Hungry people prefer larger bodies and objects: The importance of testing boundary effects.

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Abstract

Several lab-based studies have indicated that when people are hungry, they judge larger women's bodies as more attractive, compared to when they are satiated. These satiety-dependent judgements are assumed to provide explanatory power when it comes to the noted cross-cultural differences in attitudes towards women's adiposity, whereby people who live in regions that are under greater nutritional stress tend to have more favourable attitudes towards bigger bodies. However, it is premature to assume that women's bodies are the proper or actual domain of the satiety-dependent judgement shifts found within research study testing contexts until stimuli other than female bodies have also been tested: the research programme falls into the trap of confirmation bias unless we also seek out disconfirmatory evidence, and test the boundaries of the effects of hunger. Accordingly, we collected attractiveness judgements of female and male bodies manipulated to vary in size by varying level of adiposity, and objects manipulated to vary in size, from 186 participants who also reported their current hunger level. We found that larger sizes of stimuli in general, and women's bodies in particular, especially when judged by women, were judged as more attractive by the hungrier participants. We discuss these patterns in the context of the Insurance Hypothesis, the Environmental Security Hypothesis, and the impact of hunger on acquisition.

Keywords: Adiposity; Attractiveness judgements; Body image; Hunger; Nutritional stress;

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1. Introduction.

Plumpness, especially in women, is considered more desirable in some cultures than in others (J. L. Anderson, Crawford, Nadeau, & Lindberg, 1992; Brown & Konner, 1987; C. R. Ember, Ember, Korotayev, & de Munck, 2005). This variation in body ideals does not seem to be entirely arbitrary, but instead exhibits patterns related to ecological variables. Thus, cross-culturally, female plumpness seems to be more desirable in general in regions in which there is greater nutritional stress, consisting of variation in food supply with little capacity for food storage (J. L. Anderson et al., 1992; C. R. Ember et al., 2005). Along the same lines, large-scale surveys of the literature make clear that in poorer countries, plumpness is more prevalent in higher socioeconomic strata (McLaren, 2007; Sobal & Stunkard, 1989). So in countries with nutritional stresses, richer people tend to be fatter, and fatness in women is more likely to be desirable, but this is not true everywhere. In richer countries, the relationship between plumpness and socioeconomic status is inverted among women, such that women from lower socioeconomic strata tend to be fatter (McLaren, 2007; Sobal & Stunkard, 1989). Relatedly, in high income countries, women (but not men or children) have higher body weight if they have higher perceptions of food insecurity (Nettle, Andrews, & Bateson, 2017).

This relationship between environment and body fat ideals has been given an ecological explanation. If food supplies are insecure, then plumpness may indicate individuals who have better access to resources, and (in the case of women) who are better able to weather fluctuations in short-term food availability while bearing and nurturing offspring (J. L. Anderson et al., 1992; Brown & Konner, 1987; C. R. Ember et al., 2005). That is, adiposity is more beneficial when food could be in short supply, and this plays out in body size ideals. A variant on this logic has been formalised as the Insurance Hypothesis (Nettle et al., 2017), which states that individuals respond to cues in the environment that indicate that food availability is uncertain, by increasing adiposity as a buffer to predicted future shortfalls in food supply. An individual's adiposity therefore trades off the drawbacks of increased body weight, against the need to maintain sufficient fat storage given an assessment of the likelihood of future food shortages. The greater responsiveness of the female body (compared to the male body) to gain weight in the face of food uncertainty might then be a consequence of sex differences in the pay-offs for greater adiposity arising from sex differences in quantity of locomotion and fighting (Nettle et al., 2017), or female-specific adaptive shifts towards a fast life history (Chen, 2017), or because of the greater costs to women's reproduction that arise from insufficient calorific reserves (S. E. Hill, Leyva, & DelPriore, 2017). To explain why body size preferences themselves also change according to different environments, the same adaptive logic pertains, whereby preferences track environmental variables (see e.g. Roberts & Little, 2008).

The tendency for female adiposity to be more desirable against a background of food insecurity also seems to be apparent at the individual level in test settings. Thus, men like bigger female bodies more when they are hungry. As such, in one study, hungry men rated line drawings of women of average body weight to be most attractive, whereas satiated men rated line drawings of underweight women to be most attractive (Swami, Poulogianni, & Furnham, 2006). Men who were about to eat an evening meal stated a heavier ideal female body weight (on a 15-point rating scale, and also in pounds while controlling for their estimation of an average woman's weight in pounds) than did men who had just eaten an evening meal, whereas women's rating of men's ideal body weight did not vary with those women's meal status (Nelson & Morrison, 2005). Similar studies, that asked men to select the weight category in pounds of an ideal female partner (Pettijohn II, Sacco Jr, & Yerkes, 2009), or to rate photographs of women of different body mass indices (Swami & Tovée, 2006), found that hungry men gave more positive ratings to heavier women or women with a higher BMI than did satiated men.

Ratings of bigger female bodies seem to become more positive not just as men become more hungry, but also in some cases as they perceive their environment to be difficult more generally. Thus, when men's attention was directed to whether they were carrying money or not, the money-absent men stated an ideal female body weight that was higher than the money-carrying men (Nelson & Morrison, 2005). In the same set of studies, men who were made to feel poorer stated an ideal female body weight (on a 15-point rating scale) that was higher than men made to feel richer. Women who underwent similar interventions did not change their stated ideal male body weight. In separate studies, men whose stress levels were raised, by performing in front of others (Swami & Tovée, 2012), or attending an army training camp (Batres & Perrett, 2016), or being told that they would be handling a dangerous snake (Reeve, Kelly, & Welling, 2016), rated higher-BMI female photos as more attractive than men did in a control condition. In this last study, women who received the same experimental manipulation, being told that they would be handling a dangerous snake, were more attracted to higher muscle mass in men's bodies. A study that examined judgements of ideal female body size, made by male and female participants from societies of different resource status, found that ethnic Zulus (of limited educational background, and employed in low-paid work in South Africa) gave higher beauty ratings to overweight and obese female bodies, while Zulus who had moved from South Africa to the UK were slightly less accepting of larger female bodies, and UK nationals (both White and of African descent) provided lower ratings again to the larger bodies (Tovée, Swami, Furnham, & Mangalparsad, 2006). More broadly, people from lower socio-economic status regions have stronger preferences for plumper bodies (review in Swami, 2015). In sum, the overall picture is that people are more positive towards bigger, fatter female bodies when they are hungry, as well as when they are under stress in some other ways.

