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Fearing the wurst:  
Robust approach bias towards non-vegetarian food images in  
a sample of young female vegetarian eaters

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## **Abstract**

Previous studies have shown that humans show an implicit approach bias toward food related items which is moderated by hunger and properties of the food items displayed (such as their palatability and calorie content). However, little is known about if and how this approach bias is moderated by food preferences and/or diet choices. In this study, we compared approach-avoidance biases in a group of young female omnivore and vegetarian eaters towards images of vegetarian and non-vegetarian food items using a manikin stimulus-response compatibility task. While vegetarian eaters showed a slightly larger approach bias for vegetarian than for non-vegetarian food stimuli, this bias was of similar size to that observed in the omnivorous group. Most interestingly, vegetarian eaters' approach bias towards non-vegetarian food pictures also did not differ from that of the omnivorous group, despite vegetarians rating those pictures as much less pleasant. Our findings suggest that approach biases towards food items are quite robust and do not rapidly change with dietary practice. However, despite approach biases often guiding behaviour, vegetarian eaters successfully withstand these implicit action tendencies and avoid non-vegetarian produce. Potential implications of this finding for the addiction literature are discussed.

## Introduction

Imagine you are walking down a busy street at 1 pm on a weekday to run an errand on your lunch break. You had a productive morning – waking up on time, having breakfast, checking items off a to-do list and even enjoying some mid-morning birthday cake handed around the office. You reach the bank, pay in your cheque, and are returning to the office when something bright and red in your visual periphery makes you turn your head, and you notice a strawberry cake in the window of a bakery. Although you had not intended it, you cannot help but buy some cake. In this case, a large and salient object has captured your visual attention, allowing for a corresponding approach behaviour to be initiated. Now imagine a different scenario – it is still 1 pm on a busy street and it is your lunch break, but this time you slept through your alarm, missed breakfast and the office cake had disappeared by the time your morning meeting ended. In this case, not only do you want to run your errand, you are also experiencing high levels of hunger, resulting in a snap-decision to approach the bakery along the high street. In this instance, an approach behaviour towards the bakery is activated because of your internal sensation of hunger, resulting in a different motive for the initiated behavioural response.

These examples demonstrate how human behaviour is shaped by the visual world. Once attention has been captured, either stimulus-driven (bottom-up processing) via the physical properties of items (Itti & Koch, 2000), or goal-driven (top-down processing) via internal factors like our current behavioural goals (Hopfinger, Buonocore, & Mangun, 2000), it can facilitate certain behavioural responses. For example, stimuli that satisfy an internal urge, such as food when hungry, tend to elicit an automatic approach response (Smeets, Roefs, van Furth, & Jansen, 2008) while pictures of unpleasant or fear-evoking stimuli, such as spiders, can prompt an automatic avoidance response (Mayer, Muris, Vogel, Nojoredjo, & Merckelbach, 2006; Rinck & Becker, 2007). These automatic approach or avoidance action tendencies are also known as approach-avoidance biases. Despite the majority of literature examining approach-avoidance biases from a clinical perspective, in particular in relation to addictions or phobias (see Field et al., 2016; Phaf, Mohr, Rotteveel, & Wicherts, 2014), these biases are also present in non-clinical populations.

For example, approach-avoidance biases towards food-related items have been found in both, clinical and non-clinical populations. Humans display approach biases towards food for a variety of reasons, including hunger (Mogg, Bradley, Hyare, & Lee, 1998; Nijs, Muris, Euser, & Franken, 2010; Piech, Pastorino, & Zald, 2010; Tapper, Pothos, & Lawrence, 2010) and hedonic values (i.e., the individual sense of pleasure) of food consumption (Erlanson-Albertsson, 2005; Kringelbach, 2004; Lowe & Butryn, 2007; Lowe & Levine, 2005). The hedonic value of food can

be affected by hunger and satiety, where food items have a higher hedonic value when hungry and lower when satiated (Epstein, Truesdale, Wojcik, Paluch, & Raynor, 2003; Stoeckel, Cox, Cook, & Weller, 2007; Tapper et al., 2010), or can override physiological drivers of consumption altogether (Brockmeyer et al., 2016; Cox et al., 1998; Volkow, Wang, & Baler, 2011). This finding that the hedonic value of food can override physiological drivers of consumption suggests a reward response following exposure to food-related cues, which is supported by findings of neural responses in brain regions relating to pleasure and reward (Baik, 2013; Stoeckel et al., 2008; Wang, Volkow, & Fowler, 2002). This reward response, in turn, explains both automatic biases towards food-related stimuli when hungry and automatic biases towards appetising food over bland food (di Pellegrino, Magarelli, & Mengarelli, 2011; Tapper et al., 2010).

Approach-avoidance biases toward food items are reflexive and can be explained using the dual process model Incentive Sensitisation Theory (Robinson & Berridge, 1993, 2000, 2008). The Incentive Sensitisation Theory states that when we engage in a pleasurable activity such as eating palatable food, it elicits a reward-based mesotelencephalic dopamine response (Wise & Bozarth, 1987), producing a 'liking' effect of eating (Berridge, 1996; Berridge, 2007). After repeated exposure or reinforcement, we learn to associate the neurobiologically pleasurable responses with the preceding environmental cues (Berridge, 2009). For example, the taste of sugar elicits a gratifying and enjoyable response which we then learn to associate with sweet products like chocolates and candy. These environmental cues then evoke 'wanting' responses where specific foods are craved as part of the dopaminergic response system due to the stimuli being attributed high incentive-value (Berridge, 2009). As a result, the smell or sight of certain foods may elevate cravings which in turn facilitate approach behaviour (Berridge, 2009; Rolls, 2007; Rolls, 2010).

