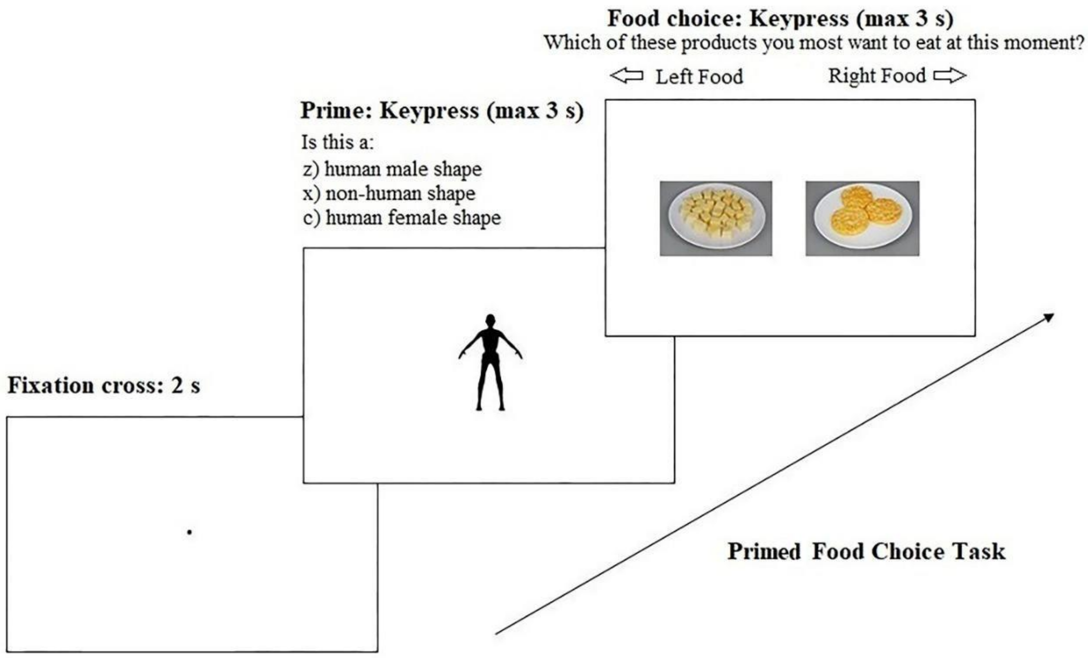

Figure 2. Primed food choice task. An example of primed food choice task trial.

2.2.5 Eye tracker recording

Eye movements during forced choice task, were recorded at 60 Hz with an Eye Tribe tracker (Copenhagen, Denmark; TheEyeTribe, 2015). A 9-point calibration and validation was completed prior to the task. Eye-tracking data from the food choice screen presentations were used to assess the effects of the primes on attention. Rectangular regions of interest were drawn around the two areas of interest (AOI), namely the left and the right product. For each trial the total dwell time, the number of fixation and the fixation duration time was calculated for both AOIs. For calculating these measures, we used the definitions as described by Holmvqist and coworkers (2011). Total dwell time was the sum of all dwell times in one and the same AOI over a trial. The number of fixations was calculated by summing up the number of fixations in one and the same AOI over a trial. Last, the mean fixation duration was calculated by dividing the total dwell time by the number of fixations on an AOI in a trial. At the end of the experiment, a 9-point calibration screen was presented to check for possible drifts in calibration over the time of the task due to head movements (Orquin & Holmqvist, 2017). Four participants were excluded because of technical problems with the eye-tracker calibration. Further, 105 trials in which the total dwell time was 0 for both AOIs were excluded from the analysis.

2.3. Data analyses

Statistica software (Statsoft, version 8.0) was used to conduct data analysis. For each participant we assessed 7 different dependent variables. The behavioral outcome was the % of HcFd chosen for each participant. This was calculated by dividing the number of HcFd chosen by the total amount of choice trials. Regarding the eye tracker we assessed for each participant the averages of the total dwell time, the number of fixations and the fixation duration for chosen, non-chosen, HcFd, LcFd, chosen HcFd and chosen LcFd. Four participants have been excluded as showing outlier values (± 3 *SD*). The normal distribution of our data was tested and confirmed by Kolmogorov-Smirnov test. For all the analyses, the significant p-value criterion was set at 0.05.

Food choices

We implemented a one-sample t-test to compare the % of HcFd chosen with the chance probability of 50% representing the same % of LcFd and HcFd choice. A repeated measures ANOVA was conducted to assess whether prime type (CO, NW, UW, OW) influenced the % of HcFd choice.

Eye tracker data

In order to test the gaze bias for chosen foods, we implemented 3 (total dwell time, the number of fixations and the fixation duration) one-sample t-test to compare the for chosen and non-chosen foods.

Also, we implemented 3 (total dwell time, the number of fixations and the fixation duration) 4 x 2 repeated measures ANOVAs with prime type (CO, NW, UW, OW) and food type (HcFd, LcFd) as within factors to assess the influence of primes on total dwell time, number of fixation and fixation duration for HcFd and LcFd.

Finally, 3 (total dwell time, the number of fixation and the fixation duration) 4 x 2 repeated measures ANOVAs with prime type (CO, NW, UW, OW) and chosen food type (HcFd, LcFd) as within factors was implemented to test the effect of the primes on total dwell time, number of fixation and fixation duration for chosen HcFd and LcFd.

3. Results

Food choices

The mean % of HcFd choice (50.28 %) was not significantly different from the 50 % chance probability. The repeated measures ANOVA aimed to test the effect of the primes on the % of HcFd choice showed no significant effects (data are reported in Table 2).

	% of HcFd chosen	
Primes	*Mean*	*SEM*
Control	50.90	1.25
Normal weight	52.02	0.98
Underweight	48.61	1.19
Overweight	49.59	1.34

Table 2. Prime effects on the % of HcFd chosen. Mean and Standard error of the mean *(SEM)* for the % of high-calorie food (HcFd) chosen after the display of the primes.