Most studies on the impact of hunger (or other stressors) on lab-based body ideal judgements have focussed on women's bodies, and on men's ratings. This is because of the founding assumption that what is being unpacked is an adaptive reaction to ecological pressures, as set out in the Insurance Hypothesis (Nettle et al., 2017) and related research ideas (J. L. Anderson et al., 1992; see e.g. Brown & Konner, 1987; C. R. Ember et al., 2005).

The assumption is that women's bodies are the proper or actual domain (Millikan, 1984) of the satiety-dependent judgement shifts found within research study testing contexts. However, study designs that only focus on the impact of hunger (or other stressors) on judgements of women's bodies do not allow for the possibility that hunger's effects are more widespread, and therefore that hunger-based shifts in ratings are part of a broader package (Swami et al., 2006) that may merit additional or revised theoretical explanations. This blind spot within the research programme is a form of confirmation bias: specifically, it is the lack of attention to the equal importance of seeking out confirmatory and (the absence of) disconfirmatory evidence when testing hypotheses (Nickerson, 1998). Yet the question of whether hunger does or does not change perceptions of the ideal proportions of other stimuli has received limited attention. The only research that we are aware of that investigated the impact of hunger on women's ratings of men's body size in a controlled setting did not find a significant impact of hunger, although the participants had to use a 15-point scale to indicate the weight of an ideal man compared to the average man, or provide an estimate of weight in pounds of the average and/or ideal man or partner (Nelson & Morrison, 2005; Pettijohn et al., 2009). However, these dependent variables collapse together differences in body fat, muscle mass, build, and height, and the participants did not rate both men's and women's bodies, precluding a comparison. One other research study (Swami et al., 2006) found a link between men's hunger and their preferences for female body size but not for object size, but did not compare the two types of stimuli in a single study with the same participants, and used only 5 object stimuli in each study. The broader literature on how wider stressors such as socio-economic status impact judgements of body size (review in Swami, 2015) have also generally focussed on men's ratings of women's bodies.

Accordingly, we set out to examine the boundaries of the previously-noted effect of hunger on lab-based judgements of body size, by testing explicitly whether hunger influences ratings of bodies (and in particular women's bodies) but not other stimuli. We assessed men's and women's attractiveness judgements of men's bodies, women's bodies, and objects, alongside their hunger levels. Following previous research (e.g. Nelson & Morrison, 2005; Pettijohn II et al., 2009; Swami & Tovée, 2006; Swami et al., 2006), we recruited participants in person close to a university campus restaurant around lunchtime to ensure wide variation in hunger levels; we also recruited online to ensure a large sample. We made use of photo-realistic image software that rendered images of male and female bodies that had been manipulated to vary realistically in adiposity, and images of objects manipulated to vary in size. If the actual domain of hunger-induced preference shifts is body fatness (and in particular female body fatness), then we would expect to find a boundary between judgements of bodies and objects: hunger should relate positively to preferences for fatter bodies (and particularly fatter female bodies), but should not affect judgements of objects. On the other hand, if the previously-described relationship between hunger and preferences for fatter bodies (and particularly fatter female bodies) is not the actual domain of hunger-induced preference shifts, then we would expect to see hunger affecting stimuli more widely than in relation to bodies alone.

2. Methods

2.1 Participants

Participants were recruited online via opportunity sampling ("the online sample"), and also in person close to the campus restaurant of a university in the North-East of England around lunchtime ("the campus sample"), to increase the sample size and to ensure wide variation in hunger levels. The online study was advertised via social media and through social contacts by the third and fourth authors when they were also based at the same university in the North-East of England, and so would have drawn from a similar pool to the campus sample. The target sample size was based on a previous study (Swami & Tovée, 2006) who used 61 participants; we had a target of minimum 120 participants. Data collection was also constrained by two of the authors' time for data collection. The final sample consisted of 186 complete responses (100 from the campus sample, and 86 from the online sample). The sample consisted of 105 women and 81 men (total: 186), with a mean age of 26.28 years (*SD*=11.92 years). Of the four published papers that are closest to ours, our sample of 186 exceeds the sample in three of them (Pettijohn II et al., 2009: *n* of 162; Reeve et al., 2016: *n* of 103; Swami & Tovée, 2006: *n* 61), and exceeds the sample sizes used in two of the four studies of the other paper (Nelson & Morrison, 2005), which range from 181 to 554 participants. Given our Bayesian analysis (Wagenmakers, 2007), we do not carry out a power analysis; we present confidence intervals to assist interpretation of true effects.

2.2 Design

Following previous research on hunger and body stimuli judgements (Nelson & Morrison, 2005; Pettijohn II et al., 2009; Swami & Tovée, 2006; Swami et al., 2006), we used a between-subjects non-experimental design. We account for our sampling design via hierarchical modelling (see “Data analysis”).

2.3 Procedure and materials

The basic protocol for this study was pre-registered at https://osf.io/t6kc4/, where our materials, analyses, and minor deviations from pre-registration are available, and approved by the ethics committee of the university where it was carried out. The study was set up online, and the online sample accessed it directly from a link, while the campus sample were given access through a hand-held tablet computer. Previous research has compared data on judgements of female body shapes, collected from laboratory studies of psychology undergraduate students, against data collected from visitors to online psychology webpages hosted by the same university, and found that online and offline data collection methods gave rise to equivalent results (Krantz, Ballard, & Scher, 1997). Online data collection methodologies entail significant advantages in terms of providing convenient access to larger sample sizes (Krantz & Dalal, 2000). After providing informed consent, participants provided some basic sociodemographic data (including age and gender), and then rated 44 pairs of computer generated images as stimuli (see Figure 1). None of the materials that were provided prior to the Debrief (i.e. recruitment advert and participant information sheet) mentioned hunger as a variable of interest.

The image stimuli were created in DAZ Studio 4.6, and rendered in Lux Render 1.3 to provide realistic light, shadows and reflections. DAZ Studio provides standardised base body models whose dimensions can be manipulated. The base body models have 320 controls to manipulate body shape below the neck, 16 of which change whole-body attributes such as adiposity. To create the female body stimuli, we used the Victoria 6 base model (from the Genesis 2 model set). We used body measurements from data taken from the Health Survey for England (HSE) 2008 dataset (Health & Public, 2013) to modify the female base model to reflect the average body shape (height, leg length, and the circumferences of bust, under-bust, waist and hips) given for White women aged between 18-35. To create the male body stimuli, we used a Michael 6 (Genesis 2) base model. We used the HSE England data to modify the male base model to reflect the average shape (height, waist and hip circumference) given for White men aged between 18-35. These female and male base models provided a baseline, which we then modified to create 11 male and 11 female images that varied systematically from lower to higher adiposity (see Figure 1 for the lightest and heaviest stimulus). Using CGI models has been found to simulate fat distribution in a realistic way as adiposity increases (K. K. Cornelissen, McCarty, Cornelissen, & Tovée, 2017). There were 7 objects (a chair, clock, pot, stool, tea cup, vase, or wine glass), created in small, medium, and large versions, sourced from the standard DAZ library. Each object was manipulated using the global scale modifier which was set to 0.75, 1.0, and 1.25 for the small, medium, and large render respectively. Where appropriate, the image stimuli were pictured sitting upon a side table image that had been sourced from the DAZ online store (see Figure 1).