Despite the developing understanding of human cognitive processing towards food, the effects of voluntary diet choices on these cognitive processes are less well understood. The preference to follow a vegetarian diet has become increasingly popular in recent years, especially in Western societies (Beardsworth & Bryman, 1999; Le & Sabaté, 2014; Leitzmann, 2014). Despite this, most literature surrounding food-related cognitive biases has focused only on omnivorous eaters. In fact, many investigations of cognitive biases and food actively avoid recruiting vegetarian participants because they could respond differently to images of meat (e.g., Hou et al., 2011; Tapper et al., 2010). While this rationale makes sense in studies where participants are presented with a mixture of vegetarian and non-vegetarian food stimuli, it has resulted in a lack of knowledge about the cognitive biases present in a large (and currently rapidly increasing) proportion of the population (see also Ruby, 2012).

Vegetarianism is defined by abstinence from consumption of meat or animal-based products to varying degrees of strictness (Back & Glasgow, 1981; Leitzmann, 2014). Rationales to pursue a vegetarian diet are diverse. In Western societies, vegetarianism is often ethically motivated with humans adopting a vegetarian diet for moral reasons, including animal welfare (Ruby, 2012) and environmental protection; i.e., minimising the carbon footprint, land and water wastage, as well as fertiliser and energy usage (Fox & Ward, 2008; Marlow et al., 2009). A vegetarian diet is also often adopted for health reasons (Ruby, 2012) as vegetarian food tends to be lower in calories, saturated fats and cholesterol but higher in beneficial nutrients than omnivorous food (White & Frank, 1994). Interestingly, ethical vegetarians tend to be more likely to experience greater conviction, consume fewer animal products and have been found to remain vegetarian longer than health-motivated vegetarians (Hoffman, Stallings, Bessinger, & Brooks, 2013). Other typical motivations for adopting a vegetarian diet include: adverse emotional reactions such as disgust and revulsion towards meat and consuming animal flesh (Janda & Trocchia, 2001; Kenyon & Barker, 1998), dislike or distaste of the sensory properties of animal products (Hamilton, 2006; Rozin & Fallon, 1987), and confirmation to social pressures (Janda & Trocchia, 2001; Lea & Worsley, 2001).

Despite the broad variety of reasons for adopting and maintaining a vegetarian diet, most of the justifications summarised above have in common that they are negatively driven towards meat and meat-containing products. Meat is avoided because it is deemed unethical, unhealthy or elicits feelings of disgust (though it should be noted that those who avoid meat based on societal pressure may still remain tempted but exercise restraint). Meat-containing products are therefore unlikely to elicit a pleasurable response. As discussed earlier, hedonic values attributed to food tend to elicit an approach bias. This suggests that approach biases towards meat-containing products for vegetarians may be measurably lower than for omnivores.

One task commonly used to assess approach-avoidance biases is the Stimulus Response Compatibility (SRC) task. The task entails moving a manikin towards (approach) or away (avoidance) from particular categories of stimuli, depending on the task instructions, and measuring the respective reaction times. Approach biases in this task are defined as the difference in reaction times between moving away from the stimulus of interest as compared to moving towards it. The overall rationale of the task is that moving the manikin is assumed to activate behavioural schemata of moving the self towards or away from objects (Krieglmeyer & Deutsch, 2010; Seibt, Neumann, Nussinson, & Strack, 2008). Despite this abstract or symbolic action of pushing buttons to move a manikin on the screen, the task has been found to provide the most reliable and sensitive measure for measuring valence-induced approach-avoidance responses (Krieglmeyer & Deutsch, 2010), in particular when the task requires an intentional evaluation of

the images presented (Kersbergen, Woud, & Field, 2015). SRC tasks have been successfully employed previously to measure approach biases for appetitive pictorial stimuli; including food in external eaters (e.g., Brignell, Griffiths, Bradley, & Mogg, 2009), cigarettes in smokers (e.g., Bradley, Field, Mogg, & De Houwer, 2004) and alcohol in social drinkers (e.g., Field, Kiernan, Eastwood, & Child, 2008; Kersbergen et al., 2015). However, to our knowledge, the task has never been used to determine the effect vegetarianism has on the approach-avoidance biases towards vegetarian and non-vegetarian food stimuli.

This is exactly what we aimed to investigate in the current study. Specifically, we compared the approach biases of a group of young female vegetarian and omnivorous participants who were asked to move a stick figure towards or away from a pictorial stimulus centrally presented on a monitor depicting vegetarian food, non-vegetarian food or a non-food item. All images were taken from the food-pic database (Blechert, Meule, Busch, & Ohla, 2014) that provides nutritional information on all food images as well as normative data on craving, palatability, and valence of all food images separate for male and female vegetarian and omnivorous eaters. As previous research suggests that food cravings, attentional biases towards meat, as well as eating attitudes and habits with regard to meat and vegetable consumption strongly vary with gender (Beardsworth et al., 2002; Love & Sulikowski, 2018; Weingarten & Elston, 1991), we opted for testing a homogenous sample of young female eaters in the current study. Furthermore, images were chosen such that vegetarian and non-vegetarian food items were matched in calorie content and did not differ in their valence, perceived palatability or craving for the female omnivores of the normative sample while the vegetarian normative sample showed clear differences in those measures (see Methods section). We also obtained an explicit measure of picture evaluation from our participants by asking them to rate the pleasantness of all stimuli.

