Article:

Carey, Mark Andrew, Knight, Ruth Elizabeth and Preston, Catherine Elizabeth Jane orcid.org/0000-0001-7158-5382 (2019) Distinct Neural Response to Visual Perspective and Body Size in the Extrastriate Body Area. Behavioural Brain Research. 112063. ISSN 0166-4328

https://doi.org/10.1016/j.bbr.2019.112063

Distinct Neural Response to Visual Perspective and Body Size in the Extrastriate Body Area

Mark Carey [1*], Ruth Knight [1], and Catherine Preston [1]

[1] *Department of Psychology, University of York, York, United Kingdom*

***Corresponding author:**

Mark Carey
Department of Psychology
University of York
Heslington
York, YO10 5DD
United Kingdom
Email: mac541@york.ac.uk

Declarations of Interest: None

Abstract

Neuroimaging research has independently implicated the extrastriate body area (EBA) in distinguishing between different visual perspectives and morphologies of bodies within visual processing. However, the combined processing of these physical attributes towards neural EBA response remains unclear, and may be crucial in influencing higher-order, aesthetic evaluation of bodies. Indeed, EBA alterations amongst eating disorder patients have been associated with disturbances in body image, and disruption to EBA activity amongst healthy individuals shown to influence aesthetic evaluations made towards bodies. Therefore, the present study used images of slim and large female bodies viewed from egocentric and allocentric perspectives, to investigate neural EBA response in healthy females (*N*=30). In addition, participants provided behavioural aesthetic and weight evaluations of all model stimuli. Results revealed an interaction, bilaterally, between visual perspective and body size in EBA activity, with multi-voxel pattern analysis revealing distinct neural patterns between the four conditions. However, EBA activity did not relate to non-clinical eating disorder psychopathology. No direct relationship was found between EBA activity and behavioural evaluations of model stimuli; however, a whole brain analysis revealed that higher-order, prefrontal regions were associated with cognitive evaluations of large bodies. Taken together, our results suggest that the EBA is an integral core region in discriminating between multiple physical attributes of the body, which is likely to provide important information to higher-order brain regions which make aesthetic evaluations towards bodies.

Keywords: Extrastriate Body Area; MVPA; Visual Perspective; Body Size; Aesthetic Evaluation

1. Introduction

Human body perception relies upon the concurrent processing of multiple inputs of sensory information, allowing us to rapidly identify features such as the gender, posture, or identity of bodies, whilst also discriminating others' bodies from our own. Recent research has identified neural correlates of visual body processing within a dedicated cortical region known as the extrastriate body area (EBA) (Downing, Jiang, Shuman, & Kanwisher, 2001), located bilaterally in the lateral occipito-temporal cortex, which responds selectively to human bodies and body parts compared with inanimate objects or faces (Downing & Peelen, 2016; Peelen & Downing, 2007).

Traditionally, the EBA has been implicated as an early category-selective region in visual body perception (Downing et al., 2001), responsible for the local processing of basic perceptual properties of bodies (Peelen & Downing, 2007). However, the precise role of the EBA in visual body processing remains contested (Downing & Peelen, 2011), with conflicting proposals for the function of this region in representing identity (Hodzic, Muckli, Singer, & Stirn, 2009; Myers & Sowden, 2008), motor control (Astafiev, Stanley, Shulman, & Corbetta, 2004; Kontaris, Wiggett, & Downing, 2009), emotion (Peelen & Downing, 2007; van de Riet, Grèzes, & de Gelder, 2009), and action goals (Kühn, Keizer, Rombouts, & Hommel, 2011; Pierno et al., 2009; Zimmermann, Verhagen, de Lange, & Toni, 2016) of bodies. Interestingly, functional EBA activity has been shown to be modulated by the visual perspective of whole bodies or body parts, irrespective of body identity (own/other body) (Chan, Peelen, & Downing, 2004; Saxe, Jamal, & Powell, 2006), with evidence of increased right EBA activation in response to allocentric (typical view of others' bodies) perspectives of bodies compared with egocentric (typical view of own body) perspectives (see also, Arzy, Thut, Mohr, Michel, & Blanke, 2006).