Participants were presented with pairs of images which consisted of either two male bodies, two female bodies, or two objects. The images within each pair were always identical apart from size (so for instance, the image of a vase was always paired with the image of a vase of a different size), meaning that judgements were based on size rather than other potential variables relating to an image such as lightness or colour. The pose of the image stimuli (with arms extended) matches that commonly used within the literature (see e.g. Brooks, Shelly, Jordan, & J.W. Dixson, 2015; K. K. Cornelissen et al., 2017). The pairs were presented in a random order, and the side on which each object in the pair was presented (left or right) was randomised. The body pairs consisted of every possible pairing of bodies that were three or four size increments apart, totalling 15 pairs of male bodies and 15 pairs of female bodies. Each of the 7 objects was shown in two size combinations (i.e. large paired with medium, or medium paired with small), totalling 14 object pairings, so that there were nearly equivalent numbers of stimuli in each class (male bodies, female bodies, objects).

Each stimulus pair was presented alongside the question, “Which image is more attractive?”. Attractiveness judgements were obtained to match previous work (Swami & Tovée, 2006, 2012; Swami et al., 2006), and the same question was used to evaluate all types of image for consistency. After providing ratings for all the image pairs, participants indicated how hungry, happy, stressed and angry they were on four slider scales that ran from 0 (“Not Very”) to 100 (“Very”). The three questions around mood were included merely to obscure that hunger was the key measure of interest; the order in which the four questions were asked was randomised. We chose to use self-reported hunger because the behavioural, physiological and subjective response systems underlying hunger are only loosely coupled (Wardle, 1987). There is no single true underlying hunger that represents a body’s need for calories, and indeed, the hunger-obesity paradox is the phenomenon that describes the co-existence of the eponymous states (Scheier, 2005). Self-perceived hunger is a valid source of information, and self-reports of perceived hunger on a single rating scale have been used extensively previously (Nelson & Morrison, 2005; Pettijohn II et al., 2009; Swami & Tovée, 2006; Swami et al., 2006; Xu, Schwarz, & Wyer, 2015). Finally, participants were asked if they had eaten in the last hour. The materials are available on the Open Science Framework (https://osf.io/t6kc4/).

Please insert Figure 1 here

2.4 Data analysis

All the analyses were conducted in R 3.3.1 (R Development Core Team, 2008). The analysis plan was pre-registered at https://osf.io/t6kc4/. Our key analyses are Hierarchical Bayesian Regression Models where the stimulus chosen was modeled as a Bernoulli trial (larger stimulus chosen or not), using the "BRMS" package in R (Buerkner, 2015). The random effect structure allowed for the nested structure of our data (individuals nested as two types of sample: online sample and campus sample). We constructed six models with the aforementioned random structure but varying in fixed effects: a null model (intercept-only), a model with all the main effects (hunger, stimulus category and rater gender), three models with two-way interactions (hunger*stimulus category, hunger*gender, gender*stimulus category) and a model with the three-way interaction (hunger*gender*stimulus category). Hunger was centred prior to the analyses. We evaluated model fit for these six models via information criteria (WAIC, LOOIC) (Vehtari, Gelman, & Gabry, 2017). These differences between models in terms of fit can be roughly interpreted according to the following rules of thumb: a difference (Δ) of 1–2 units offers little to no support over a null, a difference of between 4–7 units offers considerable support for an alternative model, and a difference of >10 units offers full support for the alternative model (e.g., Burnham & Anderson, 2002, 2004; Raftery, 1995). The conclusions based on WAIC and LOOIC were consistent with one another, and so we only present the results based on WAIC. The estimation of each model was based on four chains, each containing 4,000 iterations (2,000 for a warm-up) using weakly informative priors, as described by Mastny (2017). We adjusted the δ parameter to .9 to aid model identification (Buerkner, 2015). We examined convergence via $\hat{R}$ (close to 1 with some minor exceptions for some of the random effects; see https://osf.io/t6kc4/). For the final model, we report fixed parameter estimates and 95% credible intervals. Other models, additional analyses, and further checks are reported at https://osf.io/t6kc4/.

3. Results

3.1 Descriptive summary.

The mean hunger level reported on our 0-100 slider scale was 43.88 (*SD*= 30.88). 77 participants reported that they had eaten in the last hour, whereas 109 had not.

Stimuli were presented in pairs. The larger stimulus in each pair was chosen 58% of the time for objects (*Mean Proportion Chosen*= .58, *SD*=.49), 50% of the time for male bodies (*Mean Proportion Chosen*= .50, *SD*=.5), and 52% of the time for female bodies (*Mean Proportion Chosen*= .52, *SD*=.5).

Is reported hunger level related to a reported meal in the last hour?

Those who had eaten in the last hour reported significantly less hunger (M = 25.83, SD= 23.08) than those who had not (M = 56.62, SD= 29.37), $t(181.86)$= 8, p<.0001, Cohen's d= 1.14 with 95% CI= [.83, 1.46].

Hierarchical Bayesian Regression model comparison.

The model selection procedure showed that all models outperformed a null model (WAIC: 10455.96, all ΔWAIC > 10) with the exception of a model with a two-way interaction between gender and hunger (WAIC: 10454.98, ΔWAIC=0.98), indicating that there was little evidence that the effects of hunger on stimuli preferences overall were different for men compared to women. A model with the three-way interaction had the lowest WAIC (10424.42), but this model was on a par with a model with a two-way interaction between stimulus category and hunger on stimulus chosen (WAIC= 10426.51, ΔWAIC=2.09). The two-way interaction model performed marginally better than a main effects model (WAIC= 10427.84, ΔWAIC=3.42). We therefore settled on reporting the main effects model, the model with the two-way interaction (stimulus category and hunger), and the model with the three-way interaction (stimulus category * hunger * gender). These three models all were better supported than the null model, but there is no compelling support to favour one of these three above another.

3.2 Model parameters from the main effects model.

Table 1 shows the main (fixed) effects for the model. The main effects model supported a hunger effect: hungrier participants chose larger stimuli more often (see Figure 2). There was also a main effect of stimulus type: participants chose larger stimuli more often in the object category than they did in either the male or female body category (see Figure 3). There was no effect of gender on whether or not a larger stimulus was chosen.