Eye tracker data

As shown in Figure 3a, the one-sample t-test showed that total dwell time on chosen foods (*M*= 370.20, *SEM*= 18.08) was higher compared with non-chosen foods (*M*= 329.52, *SEM*= 14.09; p< .001). The other one-sample t-test carried-out on the number of fixations showed the same pattern (p< .001; Figure 3b), with more fixations for chosen food (*M*= 1.63, *SEM*= 0,06) compared with non-chosen foods (*M*= 1.49, *SEM*= 0.05). No difference was found between the fixation duration on chosen and non-chosen foods (descriptive data are reported in Table 3).

	Total Dwell Time (ms)		Number of Fixations		Fixation Duration (ms)	
Foods	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*
Chosen	370.20*	18.08	1.63*	0.06	204.24	7.55
Non-Chosen	329.52*	14.09	1.49*	0.05	211.88	8.44

Table 3. Dependent variables for chosen and non-chosen foods. Mean (*M*) and standard error of the mean *(SEM)* for the total dwell time (ms), number of fixation and fixation duration (ms) for chosen and non-chosen foods. * = p< .001 (chosen food vs. non-chosen food).

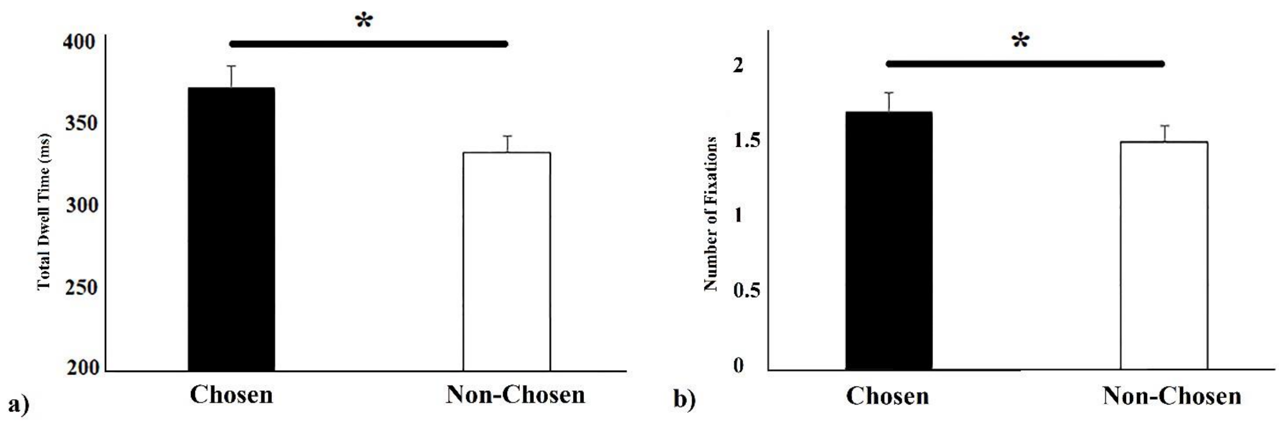

Figure 3. Attention outcomes on Chosen and Non-Chosen food. a) Total dwell time and **b)** Number of fixations for chosen vs. non-chosen foods. Data are reported as Mean values and Standard error of mean. *= p< .05

The 4 x 2 repeated measures ANOVA carried out to test the effect of the primes (CO, NW, UW, OW) on HcFd and LcFd total dwell time, showed a main effect of food type ($F_{1, 41}$= 7.702, p= .008, η_p^2= 0.158; Fig. 4a) and no other significant results. Particularly, the total dwell time was higher for HcFd (*M*= 356.11, *SEM*= 15.29) than for LcFd (*M* = 343.61, *SEM* = 13.94). The same ANOVA carried out on the number of fixations, showed the same main effect of food type ($F_{1, 41}$= 9.724, p= .003, η_p^2= 0.192; Fig. 4b) and no other significant results. Particularly, the number of fixation was higher for HcFd (*M*= 1.59, *SEM*= 0.12) than for LcFd (*M* = 1.53, *SEM* = 0.11). The last 4 x 2 repeated measures ANOVA carried out to test the effect of the primes (CO, NW, UW, OW) on HcFd and LcFd fixation duration showed a main effect of the primes ($F_{3, 123}$= 3.006, p= .033, η_p^2= 0.068; Fig. 4c) and a main effect of food type ($F_{1, 41}$= 126.15, p< .001, η_p^2= 0.754; Fig. 4d). Particularly, regarding the primes longer fixation duration on food items was caused by OW prime (*M*= 290.01, *SEM*= 18.47) compared with NW (*M*= 268.00, *SEM*= 13.65; p= .007) and CO (*M*= 272.58, *SEM*= 13.92; p= .032) primes. Regarding the food type, fixation duration was longer for LcFd (*M*= 339.61, *SEM*= 30.14) compared with HcFd (*M*= 214.39, *SEM*= 12.64; p< .001).