Given the discussed motivations towards adopting vegetarianism and the existing normative data on palatability and craving scores for our selected food images, we predicted that our vegetarian eaters would rate non-vegetarian food items as less pleasant than vegetarian ones while female omnivorous participants would show similar explicit pleasantness ratings for both types of food images. We further predicted that these differences in perceived pleasantness should reflect in the measured approach-avoidance responses. Specifically, we hypothesised that our vegetarian participants would show a reduced approach bias (potentially reflecting an avoidance bias) towards non-vegetarian food items as compared to vegetarian food items, and also that their bias towards non-vegetarian items would be significantly smaller than that of omnivorous eaters. In contrast, we expected female omnivorous participants to show similar and consistent approach-biases for both vegetarian and non-vegetarian food images.

## Materials and Methods

### *Participants*

Forty-four female undergraduate students of the University of Aberdeen participated in the study (mean age 21 years, age-range: 18 to 25 years) in return for course-credits. Two participants were excluded from analysis, as they did not follow the task instructions to respond as quickly and accurately as possible resulting in reaction times of more than 2000 ms per trial for one of them and error rates larger than 30% in one block of trials for the other (suggesting this participant mixed up the task instruction for this block). The final 42 participants consisted of 21 omnivores and 21 vegetarians. Vegetarian diet was defined as refraining from consumption of meat, poultry, seafood and any other animal flesh (Leitzmann, 2014). Hence, individuals following a vegan, pescetarian or plant-based diet were excluded from participation in our study. All our participants were non-diabetic, had normal colour vision, normal or corrected-to-normal visual acuity, and no neurological problems by self-report.

Participants' height and weight data were recorded and used to calculate their Body Mass Index (BMI). The majority of participants (85.7%) had a healthy BMI (between 18.0 and 24.9) in accordance with World Health Organisation guidelines (WHO, 2000). Participants' BMI values ranged between 17.2 and 30.1, with a mean value of 22.0 (SD=2.95). One vegetarian participant was underweight (BMI of 17.2) and five participants were slightly overweight with regard to this classification system (three omnivores: BMI values of 26.6, 28.1, and 28.5; two vegetarians: BMI values of 26.6 and 30.1). One vegetarian participant refused to provide weight information. BMI values did not differ significantly between the two dietary groups,  $t(39)=0.54$ ,  $p=.59$ . Furthermore, we recorded prior to testing the time at which participants had their last meal. On average, the omnivorous participants had last eaten  $4.8\pm 1.2$  hours and vegetarian eaters,  $3.4\pm 1.1$  hours prior to testing,  $t(40)=0.88$ ,  $p=.39$ .

All participants were naïve to the purpose of the experiment and provided written informed consent before the start of the experiment which lasted approximately 40 min. The study was approved by the School of Psychology Ethics Committee at the University of Aberdeen.

### *Apparatus and Stimuli*

Stimuli were presented on a 19-inch CRT Dell M991 monitor with the resolution set to 1280x1024 pixels and a refresh rate of 75 Hz. Responses were recorded with a two-button response box with an accuracy of  $\pm 1$  ms. Thirty-two photographs of food items and 32 photographs of non-food items selected from the “*Food-pics*” database (Blechert et al., 2014) served as stimuli (see Table 1).





Non-Vegetarian  
Pictures:

Hamburger (2), Doner Kebab (68), Roastbeef Sandwich (72), Ham Pizza (108), Lasagne (145), **Salami (176)**, Frankfurter (185), **Salmon (307)**, **Shashlik (315)**, **Sausage in Bun (318)**, Trout (323), Salmon Sushi (371), Shrimp (545), Roast Beef (552), Cutlet (361), Steak (563)



Vegetarian Pictures:

**Chocolate Muffin (48)**, Donut (119), Strawberry Cake (133), **Chocolate Croissants (184)**, Pears (241), Chocolate Bar (287), **Roast Potatoes (306)**, Boiled Egg (321), Toast with Jam (347), **Green Asparagus (359)**, Grapes (391), Éclair (400), Cooked Peas (424), Cookie, (506), Waffle (507), Cheese (515)



Non-Food Pictures:

Flower (1001), Shoe brush (1004), **Bucket (1008)**, Towel (1011), Cushion (1012), Clock (1032), Sponge (1036), **Flower Bouquet (1037)**, Stones (1045), Shoe Brushes (1049), Muffin Moulds (1072), Cake Baking Tray (1077), Muffin Baking Tray (1123), Screws and Nuts (1129), Tape (1131), Lamp sockets (1137), Books open (1144), **Books closed (1145)**, Toilet Rolls (1198), Broom (1208), Basket (1212), Plastic Bottle (1229), Fan (1241), Dustpan and Brush (1259), Electric Bulb (1267), Paint Brush (1268), Basket (1276), Leaf 1 (1282), Orchid (1283), Leaf 3 (1286), **Clover (1294)**, Lily Flower (1295)

*Table 1: Summary of stimuli selected from the food pic database. The numbers in parentheses refer to the respective image number of the photograph in the food pic database. Stimuli in bold are shown as examples (upper row: non-vegetarian stimuli, middle row: vegetarian stimuli, lower row: non-food pictures).*

The food and non-food stimuli were matched for low-level visual features such as their contrast ( $p=.18$ ), brightness ( $p=.57$ ) and spatial frequencies ( $p=.12$ ) as specified in the food pic database (Blechert et al., 2014). Furthermore, the food pictures were selected such that sixteen of the food items were suitable for vegetarians to eat (e.g., pears, boiled egg, cake) and 16 were not (e.g., burger, steak, sausages). We also ensured that all of the selected food pictures were free of other content such as plates and cutlery. In addition, vegetarian and non-vegetarian food pictures were matched for their total calorie content depicted (omnivore pictures:  $474 \pm 79$  kcal, vegetarian pictures:  $324 \pm 67$  kcal,  $p=.16$ ) as well as their calorie content per 100 grams (omnivore pictures:  $179 \pm 19$  kcal, vegetarian pictures:  $247 \pm 38$  kcal,  $p=.12$ ) as previous research has indicated that