Please insert Figures 2 and 3, and Table 1, about here

3.3 Model parameters from two-way interaction model.

The interaction model again showed main effects of hunger and stimulus category on the stimulus chosen (Table 2, Figures 2-3). The 95% Bayesian Credible Intervals do not overlap with 0. These effects were however further qualified by the interaction between stimulus category and hunger (Figure 4).

Please insert Figure 4, and Table 2, about here

3.4 Model parameters from three-way interaction model.

The model with the three-way interaction effect (Table 3) showed that the 95% credible interval for the contrast between the reference category (Hunger centered *Gender: Female* Category: Object) and Hunger centered *Gender: Male* Category: Female body did not contain 0. Thus, the effect of hunger on judgments of female bodies as opposed to objects differed between women and men. While men's judgments of female bodies and objects were affected by hunger in a similar way (bigger is more preferred when hungry), for women hunger led them prefer larger female bodies but had no discernible effect on their judgments of objects. As shown in Figure 5, for men the effects of hunger did not differ much by stimulus category. In contrast, for women hunger particularly affected judgments of female bodies but those of male bodies and objects to a lesser extent.

Please insert Figure 5 and Table 3 about here

This model predicted that women who were hungry (1SD above the mean hunger level) would choose the larger female body in 59% of the trials. In contrast, those women who reported being satiated (1SD below the mean hunger level) would choose the larger body only in 42% of the trials.

4. Discussion

Previous research had documented that greater hunger corresponds to greater approval of bigger women's bodies in test settings, and linked this to cross-cultural differences in judgements of women's body size (e.g. Nelson & Morrison, 2005; Swami & Tovée, 2006; Swami et al., 2006). However, this previous work focussed predominantly on judgements (and especially men's judgements) of women's bodies, rather than testing the boundaries of the effect: i.e. whether hunger similarly affected other stimuli. Without that contrast, a claim that hunger influences judgements of women's body size risks being misleading, because it implies that the effect is specific to women's bodies. In the current study therefore, we compared men's and women's judgements of stimuli consisting of men's and women's bodies (manipulated to vary in adiposity) and objects (manipulated to vary in size).

We found a main effect of hunger, such that participants who were hungrier were more likely to select larger stimuli as more attractive. We also found evidence that hunger had differentiated effects on the different types of stimuli (men's bodies, women's bodies, and objects): hunger had the most substantial influence on judgements of women's bodies. Further, we found evidence that the effects of hunger on the judgements of the different types of stimuli varied depending on whether men or women were making the judgements. For men, hunger seemed to have similar effects across the different stimuli: hungry men had stronger preferences for bigger men's bodies, women's bodies, and objects. When women were making the judgements, in contrast, the effects of hunger were stronger for women's bodies than for objects.

Our demonstration that hunger's effect on judgements of women's body fatness was more dramatic than its effect on judgements of other stimuli, including men's body fatness (see Figures 4 and 5), provides support for the premise that this effect of hunger has functional significance. There indeed appears to be some sort of boundary between hunger's effects on women's bodies compared to other stimuli, and on bodies compared to objects, although it is worth noting that hunger also appears to affect judgements of objects, something which we address below. The Insurance Hypothesis (Nettle et al., 2017) and related research ideas (J. L. Anderson et al., 1992; see e.g. Brown & Konner, 1987; C. R. Ember et al., 2005) explain that the prevalence of bigger bodies (especially women's bodies) under conditions of hunger is an adaptation to counter possible future shortages in food supply. It has been argued that hunger-linked shifts in judgements of ideal body size are a counterpart to this adaptation (e.g. Nelson & Morrison, 2005, ' @Swami2006; Swami et al., 2006). This set of findings adds support to the idea that previous lab-based findings of hunger's impact upon judgements of women's body weight constitute part of an adaptation to potential nutritional shortfall.

Another explanation that has been put forward for the relationship between hunger and body ideals is the Environmental Security Hypothesis (Pettijohn II & Jungeberg, 2004; Pettijohn II & Tesser, 1999). This hypothesis states that perceptions of the attractiveness of different bodies may depend in part on how secure people feel in their environment: risky environments may cause people to find greater appeal in general indicators of maturity, including increased body weight, as this might indicate increased ability to deal with threat. Problematically, the Environmental Security Hypothesis does not provide a precise definition of environmental threat, maturity indicators, or the contexts in which preferences might change. In work on body size ideals, the originators of the Environmental Security Hypothesis have operationalised environmental threat with reference to hunger (Pettijohn II et al., 2009) and also to the difficulty of social and economic conditions (Pettijohn II & Jungeberg, 2004), whereas others have relied upon snake exposure, retrospectively-recalled childhood mistreatment, and economic or existential threat measures (Fletcher & Tefft, 2013; Reeve et al., 2016; Webster, 2008). More mature women's bodies have been characterised as those that are taller and heavier, with larger waists, and lesser curvaceousness (larger waist-to-hip ratio, and smaller bust-to-waist ratio) (Pettijohn II & Jungeberg, 2004; Pettijohn II et al., 2009). However, there is a discrepancy in the literature around whether the Environmental Security Hypothesis predicts that, under conditions of adversity, female bodies should be preferred if they have lower body fat and BMI (Pettijohn II & Jungeberg, 2004), or higher body fat (Reeve et al., 2016). Our bigger female body stimuli follow the specification given by Pettijohn and colleagues for the most part (Pettijohn II & Jungeberg, 2004; Pettijohn II & Tesser, 1999), in that our bigger female bodies are heavier, with larger waists and larger waist-to-hip ratios, and smaller bust-to-waist ratios, all of which characterise the specified mature female body that should be preferred under conditions of higher adversity, but our female body stimuli are unable to comply with the discrepant recommendations around body fat, and in our study, the bigger female bodies had higher body fat and BMI.

In line with predictions of the Environmental Security Hypothesis, previous research has found that women epitomising sexual attractiveness were indeed more likely to be taller and heavier, with larger waists and waist-to-hip ratios, and smaller bust-to-waist ratios and BMIs, when more difficult social and economic times arose during a survey covering the final four decades of the 20th Century (Pettijohn II & Jungeberg, 2004). At the individual level, men who were about to eat dinner selected a heavier weight category for their stated ideal romantic partner than men who had just eaten dinner, although women's preferred weight categories did not differ according to whether they had eaten or not (Pettijohn II et al., 2009); the authors argued that this gender difference could be because women's bodies are more central than men's bodies to their mate quality (Pettijohn II et al., 2009).