In addition, evidence has highlighted the role of the EBA in processing body morphology, such as shape and size (Downing & Peelen, 2016; Urgesi, Calvo-Merino, Haggard, & Aglioti, 2007; Urgesi et al., 2012). Importantly, the perception of body size in visual brain regions is likely to provide critical information for higher-order, socio-cognitive assessments of bodies such as perceived attractiveness (Di Dio, Macaluso, & Rizzolatti, 2007). Indeed, increased EBA activation has been shown to be associated with perceived body form and posture (Arzy et al., 2006; Cross, Kirsch, Ticini, & Schütz-Bosbach, 2011). However, the specific role of the EBA towards such aesthetic evaluations of bodies remains unclear. It has been traditionally argued that the EBA plays an important role within a distributed network in body perception, with such visual processing communicating with prefrontal areas of the brain which make higher-order socio-cognitive inferences towards bodies (Peelen & Downing, 2007). However, recent research has supported a more direct, dynamic role of the EBA in the aesthetic evaluation of bodies (Calvo-Merino, Urgesi, Orgs, Aglioti, & Haggard, 2010), such that disruption within this area, using repetitive Transcranial Magnetic Stimulation (rTMS), was shown to have a direct influence towards aesthetic body judgements (Calvo-Merino et al., 2010; Cazzato, Mele, & Urgesi, 2014, 2016; Cazzato, Mian, Serino, Mele, & Urgesi, 2015). Thus, research remains equivocal in determining whether the EBA plays a role primarily in discriminating between physical information of bodies, or is directly involved in higher-order, socio-cognitive evaluation of bodies.

Despite evidence highlighting the role of the EBA in processing visual perspective and body size independently, it is yet to be understood how the combined processing of such visual inputs interact to modulate functional EBA activity. In addition, fMRI studies which identify differences in neural response to visual perspective have exclusively employed univariate analyses (Chan et al., 2004; Saxe et al., 2006), therefore it is unclear whether changes in overall EBA activation also influences the pattern of response in this region. Such changes in EBA activity in response to these combined physical attributes may be key in influencing aesthetic evaluations made towards bodies (Cazzato et al., 2014), particularly body image which encompasses perceptual and attitudinal components of one’s own body representation (de Vignemont, 2010). This research question is particularly important amongst those who experience perceptual distortions of body size, such as individuals suffering with an eating disorder (ED) (Mai et al., 2015; Mohr, Rickmeyer, Hummel, Ernst, & Grabhorn, 2016; Suchan et al., 2013). Indeed, recent neuroimaging research has directly linked atypical visual processing and body misperception within the EBA with disturbances in body image amongst ED patients (Suchan et al., 2013; Suchan, Vocks, & Waldorf, 2015), with evidence of reduced functional (Uher et al., 2005) and structural (Suchan et al., 2010) EBA activity amongst ED patients compared with healthy controls (see also, Vocks et al., 2010, 2011). This suggests that alterations in EBA functioning, as a core region in visual body processing, may be implicated in the perceptual component of body image disturbances (Castellini et al., 2013; Groves, Kennett, & Gillmeister, 2017), facilitating its development and maintenance within EDs (Urgesi et al., 2012). Crucially, it remains unclear whether such perceptual or neural alterations are a cause or consequence of EDs (Frank, 2013; Hay & Sachdev, 2011; Stice, Marti, & Rohde, 2010). Therefore, it is critical to undertake controlled experiments within the non-clinical, healthy population to study brain regions that are implicated in EDs and investigate links between body perception and ED vulnerability (Berg, Frazier, & Sherr, 2009; Eisenberg, Nicklett, Roeder, & Kirz, 2011; Preston & Ehrsson, 2014, 2016).

It must be noted that neural regions associated with the perception of bodies are not restricted to the EBA, with evidence highlighting an accompanying core body-selective region in the fusiform body area (FBA), found ventrally in the fusiform gyrus (Peelen & Downing, 2005; Schwarzlose, Baker, & Kanwisher, 2005). The FBA is also regarded as an important region in extracting body-related information, which is argued to operate within a wider network towards higher-level, social evaluations of bodies (Downing & Peelen, 2011). However, given the converging evidence above, which highlights the close association between both structural and functional EBA activity with body image disturbances amongst EDs, our primary region of interest was focused towards the lateral occipito-temporal cortex within the present study.