differences in caloric value may be associated with differing attention allocation towards food stimuli (Placanica, Faunce, & Soames Job, 2002). Table 2 shows the average craving and palatability scores for the sixteen selected vegetarian and non-vegetarian food-pictures separately for female vegetarian and non-vegetarian eaters as provided by the normative sample data of the food-pic database (Blechert et al., 2014). While the female omnivorous participants from the normative sample provided similar palatability and craving scores for vegetarian food and non-vegetarian food pictures (both  $p > .59$ ), the rating scores from the female vegetarian normative sample were considerably lower for the selected non-vegetarian food images as compared to the vegetarian food images (both  $p < .001$ ). Moreover, the selected vegetarian food pictures obtained similar palatability ( $p = .24$ ) and craving ( $p = .14$ ) scores from the female vegetarian and omnivorous normative sample, whereas for the selected non-vegetarian food images, the normative female vegetarian sample rated these as significantly lower (both  $p < .001$ ).

	Female vegetarian		Female omnivorous	
	Craving	Palatability	Craving	Palatability
Vegetarian Food				
pictures	25.4 (2.74)	51.7 (3.99)	31.0 (2.51)	57.3 (2.36)
Non-Vegetarian				
Food pictures	9.8 (6.68)	24.8 (3.31)	31.4 (7.98)	55.6 (2.05)

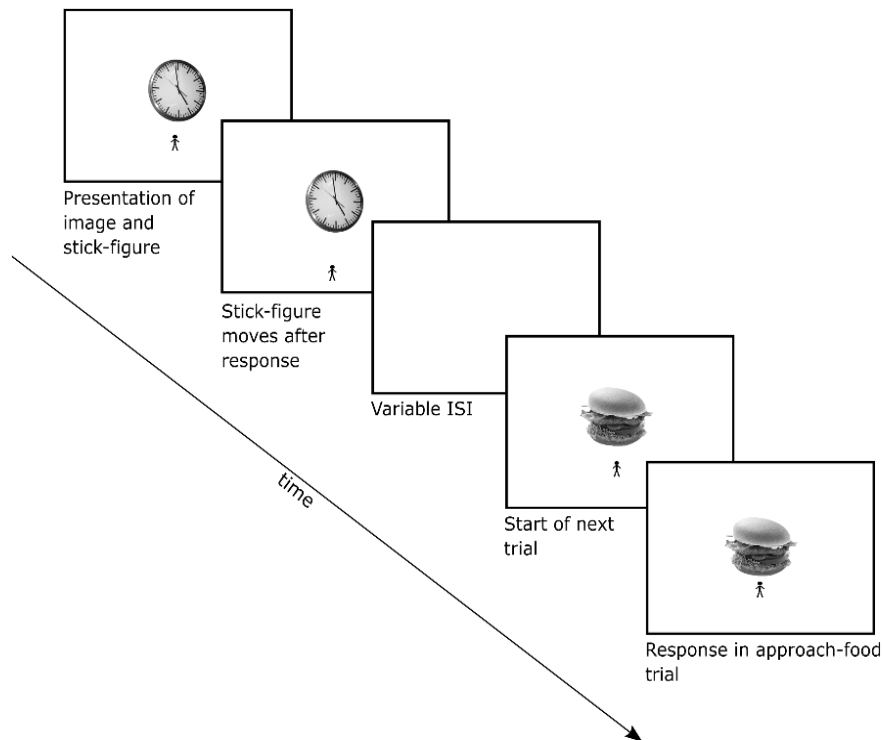
*Table 2: Average Craving and Palatability scores of the normative sample data for the N=16 vegetarian and non-vegetarian stimulus pictures.*

During the experiment, all stimuli were presented in the centre of the screen and at a consistent size of 600x450 pixels. The experiment was programmed in Matlab using the Psychophysics toolbox extension (Brainard, 1997; Kleiner, 2007; Kleiner, 2010). Participants' food craving traits were assessed using the reduced Food Cravings Questionnaire (FCQ-T-r) (Meule, Hermann, & Kübler, 2014).

#### *Procedure*

Participants sat at a desk in a darkened room and viewed the screen from a distance of about 70 cm. They were asked to place two fingers on the response buttons of the button box which were arranged vertically (i.e., “up” and “down”). Each trial started with the presentation of one of the stimulus pictures (food or non-food) in the middle of the screen against a white background together with a black-stick figure (H: 20 mm, W: 10 mm) positioned either below or

above the picture. The distance between the outer edge of the stimulus and the outer edge of the stick figure was 25 mm. The task required participants to move the stick figure towards or away from a centrally presented picture using the two buttons on the response box. There were two conditions: “*food-approach*” versus “*food-avoid*”. In the food-approach condition, participants were required to move the stick figure towards food pictures and away from non-food pictures, whereas in the food-avoid condition, they had to move the stick figure away from food pictures and towards non-food pictures. That is, if the stick figure was positioned above a food picture, they had to press the lower button in the food- approach condition and the upper button of the response box in the food-avoid condition and vice versa when the stick figure was presented below (see Figure 1). Participants were instructed to respond as quickly and as accurately as possible. In response to their button press, the stick figure would move in the indicated direction by 25 mm (steps of 5 pixel) to enhance the impression of approach or avoidance of the stimulus. Once participants had provided their response and the figure stopped moving, the next trial would begin after a randomly determined inter-trial interval of 500, 750 or 1000 ms (blank white screen). The latency between trial onset (simultaneous presentation of picture and stick figure) and the participants’ button press was defined as their reaction time.



*Figure 1:* Illustration of experimental sequence in the food-approach condition. The stick figure appeared randomly above and below the stimulus and moved in response to the participants' button press (for more details see text).