Our findings are arguably consistent with the Environmental Security Hypothesis, in that hunger appeared to be most influential on judgements of female bodies, and somewhat influential on judgements of male bodies. However, the Environmental Security Hypothesis is less satisfying as an explanation when we consider that men's bodies and objects appeared to be influenced similarly by hunger. In any case, our data are not the only challenge to the Environmental Security Hypothesis. For instance, contrary to the Environmental Security Hypothesis, women epitomising sexual attractiveness were more likely to be taller and heavier during prosperous times according to one of two different economic measures, although they were also more likely to have lower BMIs during times of existential threat (Webster, 2008). Similarly, men who reported having experienced more childhood mistreatment were more likely to have obese female partners during young adulthood, consistent with the Environmental Security Hypothesis, whereas women reporting more childhood mistreatment were more likely to have thin male partners, contrary to the Environmental Security Hypothesis (Fletcher & Tefft, 2013).

Although hunger had the biggest influence on judgements of bodies (and particularly women's bodies), we also found that hungry people were more likely to select bigger objects as more attractive. Other work has linked hunger to a greater desire to have various objects, to the purchase of more non-food items and greater financial spend overall on non-food items in a department store, and to taking more samples of non-food objects (binder clips) (Xu et al., 2015). That is, hunger seems to increase acquisition-related concepts and behaviours, influencing behaviours in domains that are irrelevant to reducing hunger (Xu et al., 2015). This phenomenon might help explain why our hungry participants preferred the bigger stimuli in general; hunger appears to motivate people towards bountifulness more generally. However, previous work has not found an impact of hunger on people's subjective evaluations of various objects (Xu et al., 2015). Further, a set of studies by Swami and colleagues (2006) asked men to judge how aesthetically pleasing were images of anvils of five different sizes, or empty milk bottles of five different sizes, or milk bottles of five different fill levels (empty to full), and also asked the men how hungry they were. None of that work found evidence that hunger influenced judgements of these other types of objects. Our study used more participants, more stimuli, a forced-choice design, and a more powerful analysis, and accordingly should have been better able to detect a small effect of hunger on object size preference. Accordingly, it might be that the previous null results constitute a Type 2 error, although it is also possible that judgements of attractiveness (our study) are differently affected by hunger compared to judgements of how aesthetically pleasing objects are (Swami et al., 2006), or how much people like or react favourably to different objects (Xu et al., 2015).

We did not anticipate that the influence of hunger would be stronger for women's bodies than objects when it came to women's judgements but not men's. This difference could be explained very prosaically, in that women might be especially attentive to the task, and/or to very subtle differences in fatness in other women's bodies, given the special importance of body adiposity to women's self image and self-esteem (Grogan, 2016). Indeed, the object stimuli are perceptually dissimilar from the body stimuli in many ways, including the perceptual difference in size of the two stimuli within a pair, which complicates a direct comparison with body size judgements. Further, it is worth noting that hunger certainly does not explain all variation over time in body size preference; for instance, in Nicaraguan villages, television consumption was found to have a greater influence on body size judgements than nutritional status (Jucker et al., 2017).

One limitation of our study is that we asked people to judge bodies and objects in the same sitting, which might have set up response biases that would not otherwise have existed. That is, perhaps our hungry participants recognised that they were tending to select bigger bodies, or bigger female bodies, within each pair, and so continued this pattern of responses when they viewed objects, or male bodies. To determine whether that explanation could be ruled out, a future study might employ our methodology but show participants only the male body stimuli, or only the object stimuli. Further, although we used CGI models to create body stimuli that simulate fat distribution in a realistic way as adiposity increases, we do not know which specific aspects of our stimuli were particularly salient to participants when they were making their judgements; body attractiveness judgements rely on cues in concert and arise from trait interactions (see e.g. Brooks et al., 2015; A. K. Hill et al., 2013). A perennial limitation of studies that, like ours, asked participants to rate stimuli in a lab context is that we can only infer how this might translate to real-world behaviour (Baumeister, Vohs, & Funder, 2007). Finally, in asking people to rate "attractiveness", we are focussing on just one aspect of their perceptions, whereas other aspects (that we did not explore) are also valuable. Having said that, our focus on perceived attractiveness allows our study to be easily assimilated with the existing studies that examine hunger and judgements of attractiveness (reviewed above), and indeed into the very broad literature on attractiveness judgements of others (reviewed in e.g. Roberts & Little, 2008).

In sum, our data present a picture whereby larger sizes of stimuli in general, and women's bodies in particular (especially when judged by women), are preferred more under conditions of hunger. This pattern can be explained by both the Insurance Hypothesis and related explanations, combined with the tendency for hunger to promote acquisition; these explanations are not mutually exclusive, and could influence perception in parallel. Future work might seek to uncover whether there are specific aspects of body size (e.g. those deriving from fat, muscle, height, and frame) that are particularly influenced by hunger, to provide material to further develop the theoretical framework in which to position these findings.

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Table captions

Table 1. Fixed parameter estimates and concomitant statistics for main effects model

Table 2. Fixed parameter estimates and concomitant statistics for interaction model

Table 3. Fixed parameter estimates and concomitant statistics for three-way interaction model

Table 1

Fixed parameter estimates and concomitant statistics for main effects model

	Variable	Estimate	Std.error	Lower.CI	Upper.CI
1	Intercept	0.2827	0.0876	0.1390	0.4265
2	Gender: Male	0.1155	0.1016	-0.0500	0.2825
3	Hunger (centered)	0.0078	0.0019	0.0047	0.0110
4	Category: Female body	-0.2363	0.0626	-0.3382	-0.1348
5	Category: Male body	-0.3076	0.0601	-0.4071	-0.2096

Table 2

Fixed parameter estimates and concomitant statistics for interaction model

	Variable	Estimate	Std.error	Lower.CI	Upper.CI
1	Intercept	0.3336	0.0746	0.2100	0.4545
2	Hunger (centered)	0.0058	0.0025	0.0017	0.0099
3	Category: Female body	-0.2353	0.0639	-0.3408	-0.1303
4	Category: Male body	-0.3073	0.0605	-0.4063	-0.2088
5	Hunger (centered) $*$Category: Female body	0.0050	0.0022	0.0012	0.0086
6	Hunger (centered) $*$Category: Male body	0.0016	0.0021	-0.0019	0.0051

Table 3

Fixed parameter estimates and concomitant statistics for three-way interaction model