In brief, the present study investigated differences in functional EBA activity following presentation of large and slim female bodies, viewed from egocentric and allocentric perspectives. Based upon previous research, we hypothesised that EBA activity will be increased for allocentric perspectives compared with egocentric perspectives amongst healthy females. However, it was expected that EBA neural response will be further modulated by the combined processing of both visual perspective and body size. In conjunction with the present hypotheses directed towards EBA activity, we acknowledge that other neural regions may contribute to the perception and aesthetic evaluation of bodies; therefore, an exploratory whole brain analysis was also run to assess whether any significant activations were observed outside of our defined region of interest. In addition to univariate analyses, we used multi-voxel pattern analysis (MVPA) to compare the pattern of neural response to each of our four conditions. Moreover, we wished to investigate whether EBA activity is associated with non-clinical ED psychopathology in healthy individuals, without the confounding issues surrounding a clinical ED diagnosis. Finally, behavioural ratings of aesthetic and weight evaluations of all body stimuli (recorded outside the scanner) were investigated in relation to EBA activity. If the EBA has a functional role in higher-level, socio-cognitive evaluation of bodies in visual processing, it was hypothesised that behavioural aesthetic and weight ratings would positively correlate with EBA activity.

2. Methods

2.1 Participants

32 female participants, recruited from the University of York, completed a single 1-hour study session. Data from two participants were excluded due to uncorrectable fMRI motion artefacts, therefore data from 30 participants (Mean age = 19.40, SD ± 1.25, range = 18-24) was analysed (see Table 1). All participants were right-handed, with normal or corrected-to-normal vision and no current or previous psychological or neurological disorders. All participants gave informed, written consent to take part in the study. The study received ethical approval from York Neuroimaging Centre (YNiC) Ethics Committee and was conducted in accordance with the Declaration of Helsinki.

2.2 Experimental Stimuli

Stimuli were greyscale photograph images of 10 female bodies, seated on a chair with hands placed by their sides. Real-life bodies were used as stimuli in the present experiment, providing a more ecologically valid stimulus set compared with previous methodologies (Downing et al., 2001; Uher et al., 2005). All model stimuli were photographed against a black background, and wore a white fitted t-shirt and jeans, with no other defining features. Images were taken using an SJCAM camera (SJ4000, Resolution 1920 x 1080), scaled to 460 x 460 pixels. The heads of all stimuli were excluded to ensure that the identity of each model was anonymous. Importantly, research has highlighted that headless bodies are suitable stimuli for investigating body-selective perceptual processing, without evoking face-processing mechanisms (Groves, Kennett, & Gillmeister, 2018). Each model was photographed from an egocentric (first-person) and allocentric (third-person) visual perspective (see Fig. 1a). Egocentric perspectives were taken by placing the camera in line with each models' eyeline and facing the lens down towards their lap. Allocentric perspectives were taken from a distance of 1.5 metres from the model. A large database of stimuli was collected prior to the experiment, with images selected based on a body mass index (BMI) of each model. Stimuli with a BMI < 25 were categorized into the Slim (*N* = 5) group and stimuli with a BMI > 25 were categorized into the Large (*N* = 5) group. Slim stimuli models had a group mean BMI of 18.52 (*SD* ±1.37, range = 16.45-20.30), and large stimuli models had a group mean BMI of 27.61 (*SD* ± 1.07, range = 25.91-28.58). A significant difference in BMI was established between groups (t (8) = -11.66, p <.001). Images were presented, and responses were recorded, using *PsychoPy2* (Peirce, 2007) for both the fMRI and behavioural experiment.