The food-approach and food-avoidance conditions were blocked and counterbalanced between participants with half of them starting with the food-avoid condition and half starting with the food-approach condition. In both conditions, each of the 64 pictures was presented twice once with the stick figure positioned below the picture and once with the stick figure above the picture, resulting in 128 trials per block and 256 trials in total. Within each block, all pictures (object, vegetarian and non-vegetarian) were presented in pseudo-randomised order. This ensured that participants did not adopt a strategy to respond to one type of image. It also prevented participants from using a consistent strategy in response to perceived unpleasant images, since it has been found that the anticipation of a negative stimulus can affect attention (Devue, Belopolsky, & Theeuwes, 2011). Thus, presenting vegetarian, non-vegetarian and object images interleaved in each block ensured that an approach-avoidance bias was not unwittingly trained. After every 32 test trials, participants were offered a short break. Finally, each block was preceded by 15 practice trials to accustom participants to the task (block 1) or familiarise them with the change in instructions (block 2). During practice trials, but not during the main experiment, participants were

given feedback about their performance (i.e. green tick after a correct response and a red cross after an erroneous response).

After the completion of the SRC task, participants were asked to rate the perceived pleasantness of each stimulus on a 7-point Likert scale ranging from -3 [*very unpleasant*] to +3 [*very pleasant*]. All 64 pictures were again presented in the middle of the screen in pseudo-randomised order with the rating scale presented in black beneath each picture. Participants provided their responses by clicking on one of the 7 numbers of the scale with a computer mouse. Following the rating task, every participant was asked to fill in the Food Craving Questionnaire (FCQ-T-reduced) to assess their general food cravings. The FCQ-T-reduced (Meule et al., 2014; Meule, Lutz, Vögele, & Kübler, 2012) consists of 15 statements regarding participant trait level food cravings. Participants have to indicate how frequently each statement is true for them on a 6-point scale (“*never*”, “*rarely*”, “*sometimes*”, “*often*”, “*usually*” and “*always*”). A final personal craving score is obtained by adding the values across all 15 statements (i.e. minimum score of 15 and maximum of 90).

## Results

### *Rating Task*

First, we wanted to determine if vegetarian and omnivorous participants differed in their pleasantness ratings for vegetarian, non-vegetarian, and non-food object pictures. To do so, the ratings were averaged within all three picture categories for each participant and analysed using a 3 (picture category) x 2 (dietary group) mixed ANOVA. Results showed significant main effect of picture category,  $F(2,80)=30.73, p<.001, \eta_p^2 =.43$  as well as dietary group,  $F(1,40)=25.45, p<.001, \eta_p^2 =.39$ . Most importantly, there was a significant interaction effect between both variables,  $F(2,80)=18.48, p<.001, \eta_p^2 =.32$ , indicating that the pleasantness ratings of the different picture categories was moderated by the participants’ diet. Note that due to this interaction effect, main effects cannot be meaningfully interpreted and are thus not further discussed (see Figure 2). Post-hoc independent-samples t-tests conducted separately for each picture category confirmed that vegetarians and omnivores rated non-food pictures,  $t(40)=0.42, p=.68$ , and vegetarian pictures,  $t(40)=1.76, p=.09$ , as similarly pleasant. In contrast, non-vegetarian food pictures were rated as being much less pleasant by the vegetarian participants than by the omnivorous participants,  $t(40)=5.97, p<.001$  (see Figure 2). Finally, paired-samples t-tests confirmed that omnivores rated vegetarian and non-vegetarians food pictures as being similarly pleasant ( $p=.13$ , Bonferroni-corrected), while vegetarians rated non-vegetarian food as significantly less pleasant than vegetarian food pictures,  $t(20)=8.63, p<.001$ .

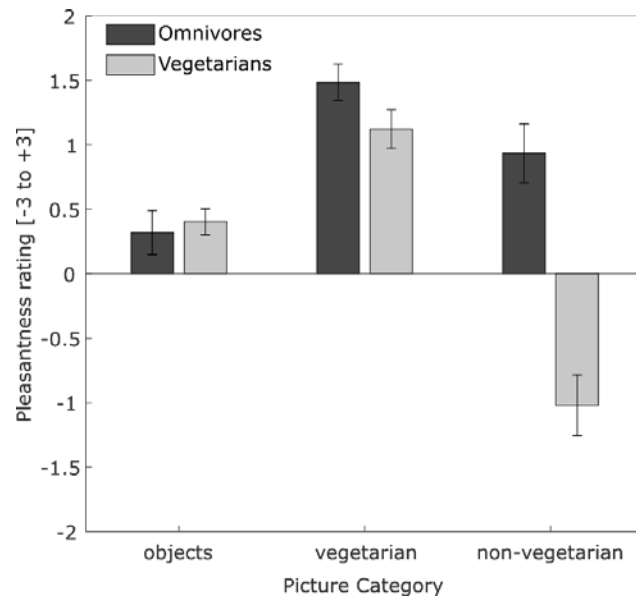


Figure 2: Average pleasantness ratings for each picture category as a function of diet type. Error bars represent  $\pm 1$  SEM between subjects.

### SRC Task

To determine participants' approach-avoidance response times, we calculated for each participant the median reaction times across all correct responses to stimuli belonging to each of the three picture categories (vegetarian, non-vegetarian and non-food), and separately for the two different response directions (i.e. approach food/avoid non-food vs. avoid food/approach non-food), resulting in a total of six mean values. Food approach-avoidance scores for each of the two food-picture categories were then computed by averaging reaction times for object pictures with those obtained for each of the two food-picture categories. Note that overall, participants made only very few mistakes (omnivores:  $3.57 \pm 0.56\%$  vs. vegetarians:  $4.78 \pm 0.84\%$ ) and error rates did not significantly differ between vegetarian and omnivorous participant groups,  $t(40)=1.20$ ,  $p=.24$ .