	Variable	Estimate	Std.error	Lower.CI	Upper.CI
1	Intercept	0.2712	0.0898	0.1236	0.4189
2	Gender: Male	0.0796	0.1157	-0.1107	0.2707
3	Hunger	0.0019	0.0034	-0.0037	0.0075
4	Category: Female body	-0.2530	0.0766	-0.3795	-0.1279
5	Category: Male body	-0.2990	0.0723	-0.4183	-0.1800
6	Gender: Male ∗Hunger	0.0079	0.0051	-0.0006	0.0164
7	Gender: Male ∗Category: Female body	0.1163	0.1036	-0.0544	0.2853
8	Gender: Male ∗Category: Male body	0.0025	0.0996	-0.1648	0.1623
9	Hunger ∗Category: Female body	0.0089	0.0031	0.0038	0.0141
10	Hunger ∗Category: Male body	0.0026	0.0029	-0.0022	0.0074
11	Hunger ∗Gender: Male ∗Category: Female body	-0.0094	0.0046	-0.0169	-0.0019
12	Hunger ∗Gender: Male ∗Category: Male body	-0.0024	0.0044	-0.0096	0.0048

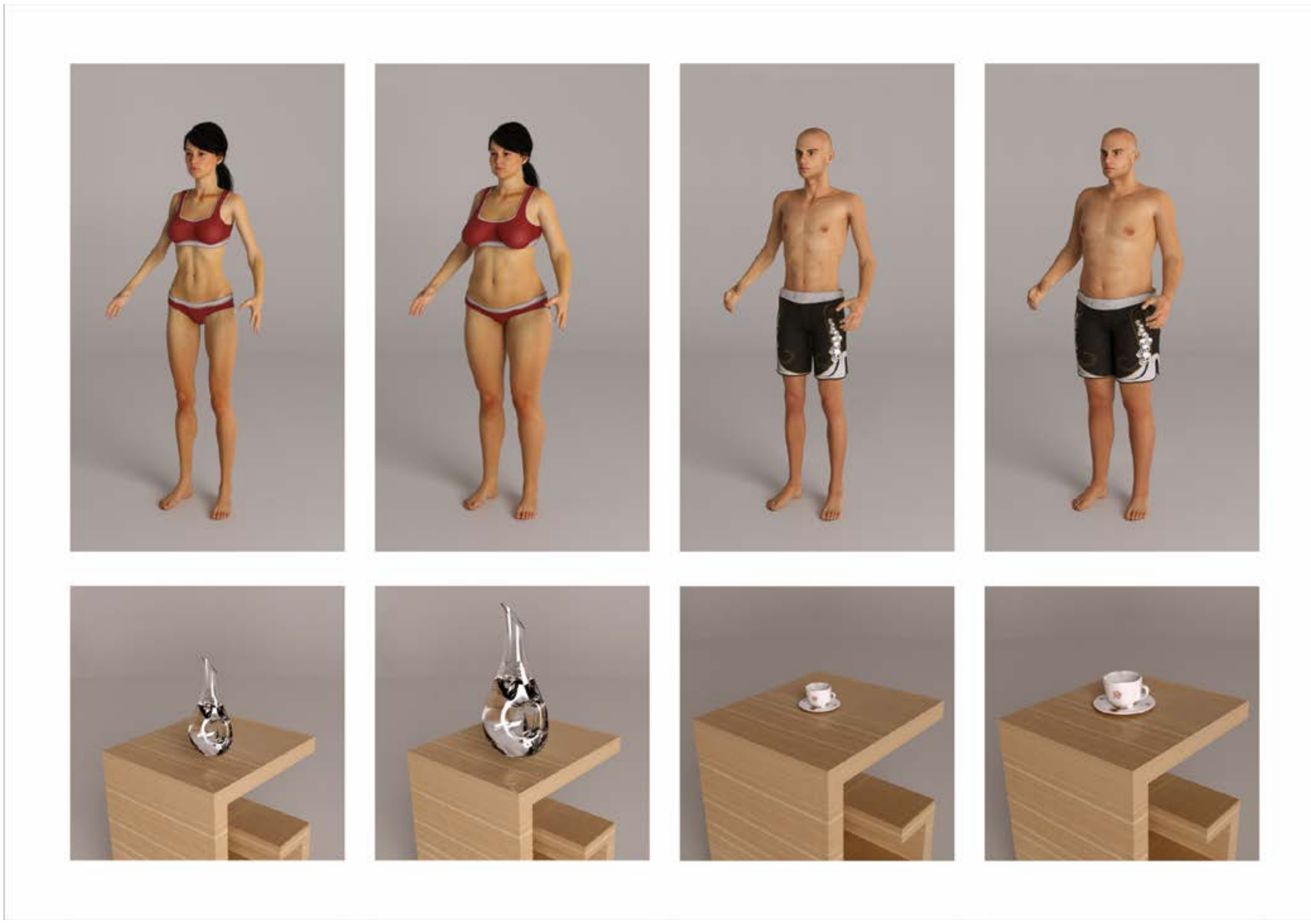

Figure 1. Examples of male body, female body, and two types of objects stimuli. The smallest and largest stimulus of each type is shown.