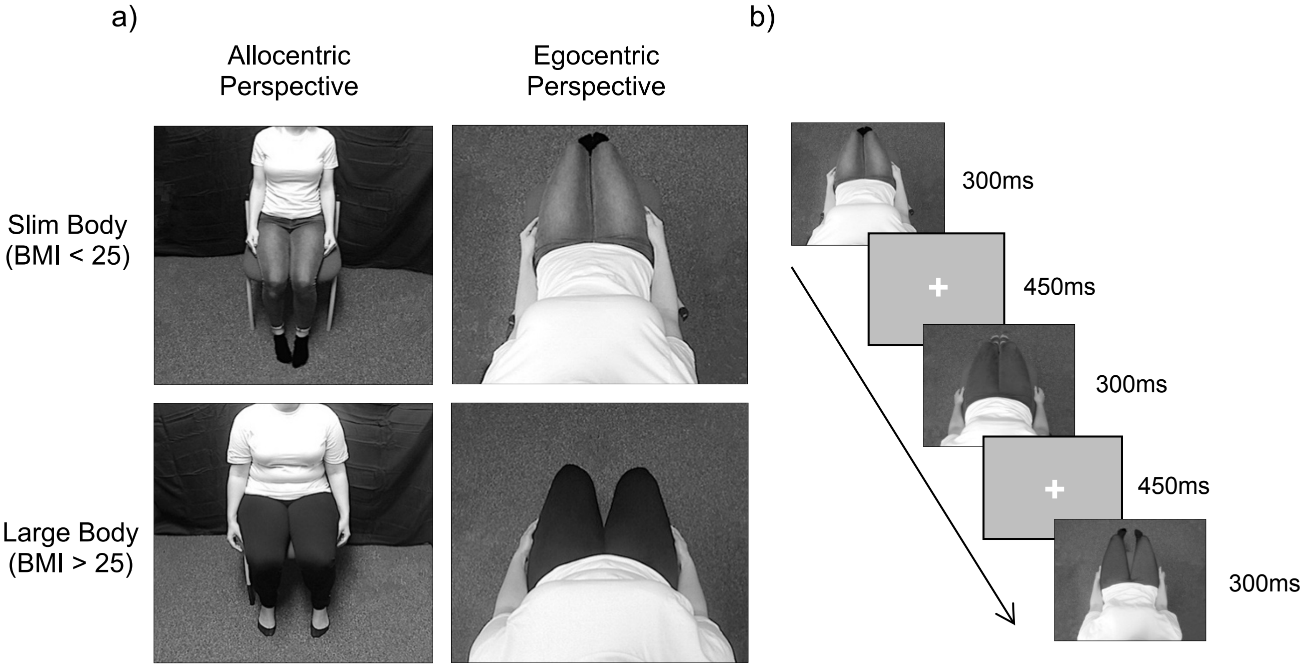

Fig. 1 - a) Sample stimuli from the experiment. Columns show the two visual perspectives (Allocentric/Egocentric), and rows show the two body sizes (Slim/Large). b) time series of experimental stimuli per block.

2.3 fMRI Experiment

fMRI data were acquired using a GE 3 Tesla Signa HD Excite MRI scanner at York Neuroimaging centre (YNiC), University of York, with an eight-channel phased array head coil tuned to 127.4 MHz. For each participant, a gradient-echo echo-planar imaging (EPI) sequence was used to acquire 38 contiguous axial slices (TR = 3000ms, TE = 32.7ms, flip angle = 90°, FOV = 288 x 288mm, matrix size = 128x128, slice thickness = 3mm). Individual stimuli in all functional runs were presented for 300ms with a 450ms inter-stimulus interval (ISI) (see Fig. 1b), based on a previously published design (Chan et al., 2004). The total duration for each run was 387 seconds. Stimuli were presented on a 40 x 23 cm projector screen, at a viewing distance of 57cm, at the rear of the scanner, and viewed via a tilted mirror placed immediately above the participant’s head.

2.3.1 EBA Localizer

Prior to experimental runs, participants first completed a block-designed localizer run which was used to localize the EBA for each participant, using validated stimuli (Downing et al., 2001; Peelen & Downing, 2005). One block included greyscale images of whole bodies (excluding heads) in a variety of postures, and another block included greyscale images of chairs (http://pages.bangor.ac.uk/~pss811/index.html). Each block comprised 5 exemplar images from each category, with 20 images presented within each block. The order of the stimuli within each block was randomized, with a 6-second white fixation cross between each block. Within blocks, each stimulus was presented for 300 ms, with an ISI of 450 ms. There was a total of 20 15-second blocks for the entire run; 8 repetitions of each category were presented, with blocks 1, 6, 11 and 16 fixation-only baselines. Participants performed a "one-back" repetition detection task during all localiser and experimental runs, in which they were required to press a button on the response box when two identical stimuli appeared in immediate succession within the block, which occurred once per block.

2.3.2 Experimental Task

The experimental task followed an identical procedure as the localizer task. Two block-designed runs, containing four conditions (Slim/Large x Egocentric/Allocentric) of greyscale body stimuli were used for the experimental task (see Fig. 1). Block design, stimulus presentation time, ISI, and participant task was identical to the EBA localizer run.