Reaction time data was analysed using a 2 (food category: vegetarian vs. non-vegetarian) x 2 (task: approach vs. avoid) x 2 (diet type) mixed ANOVA. As we hypothesised that approach-avoidance responses towards vegetarian and non-vegetarian stimuli might be moderated by participants' diet, we were particularly interested in the 3-way interaction between the variables. The analysis revealed a main effect of picture category,  $F(1,40)=4.56$ ,  $p=.039$ ,  $\eta_p^2=.10$ , and a main effect of task,  $F(1,40)=51.78$ ,  $p<.001$ ,  $\eta_p^2=.56$ . As can be seen in Figure 3, participants tended to respond quicker when they were instructed to approach food stimuli and avoid object stimuli than when they were instructed to avoid food pictures and approach object pictures ( $M_{diff}=93 \pm 13$  ms). Importantly, the two main effects were moderated by a significant interaction effect between them,

$F(1,40)=7.18$ ,  $p=.011$ ,  $\eta_p^2=.15$ , indicating that reaction times for food-approach and food-avoidance responses differed for vegetarian and non-vegetarian food pictures (see Figure 3, upper panel). Most importantly, there was also a significant 3-way interaction between all variables,  $F(1,40)=8.10$ ,  $p=.007$ ,  $\eta_p^2=.17$ , suggesting that approach-avoidance responses for vegetarian and non-vegetarian food pictures also differed between the dietary groups. The main effect of group ( $p=.12$ ) and the interaction effect between group and task ( $p=.52$ ) were not significant. To follow-up the 3-way interaction effect, we calculated the approach bias for each participant and each condition by subtracting the average RTs in the food-approach condition from the average RTs measured in the food-avoidance condition (see Figure 3, lower panel).

Firstly, one-samples t-tests against zero on this data confirmed that significant food-approach biases existed in all conditions (all  $p<.001$ ). Furthermore, paired-samples t-tests comparing the size of the food-approach bias between vegetarian and non-vegetarian pictures in each dietary group separately revealed that the vegetarian group showed a larger food-approach bias for vegetarian pictures than for non-vegetarian pictures ( $M_{\text{diff}} = 49 \pm 16$  ms),  $t(20)=3.04$ ,  $p=.006$ , while there was no difference in the size of the two biases in the omnivorous participant group, ( $M_{\text{diff}} = 1 \pm 8$  ms),  $t(20)=0.20$ ,  $p=.85$ . Descriptively, vegetarian participants also showed slightly larger food-approach biases than omnivorous participants when vegetarian pictures were presented ( $M_{\text{diff}}=42 \pm 30$  ms). Post-hoc independent samples t-tests revealed that this group difference was, however, not significant,  $t(40)=1.39$ ,  $p=.17$ . Most interestingly, comparing the food-approach biases for vegetarian and omnivorous participants when non-vegetarian images were presented revealed that approach biases were of very similar size in both dietary groups ( $M_{\text{diff}}=9 \pm 24$  ms),  $t(40)=-0.37$ ,  $p=.72$ . Thus, both vegetarian and omnivorous participants were faster when responding to non-vegetarian pictures with a food-approach response than with a food-avoidance response.

Finally, we also determined the food craving scores as determined by the FCQ-T questionnaire for each dietary group separately and tested if these correlated with the food-approach biases measured in the SRC-task. An independent samples t-test confirmed that craving scores did not differ significantly between the two dietary groups (omnivores:  $43.3 \pm 2.9$  points, vegetarians:  $46.8 \pm 2.4$  points),  $t(40)=0.91$ ,  $p=.37$ . Moreover, no significant correlations between craving scores and size of the approach biases in the SRC-task were found for the omnivorous or the vegetarian participant group (all  $p>.15$ ). However, given that there was very little variation in the craving scores and most participants scored in the lower-middle range this lack of association is not surprising.