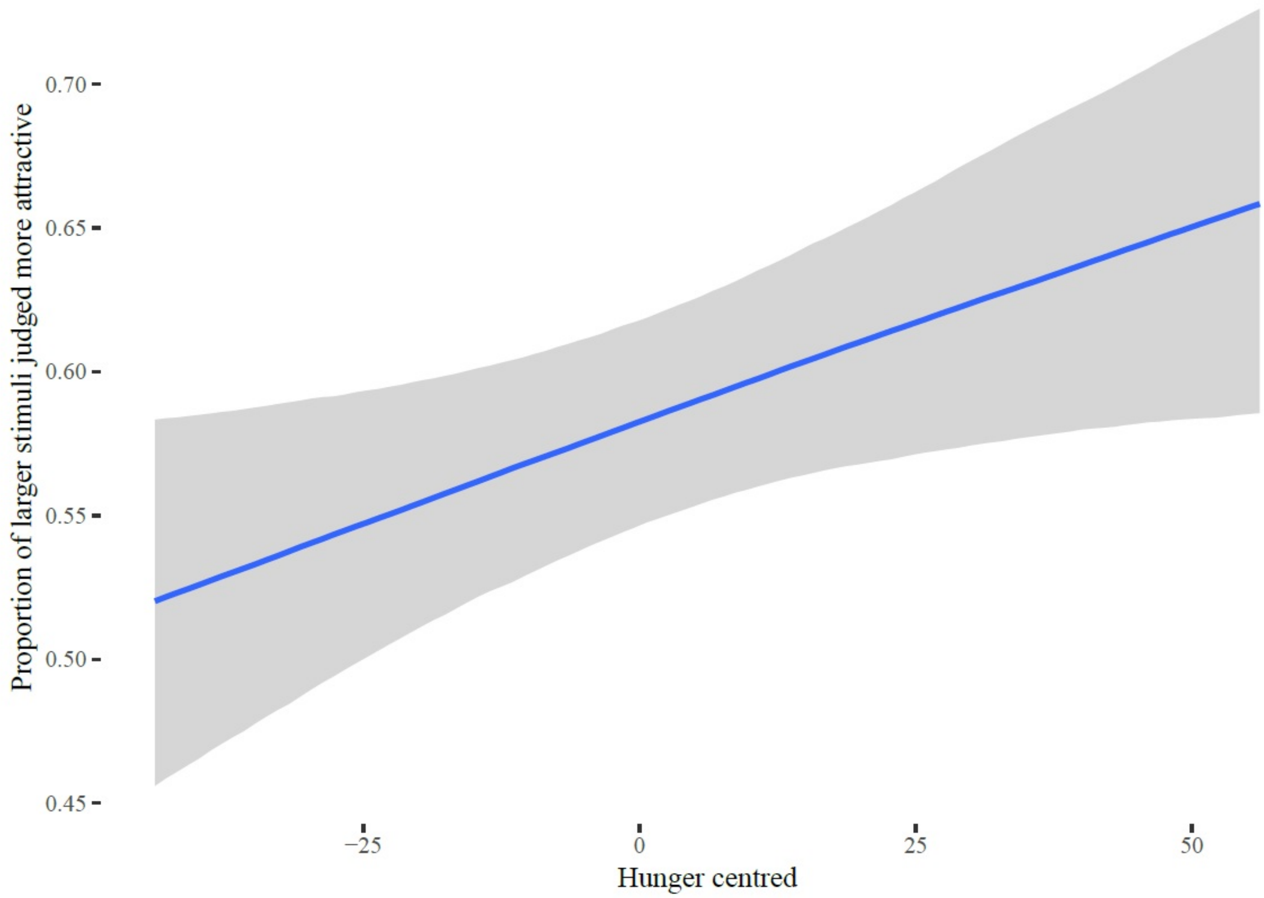

Figure 2. Marginal effects plot of hunger level (centred) against proportion of larger stimuli judged as more attractive, with 95 % confidence interval.

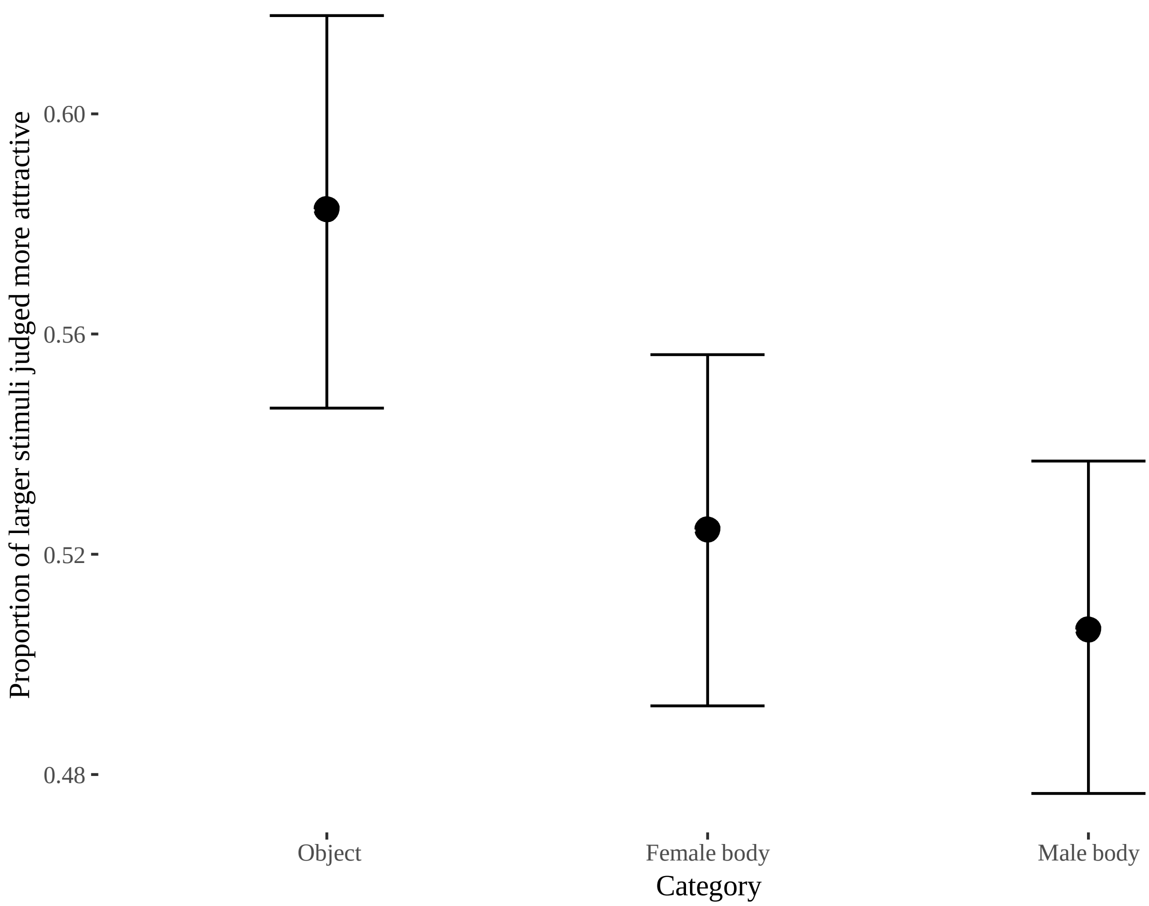

Figure 3. Marginal effects plot of the proportion of larger stimuli judged as more attractive per category, with 95 % confidence interval.