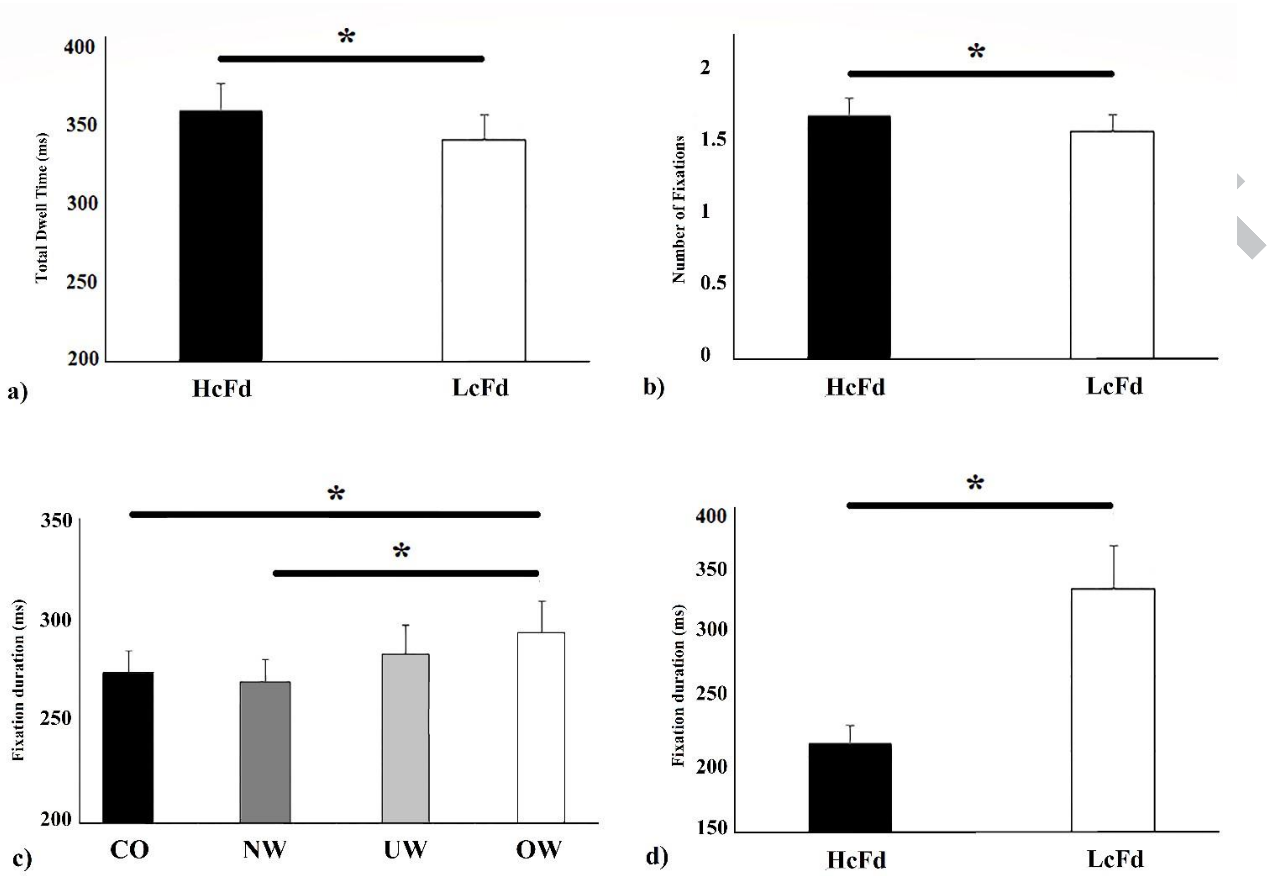

Figure 4. Interactions between primes and food type. a) Total dwell time (ms) on high-calorie and low-calorie food; b) Number of fixations on high-calorie and low-calorie food; c) Fixation duration (ms) after control, normal weight, underweight and overweight primes; d) Fixation duration (ms) on high-calorie and low-calorie food. *= p< .05

Finally, regarding the effect of the primes on the total dwell time of chosen food type (HcFd, LcFd), the 4 x 2 ANOVA showed a significant interaction between prime and type of chosen food total dwell time ($F_{3,\ 123}$= 2.703, p= .048, η_p^2= 0.061; Fig. 5a). Duncan post-hoc analysis showed a significant difference between the total dwell time on chosen HcFd when preceded by the OW prime compared with the UW prime (p= .040). Also, there is a marginally significant difference between the total dwell time on chosen HcFd when preceded by the OW prime compared with the NW prime (p= .050). Further, the OW prime caused a prolonged gaze on HcFd compared with chosen LcFd (p= .039). The same ANOVA carried out on the number of fixations, showed a main effect of chosen food type ($F_{1, 41}$= 4.194, p= .047, η_p^2= 0.093; Fig. 5b) and no other significant results. Particularly, the number of fixations was higher for chosen HcFd (*M*= 1.67, *SEM*= 0.14) than for chosen LcFd (*M* = 1.59, *SEM* = 0.12). The last 4 x 2 repeated measures ANOVA carried out to test the effect of the primes (CO, NW, UW, OW) on chosen food type fixation duration showed no significant results.

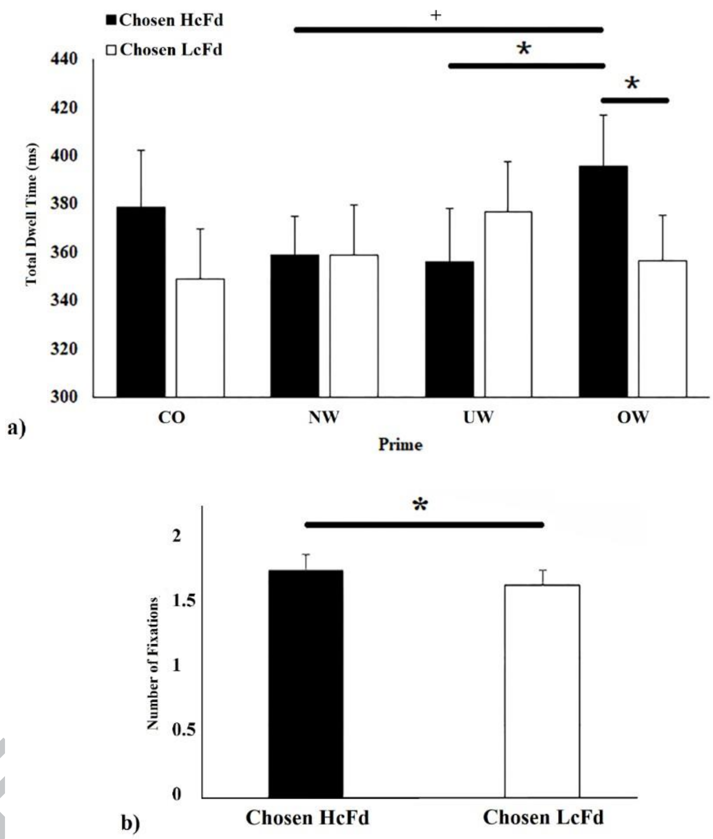

Figure 5. Interaction between prime and chosen food type. a) Total dwell time interaction effects and; b) Number of Fixations for Chosen HcFd and Chosen LcFd. Data are reported as Mean values and Standard error of mean. + = p= .05; * = p< .05