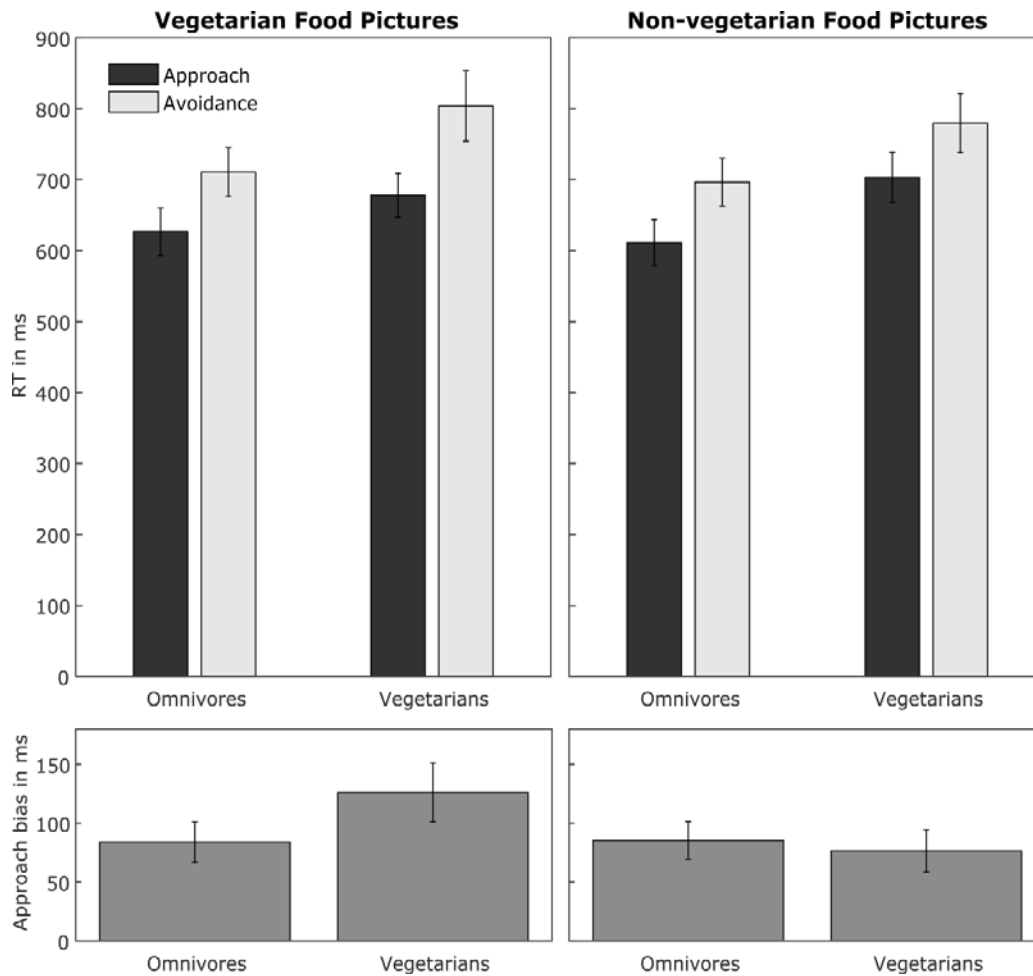


Figure 3: Upper panels: Average reaction times as a function of picture category, task and dietary group. Lower panels: Approach biases as a function of picture category and dietary group. All error bars depict  $\pm 1$  SEM between subjects.

## Discussion

In this study we used a Stimulus Response Compatibility (SRC) task that required participants to move a stick figure towards or away from three categories of images (vegetarian foods, non-vegetarian foods and non-foods) to investigate if young female vegetarian and omnivorous eaters display different approach or avoidance biases to vegetarian or non-vegetarian food images. We also examined the explicit pleasantness ratings for each image category to examine the connection between explicit and implicit attitudes to the different food groups.

Pleasantness ratings of the different picture categories used in the study were significantly moderated by diet. As expected, diet did not influence the ratings of vegetarian or non-food items. However, female vegetarian participants rated non-vegetarian food pictures as significantly less



pleasant than female omnivores. This finding is in line with our predictions. As outlined in the introduction, most motivations for adopting and maintaining a vegetarian diet are negatively driven towards meat and meat-containing products. Therefore, it can be expected that meat-containing images will be assessed as being less pleasant by vegetarian eaters. Our findings are also congruent with the craving and palatability ratings of vegetarian and non-vegetarian foods in female omnivores and vegetarians from the normative sample data of the food-pic database (Blechert et al., 2014).

Regarding the implicit measurement of approach-avoidance biases, as expected, vegetarian participants displayed a larger approach-bias towards vegetarian pictures compared to non-vegetarian pictures. This is in-line with the explicit ratings of the food images, where vegetarian participants rated vegetarian images as significantly more pleasant than non-vegetarian images. Similarly, the non-significant difference between female vegetarian and omnivorous participants' explicit ratings of vegetarian pictures corresponded to a non-significant difference between the implicit approach biases of both groups towards the vegetarian images. Thus, in these instances, explicit and implicit measures towards vegetarian and non-vegetarian images in vegetarians and omnivores appear to correspond. In contrast, however, while there was a significant difference between vegetarians and omnivores in the pleasantness ratings of non-vegetarian images (with vegetarian participants rating these as significantly less pleasant than omnivores), this finding was not reflected in the implicit measurement of their approach-avoidance biases. In fact, the reaction time data in the SRC task showed a clear, and similarly large, approach bias towards non-vegetarian food pictures for both vegetarian and omnivorous participants. This finding suggests a dissociation between explicit biases (i.e., conscious ratings of images) and implicit biases (which include attentional and approach-avoidance biases). In the following we will discuss these main findings in more detail.

First, let us consider the somewhat unexpected finding that approach biases towards non-vegetarian food items were unaffected by dietary preference. A possible explanation for this finding is that approach biases towards appetising foods (and food in general when hungry) serve an evolutionary purpose (Cosmides & Tooby, 2013). Thus, it is plausible that, irrespective of explicit ratings of foods, the innate drive to approach food items persists at least for some time following changes in human lifestyle. Further (indirect) support for the argument that food approach biases may, at least temporarily, survive dietary changes comes from studies investigating the physiological responses of vegetarian eaters to non-vegetarian food stimuli. Firstly, it has been found that while vegetarians explicitly report a lower desire to eat non-vegetarian food and rate non-vegetarian food as less pleasant, their ERP responses to non-vegetarian foods did not differ

from those of omnivores (Giraldo, Buodo, & Sarlo, 2019). Similarly, it has been observed that while vegetarians have increased explicit disgust ratings to non-vegetarian foods, their heart-rate and facial EMG responses were comparable to those of omnivores (Anderson, Wormwood, Barrett, & Quigley, 2019). Thus, just like basic physiological reactions towards food items, automatic and more reflexive behavioural responses, as measured in the SRC-task, seem to be also unaffected by dietary choices and food attitudes.

Incidentally, the existence of an approach bias toward non-vegetarian produce may explain why vegetarian produce is often designed to mimic meat, like burgers, sausages, chicken breasts and so on (Elzerman, Van Boekel, & Luning, 2013). This seems to capitalise on our innate bias to approach meat-containing products and readily taps into the implicit approach bias towards meat produce of both omnivorous and vegetarian eaters. That this may be a successful strategy is evidenced by sales of meat-like vegetarian (and vegan) foods raising year by year (Statista, 2019). It is also possible, though purely speculative, that the availability of more meat-substitutes may contribute to maintain implicit biases towards meat produce as in many instances, an approach bias towards a meat-like food is reinforced because the product is actually suitable for vegetarian eaters.