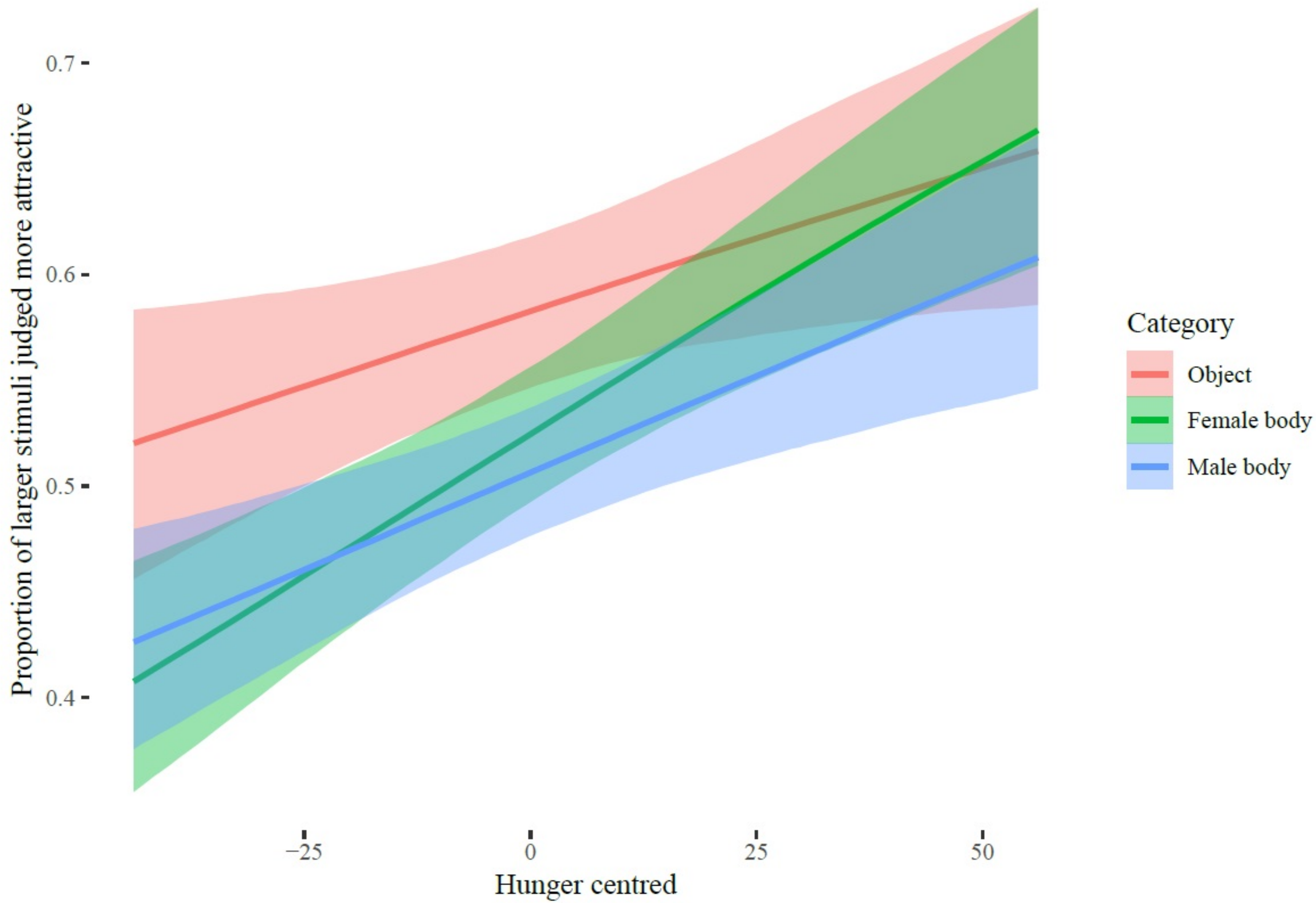

Figure 4. Marginal effects plot of the relationship between hunger and proportion of larger stimuli judged as more attractive, separated by category, with 95 % confidence interval.

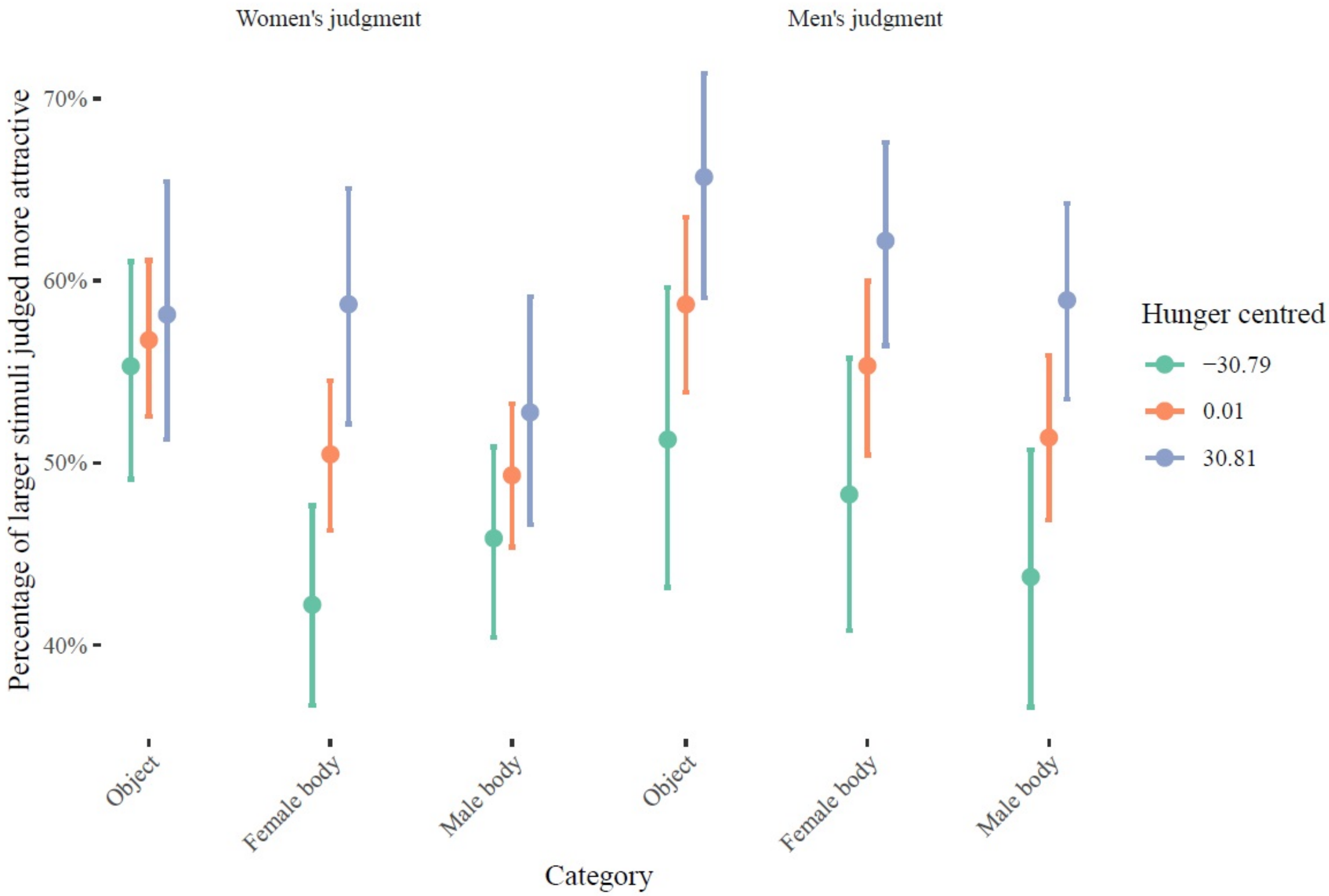

Figure 5. Marginal effects plot for the three-way interaction (means +/-1SD for hunger centred), with 95 % confidence interval.