4. Discussion

Our aim was to study whether top-down processes influenced attention and food choice. We were mainly interested in understanding which processes are responsible for the gaze bias in food choice and what could be the effect of different health goals (Papies, 2016), primed by using body shapes, on food choice and attention. Although body primes did not affect food choices, some effects have been observed on attentional processes. After exposure to OW body primes, there was a longer total dwell time on chosen HcFd than chosen LcFd and compared with chosen HcFd after the UW prime presentation. Also, after the OW shape, the fixation duration on food pairs increased compared with CO and NW primes. Also, the number of fixations were higher for chosen HcFd compared with chosen LcFd. Last, the total dwell time and the number of fixations were higher for chosen food compared with non-chosen food and the same was for HcFd compared with LcFd. Despite that, high-calorie products were not chosen more often than low-calorie ones.

Body shapes did not influence food choice in this study. Earlier studies (Stöckli et al., 2016, Brunner & Siegrist, 2012) demonstrated that consumers bought more healthy snacks if skinny Giacometti's sculpture posters were used as cue and consumed less chocolate when they were exposed to a PC screensaver showing the same sculptures. Similarly, van Ooijen and coworkers (van Ooijen, Fransen, Verlegh, & Smit 2017) have shown that a package simulating a slim body shape acts as a symbolic cue for product healthiness (e.g., low in calories) and increases choice and product attitude, as opposed to a package that simulates a wide body shape. Further, Hollands & Marteau (2016) found in an evaluative conditioning paradigm that presenting people with stimuli on the potentially negative outcomes of overeating (i.e., images of obesity, arterial disease and heart surgery) activated the mental representations of healthy products and resulted in a preference for low-calorie food. We used a classic priming paradigm (e.g., Klauer & Musch, 2003; Manippa et al., 2018) differently from the aforementioned studies, and we instructed participants to pay attention to a feature irrelevant to weight, i.e., they were instructed to classify the shapes into different types (i.e., non-human, human female or human male shape). In our study, this kind of priming does not appear to influence choice toward HcFd and LcFd as studies in which attention was not distracted from the weight-related aspects. Similarly, Aguado and coworkers (Aguado, Garcia-Gutierrez, Castañeda, E., & Saugar, 2007) showed that orienting the observers' attention to a property irrelevant to affect (i.e., the gender of a face instead of the emotion), strongly attenuated the affective priming effects. Despite that, some interesting insights are provided by eye tracking data. First, when primed by OW shapes, participants increased the mean fixation duration on food pairs compared with CO and NW primes. The presentation of OW shapes caused a longer processing of subsequent food pairs probably due to the increasing relevance of food items and their choice (Orquin & Mueller Loose, 2013) compared with when the same foods were preceded by CO and NW primes. Second, chosen HcFd received more fixations than chosen LcFd and, particularly, after the OW shape, compared with UW shape, participants looked at HcFd longer before choosing it. Also, following the presentation of OW, the total dwell time on chosen HcFd was higher compared with chosen LcFd. Thus, although there was no main effect of the primes on choice, following OW shapes, the subsequent HcFd choice was performed after a prolonged gaze. According to a cognitive-behavioral account of eating disorders (e.g., Fairburn & Harrison, 2003; Lee & Shafran, 2004) looking longer to a food could reflect worry, in terms of health, about consuming the food (Werthmann et al., 2015). Therefore, our data may reveal that a weight-related conflict has been activated by the OW prime: the viewing of OW shape may have reminded the participants of her weight considerations, and thereby increased the level of conflict in the choice between the HcFd and LcFd, prolonging their fixation duration. Choosing the HcFd is not in line with weight-considerations and therefore more difficult to choose (i.e., longer total dwell time due to worries increase) while choosing the LcFd choice was in line with weight-considerations and therefore easier. On the contrary, the UW prime, compared with OW prime, makes the choice of HcFd less conflictual (i.e., lower total dwell time due to a decrease in worries). Thus, we hypothesize that OW shapes may increase the perception of HcFd being a threat to weight-related long-term goals, while the opposite may be true for UW shapes. From a weight-balance point of view, a HcFd is an appropriate food to eat in a UW context (weight-gain goal activation), whereas HcFd is generally perceived as less healthy compared with LcFd (e.g., Charbonnier et al., 2016; Prada et al., 2017), would be perceived as even more unhealthy in a OW context (weight-loss goal activation) as occurred in the studies of Hollands (Hollands et al., 2011; Hollands & Marteau, 2016). From this perspective, we can speculate that extremely UW and OW body shape primes may have activated, at least partially, specific health goals/worries.