What makes the finding that vegetarian eaters show a persistent implicit approach bias towards non-vegetarian products even more interesting is the fact that their explicit ratings indicated that they found those food items quite unappealing. Even though this dissociation between implicit behaviour and explicit judgement (and subsequent behavioural choices) mirrors to some extent the findings from recent physiological studies (Anderson et al., 2019; Giraldo et al., 2019), it is interesting as it is opposite to the findings from the addiction literature and is thus contrary to a large amount of literature on approach-avoidance biases. The classic accounts of approach-avoidance biases in addiction suggests that approach biases develop in a goal-oriented way to satisfy an urge or craving to engage in a particular behaviour, such as smoking or going to a pub (Belin, Belin-Rauscent, Murray, & Everitt, 2013). As the neural regions responsible for executive control are often compromised by substance-abuse (Everitt & Robbins, 2013; Goldstein & Volkow, 2011), addicts are less able to exert control over approach behaviour that is based on attentional biases and thus become more likely to surrender to their behavioural impulses (Goldstein et al., 2004). As our current sample were all undergraduate students at a high-ranking UK university, it seems reasonable to assume that their executive functions and cognitive control were uncompromised (for a similar argument see Knight, Smith, Knight, & Ellison, 2018). It is therefore likely that our vegetarian participants' implicit approach bias towards non-vegetarian produce is moderated by their explicit cognitions. Thus, while the effects of attentional bias on

behaviour may be elevated in addictive populations, because of their comprised executive functioning, in healthy populations, a fully functioning executive control system can potentially nullify the effects that approach biases have on proceeding behaviour (Knight et al., 2018). Further investigation of this link could prove invaluable for aiding those with addictive behaviours who are unable to exert such control over their implicit biases.

The third noteworthy finding of our study is that approach biases towards food-items can be found consistently and reliably in healthy non-pathological samples (independent of diet). So, the question arises of how and why these biases are formed. As outlined in the introduction, the Incentive Sensitisation Theory (Robinson & Berridge, 1993, 2000, 2008) can offer a neurobiological account. The repeated pairing of food-related stimuli and the resulting reward-based mesotelencephalic dopamine response from eating those foods causes the food-cues to raise in their incentive value, facilitating automatic approach behaviours towards food-cues (Berridge, 1996; Berridge, 2009; Rolls, 2007; Rolls, 2010). This mechanism may also underlie the formation of a general food-approach bias that is not mediated by craving even in non-restrictive eaters (such as omnivores over vegetarians), as evidenced by our findings.

### **Limitations and Future Directions**

What is unknown from the current study is whether the observed implicit approach bias occurs in conjunction with an increased attentional bias towards non-vegetarian products in vegetarians, or if the approach bias is independent of an attentional bias. While an attempt to investigate this in an EEG study via late positive potentials has suggested that vegetarians indeed show attentional capture of non-vegetarian food items (Stockburger, Renner, Weike, Hamm, & Schupp, 2009), the study presented only one image at any time. Consequently, Stockburger et al.'s findings likely reflect the increased negative valence attributed to meat pictures in vegetarians rather than being indicative of an attentional bias towards non-vegetarian food items, as the authors themselves suggest. One way to determine the presence of an attentional bias in vegetarians unequivocally (and the ultimate purpose of this bias), would be via a dot-probe task with probes replacing images with variable stimulus onset asynchronies. Faster reaction times in vegetarians when a probe replaces a non-vegetarian food stimulus at shorter SOAs would indicate an initial capture of attention. In contrast, slower reaction times when the probe replaced a non-vegetarian food stimulus at longer SOAs would indicate that vegetarian participants' ultimate goal is to avoid the non-vegetarian food, since after a longer SOA, participants have had a chance to shift attention away from a particular stimulus. This pattern has been found in abstinent patients with alcohol use

disorder who show an attentional bias towards alcohol at short SOAs but not long ones (Noël et al., 2006).

It would also be of interest to examine the differences in explicit and implicit approach biases between different categories of vegetarians to ascertain that these can actually be treated as a homogenous group. For example, morally-driven vegetarians may display a different behaviour than socially-influenced or health-vegetarians, as it has been suggested that both groups show different explicit disgust measurements (Hamilton, 2006). However, whether this translates to different implicit measurements remains to be determined. Furthermore, we did not assess the length of time participants had been vegetarian for in the current study. For example, one could expect that attitudes towards non-vegetarian produce may be different for vegetarian eaters that were raised in vegetarian families and never consumed meat in their lifetime as compared to participants who adopted a vegetarian diet in young adulthood. Future research should therefore investigate if and how the duration of being a vegetarian eater affects the explicit attitudes towards vegetarian and non-vegetarian food items, and how this mediates implicit cognitive biases. This could help to determine how in-group identity shapes opinions over time, and what the subsequent effects on automatic behaviour are. In sum, our findings open a lot of interesting avenues for future investigations, both for the more specific question of how certain diets affect attention towards specific food items, and more general questions of the relationship between attentional bias and approach-avoidance biases.

## **Conclusion**

In conclusion, the current study finds that both vegetarian and omnivores in a sample of young female eaters display an approach bias towards non-vegetarian foods. This is contrary to explicit measurements of pleasantness, displaying a dissociation between implicit approach biases, explicit measurements of approach and the ultimate behavioural goals. These findings help contribute to the relatively unexplored area of approach biases towards food and provide a novel insight into cognition surrounding voluntary, non-pathological dietary choices.

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