Another interesting result of our study regards the gaze bias theory (Schotter et al., 2010): although chosen foods were longer viewed and received more fixations than non-chosen foods, the same attentional patterns occurred for HcFd compared with LcFd, but this did not influence the product choice. Refixations are probably due to top-down control (Orquin & Mueller Loose, 2013): for example, the task request (i.e., to choose which of the two products you most want to eat at this moment) would explain the higher number of fixations and the consequent higher total dwell time toward chosen food. The same data involving high- and low-calorie foods, are not explained by the task request, as high-calorie products received more fixations and were looked at longer without an increasing of their choice. A similar discrepancy between the (longer) total dwell time on high-calorie products and their (missed) selection was observed in a research of Werthmann and coworkers (2011) and in a recent real-life study (*ad libitum* buffet setting) of Wang and coworkers (2018). These data suggest that the gaze bias theory, i.e., the direct relation between total dwell time and choice, would be difficult to generalize also to food choice. Indeed, regarding the prolonged total dwell on HcFd compared with LcFd, one study did not find this bias (Graham et al., 2011) and another one even found the opposite, namely that women paid more attention to low-calorie food (Hummel et al., 2017). These results could depend on the different paradigm used to show the items and the potential effect of pre-existent preferences/subjective liking. It is acknowledged that foods are relevant stimuli able to activate brain reward circuits (e.g., Beaver et al., 2006; Passamonti et al., 2009) whose links with the attentional system are well established (Vuilleumier, 2005): high-calorie products may trigger stronger levels of arousal, due to post-ingestive consequence, than low-calorie products (e.g., Piech, Pastorino, & Zald, 2010) and this would cause prolonged gazing (e.g., Doolan at al., 2014; Cunningham & Egeth, 2017). Other authors hypothesized that the health worries associated with HcFd consumption (e.g., Prada et al., 2017; Charbonnier et al., 2016) could be responsible for this attentional bias. For example, Werthmann and coworkers (2011) showed that the intake of HcFd was associated to an approach-avoidance pattern of attention. Therefore, the direction of the first gaze on HcFd would represent the automatic (bottom-up) attraction of this products due to their arousing/desiring features. On the other hand, the prolonged total dwell time (and in our study also the higher number of fixations) on high-calorie products, would be linked to the related top-down health worries (Werthmann et al., 2015; Rayner, 2009). For these reasons, the prolonged viewing of a food would not be necessarily translated into choice, refuting the idea that the longer total dwell time on a product causes its choice and is linked to its preference (Shimojo et al., 2003; van der Laan et al., 2015; Wang et al., 2018).

We have to point out that the difference between the total dwell time on HcFd and LcFd, although significant, was small and this could also be an explanation for the lack of significant effects on choice. Also, since we did not assess pictures complexity *a priori*, we found a trend for LcFd pictures to be more complex than HcFd pictures. Due to the more complex stimuli requiring longer processing time, this trend could be responsible for the longer mean fixation duration to LcFd compared with HcFd (Just & Carpenter, 1976).

Overall, it is unclear if a gaze bias for food choice exists (e.g., Armel et al.,2008; Werthmann et al., 2015; Wang et al., 2018). Particularly, although chosen foods received more fixations and were looked at longer than non-chosen foods, the prolonged gaze and the higher number of fixations for HcFd compared with LcFd (probably caused by the worries about weight) did not affect the choice. These results suggest that different cognitive mechanisms can lead to similar attentional processes causing different behavioral responses. In contrast, OW prime increased the fixation duration of food pairs and chosen HcFd was looked at longer than chosen LcFd when preceded by an OW prime and chosen HcFd preceded by UW prime. These effects may indicate a health goal activation leading to a more indulgent analysis of chosen HcFd in an UW context and a more careful analysis after being presented with the OW prime. These findings, taken together, cast doubt on the gaze bias theory in food choice: attention supports choice but it may not be the cause itself due to the complex interaction between top-down and bottom-up processes involved in food choice. Despite we are not able to infer certainty about the top-down components involved in our task, our results suggest the importance to interpret the total dwell time considering other attentional measures e.g. the number of fixations and the mean fixation duration (Orquin & Holmqvist, 2017). Also, although several observations (e.g., Krajbich et al., 2010; Schotter et al., 2010) suggest that attention plays an active role in constructing decisions, decision theories have ignored the constructive role of attention by assuming that it is entirely determined by heuristics, or that it consists of stochastic information sampling. These expectations are implausible (Orquin & Mueller Loose, 2013), and more accurate assumptions should be made based on prior attention and eye movement research.

The reason we only included young females and asked them to eat a meal one hour prior to the study was to minimize the influence of age, sex and physiological state, which are factors that play an important role in feeding behavior (e.g., Padulo et al., 2017; Finlayson et al., 2008; Hummel et al., 2017). We suggest to investigate the effects in different samples (i.e., males, different age groups, weight status or physiological states) and clinical populations (i.e., anorectic and obese individuals) because our population consisted of only normal weight young females and it is important to know if the effects extrapolate to other populations. Finally, this data should be improved considering inter-individual factors such as eating patterns or weight/body concern, and other food features such as taste, level of transformation and the complexity of food items (e.g., Graham et al., 2011; Padulo et al., 2017; Padulo et al., 2018). Furthermore, potential social desirability effects should be taken into account.

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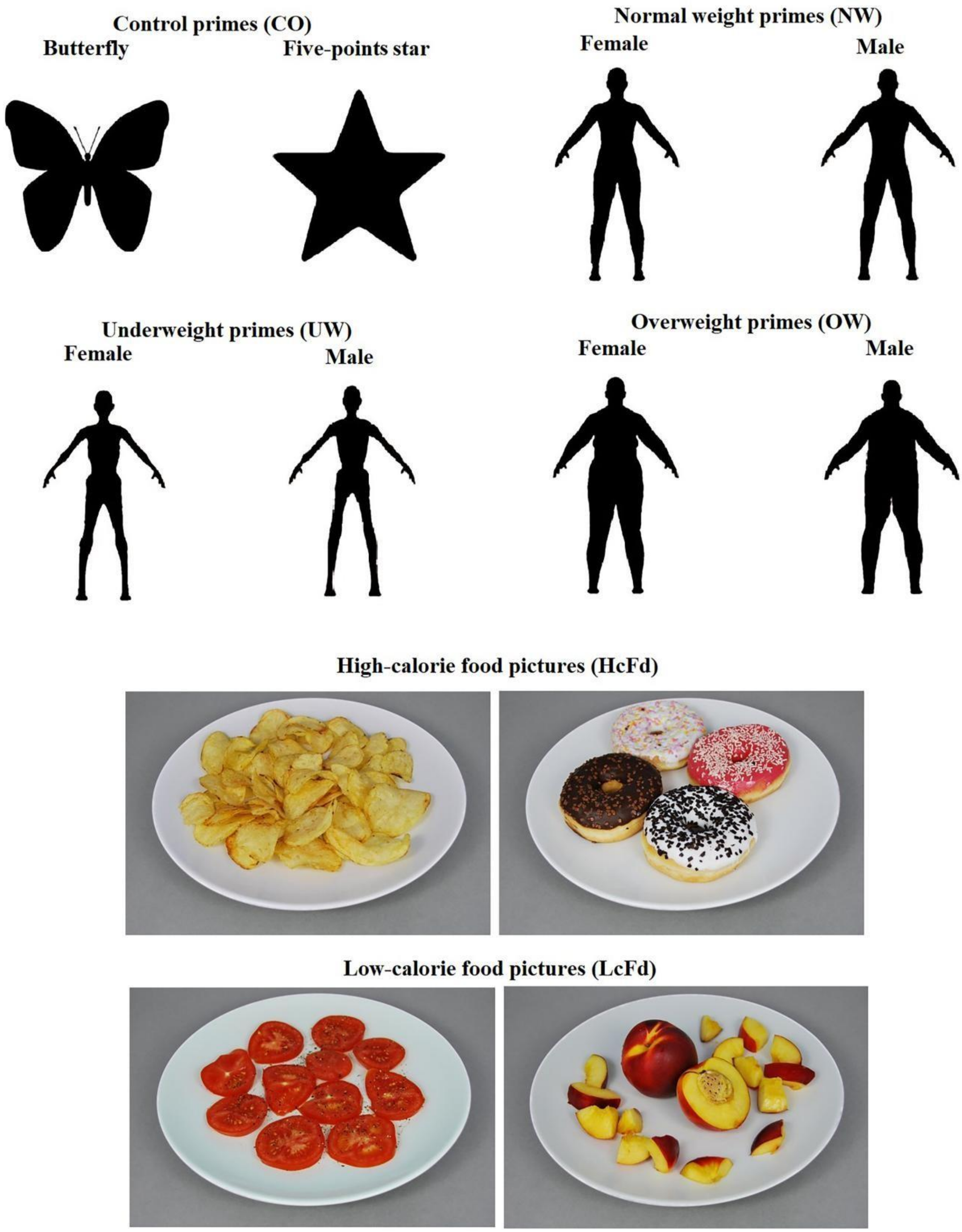
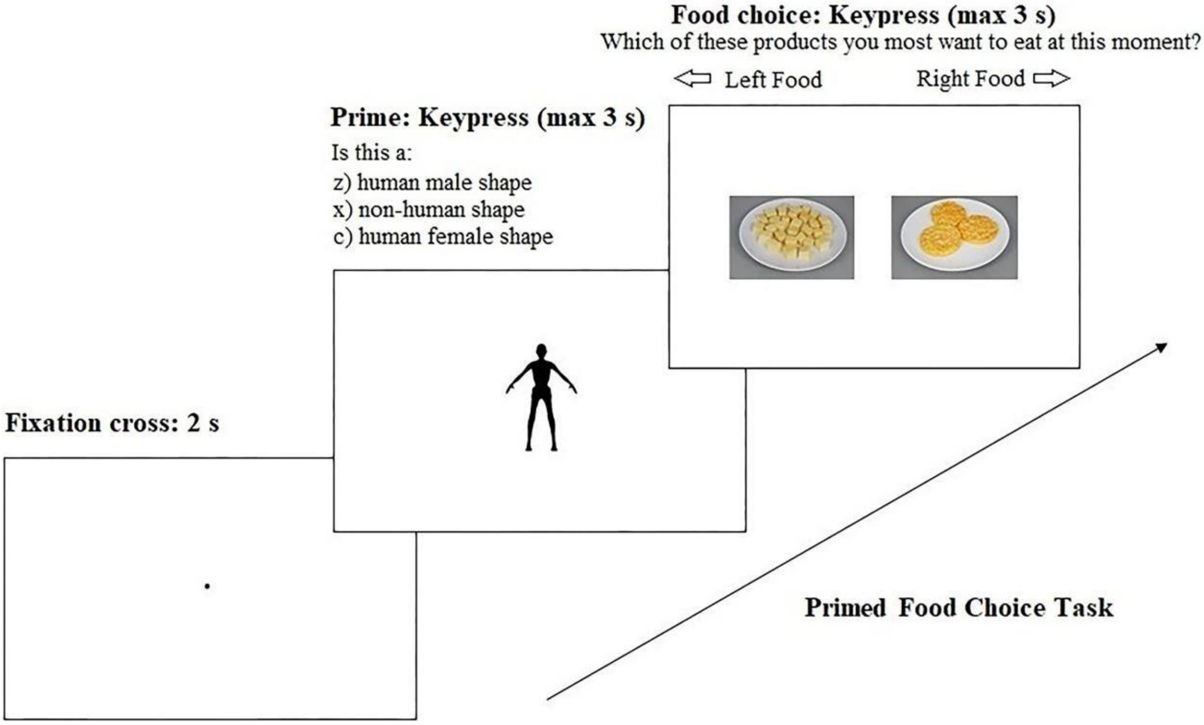
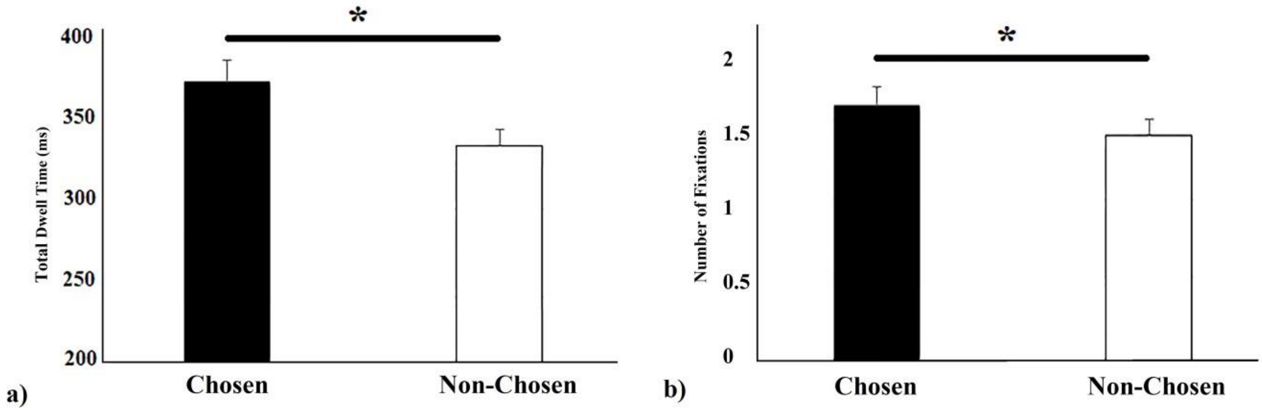
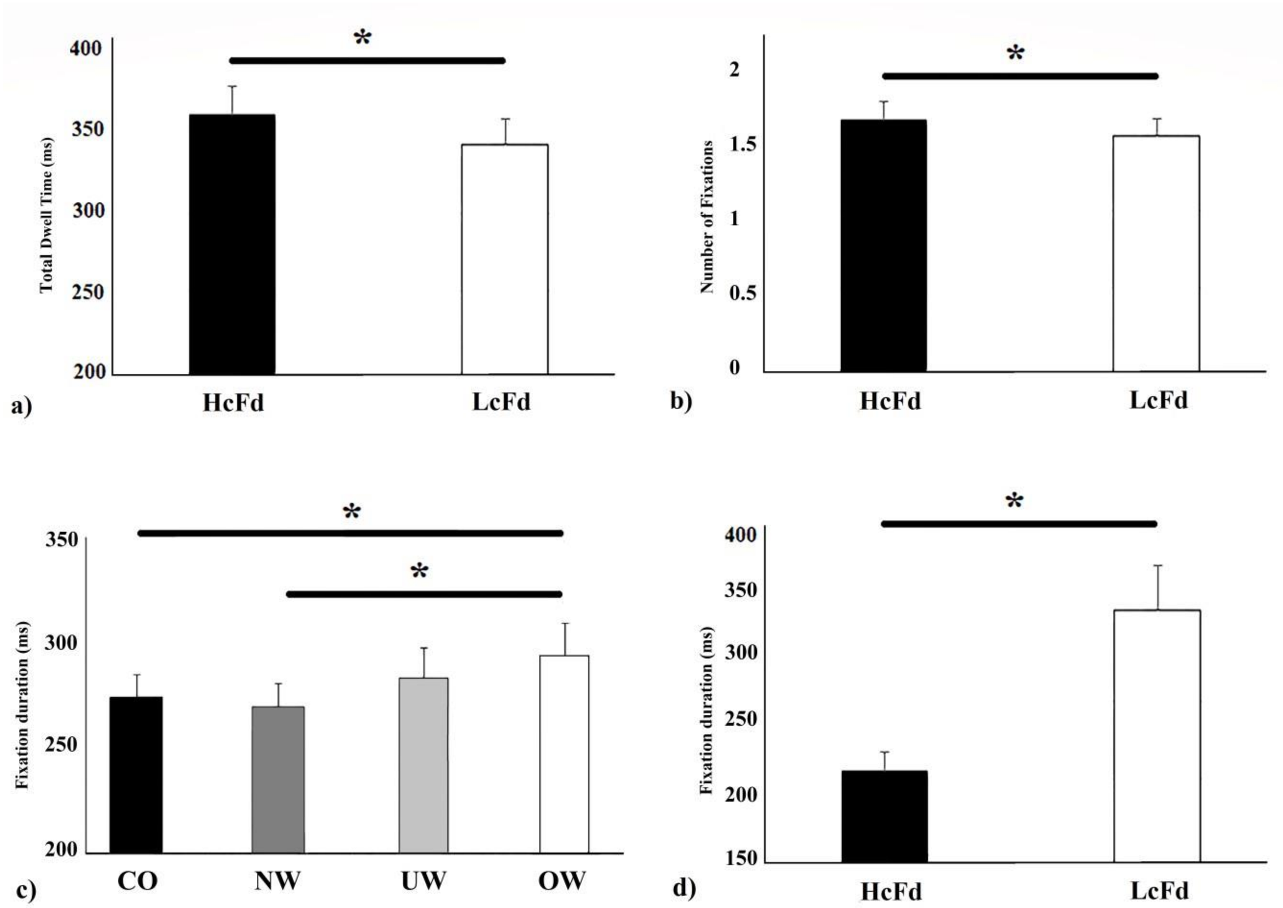
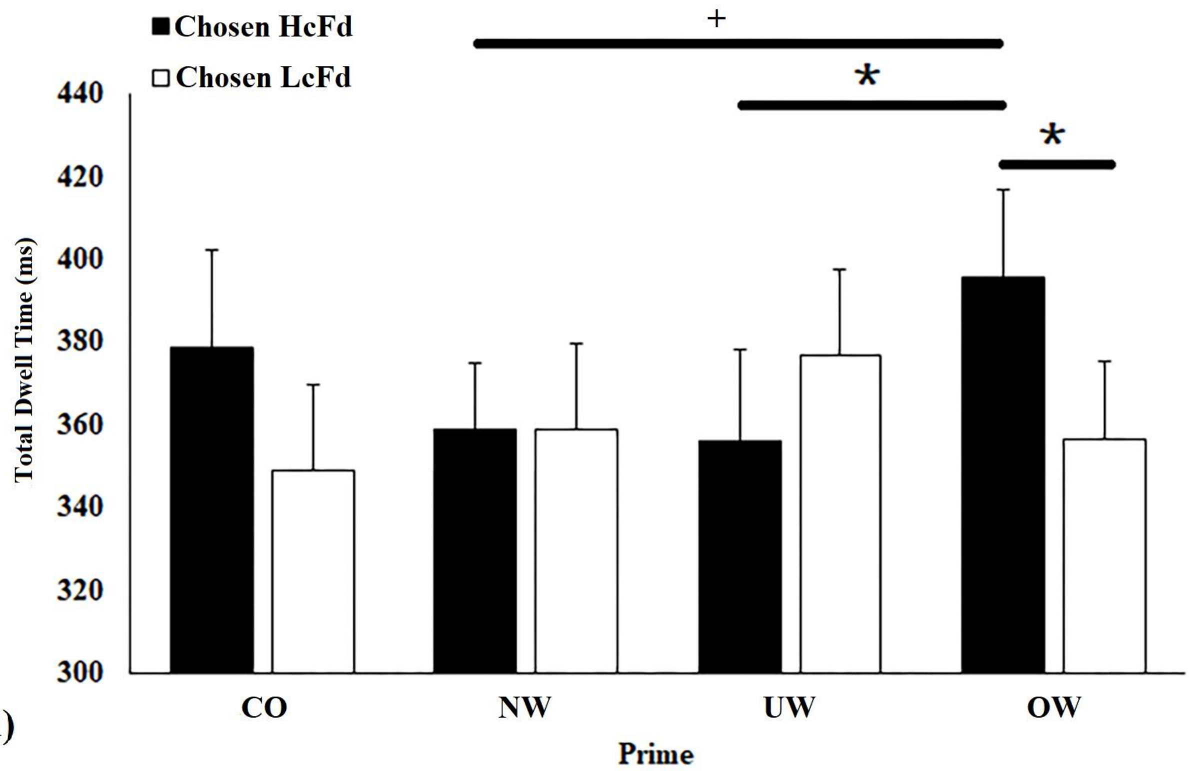

Control primes (CO)
Butterfly
Five-points star
Normal weight primes (NW)
Female
Male
Underweight primes (UW)
Female
Male
Overweight primes (OW)
Female
Male
High-calorie food pictures (HcFd)
Low-calorie food pictures (LcFd)

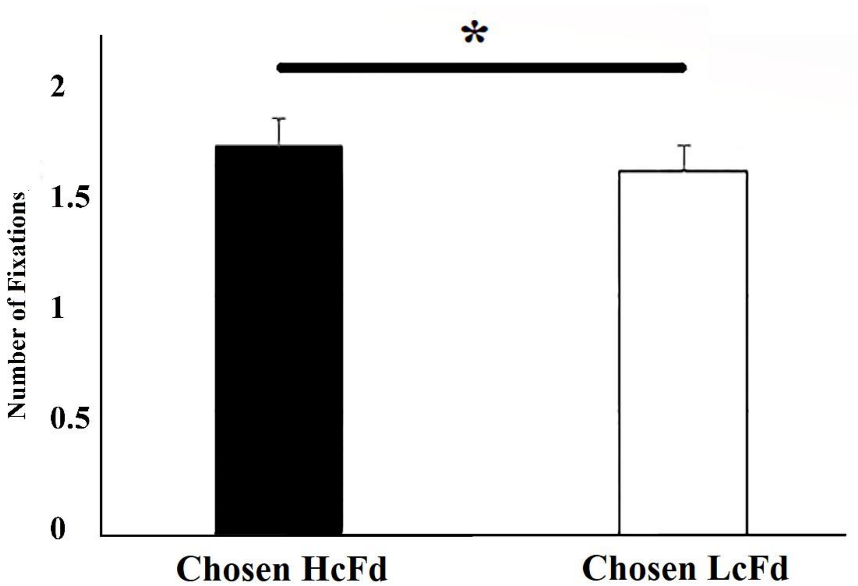

Food choice: Keypress (max 3 s)
Which of these products you most want to eat at this moment?
Left Food
Right Food
Prime: Keypress (max 3 s)
Is this a:
z) human male shape
x) non-human shape
c) human female shape
Fixation cross: 2 s
Primed Food Choice Task


*
400
350
300
250
200
Total Dwell Time (ms)
Chosen
Non-Chosen
a)
*
2
1.5
1
0.5
0
Number of Fixations
Chosen
Non-Chosen
b)


a)
Total Dwell Time (ms)
400
350
300
250
200
*
HcFd
LcFd
b)
Number of Fixations
2
1.5
1
0.5
0
*
HcFd
LcFd
c)
Fixation duration (ms)
350
300
250
200
*
*
CO
NW
UW
OW
d)
Fixation duration (ms)
400
350
300
250
200
150
*
HcFd
LcFd


■ Chosen HcFd
□ Chosen LcFd
+
*
*
Total Dwell Time (ms)
440
420
400
380
360
340
320
300
CO
NW
UW
OW
Prime

a)


*
Number of Fixations
2
1.5
1
0.5
0
Chosen HcFd
Chosen LcFd

b)

- Chosen foods are gazed more than non-chosen foods
- High-calorie products are gazed more than low-calorie products
- Overweight and underweight body primes may activate specific health worries
- Gaze bias theory is only partially applicable to food choice