2.4 Behavioural Measures

2.4.1 Aesthetic and Weight Evaluations

Following the fMRI session, participants were asked to make aesthetic and weight evaluations of each of the 20 stimuli presented in the fMRI experimental task, outside of the scanner. Stimuli were presented in a randomized order within each block, with all blocks counterbalanced across participants to control for any visual adaptation (Brooks, Mond, Stevenson, & Stephen, 2016). For aesthetic evaluation blocks, stimuli were presented in the centre of the screen, with a prompt *"Please rate the* *attractiveness of this model"* appearing at the top of the screen. Below the image, participants were presented with a visual analogue scale (VAS), anchored by *"Very Unattractive"* and *"Very Attractive"*. Weight evaluation blocks were identically presented, with the different prompt as *"Please rate the weight of this model"*, anchored by *"Very Underweight"* and *"Very Overweight"* (Cazzato et al., 2014; Cazzato, Siega, & Urgesi, 2012). Numeric values of the scale were not presented to participants, but each VAS ranged from 0 to 100.

2.4.2 Eating Disorder Examination Questionnaire (EDE-Q)

The EDE-Q is a 28-item questionnaire used as a self-report measure of eating disorder psychopathology (Fairburn & Beglin, 1994) amongst clinical and non-clinical populations. The questionnaire assesses disordered eating attitudes and behaviours within the past 28 days, in which there are four subscales: Restraint (5 items), Eating Concern (5 items), Shape Concern (8 items), and Weight Concern (5 items), with a 'Global Score' calculated from the average of the four subscales. Items are rated along a 7-point Likert scale, ranging from 0 to 6, in which higher scores signify higher ED psychopathology. This scoring is with the exemption of six items measuring frequency of eating disorder behaviours within the past 28 days, such as binge episodes, laxative misuse and self-induced vomiting. Such disordered eating behaviour items do not contribute to the above subscale scores and were not used in the present study, with ED psychopathology assessed based on the 22-item attitudinal scores (NB. Item 8: *Preoccupation with Shape or Weight* included in Shape Concern and Weight Concern subscales). Overall, the EDE-Q has good internal consistency, with Cronbach's alpha ranging from .78 to .93 in a non-clinical sample (Berg, Peterson, Frazier, & Crow, 2012; Peterson et al., 2007). The current data had a Cronbach's alpha of .89. EDE-Q scores within the present study are shown in Table 1, alongside normative EDE-Q data of UK females within the non-clinical population (Carey et al., 2019) to provide a context within which to interpret the present sample of females.

Table 1. Total means and (standard deviations) of participant age, BMI and eating disorder psychopathology (*N*=30)

Measure	**Present Study** **(N=30)**	**UK EDE-Q Norms (Carey et al., 2019) (N=851)**
Age	19.40 (1.25)	19.77 (1.73)
BMI	22.46 (3.08)	22.60 (4.11)
Restraint	1.64 (1.30)	1.37 (1.34)
Eating Concern	1.07 (.99)	1.03 (1.11)
Shape Concern	2.64 (1.63)	2.51 (1.58)
Weight Concern	2.16 (1.64)	2.10 (1.57)
EDE-Q Global	1.88 (1.64)	1.75 (1.25)

2.5 Data analysis

2.5.1 fMRI analysis

Univariate analysis of the fMRI data was undertaken using FEAT (FMRI Expert Analysis Tool) version 6.00 (http://www.fmrib.ox.ac.uk/fsl). The first 9 seconds (3 volumes) from all scans were discarded to avoid T1 saturation. MCFLIRT (FSL) motion correction, spatial smoothing (using a Gaussian kernel of FWHM 5mm), and temporal high-pass filtering (Gaussian-weighted least-squares straight line fitting, with sigma=50.0s) were also applied. All functional data were registered to a high resolution T1 anatomical scan taken in the same session (1.13 x 1.13 x 1 mm voxel) using FLIRT (Jenkinson, Bannister, Brady, & Smith, 2002; Jenkinson & Smith, 2001). High resolution structural images were subsequently registered onto the standard MNI152 brain using FNIRT nonlinear registration (Andersson, Jenkinson, & Smith, 2007).

2.5.1.1 Region of Interest

A region of interest (ROI) was established for participants in both the right and left hemisphere using an EBA localizer scan conducted immediately prior to the experimental run. Body-selective ROIs were defined by the *Bodies* > *Chairs* contrast (Downing, Wiggett, & Peelen, 2007), using the cluster of contiguous voxels, at the group level, in extrastriate cortex. To account for multiple comparisons, statistical thresholding was undertaken using clusters determined by Z > 3.1 with a corrected cluster significance of $p = 0.05$ (Worsley, 2001). The group level spatial co-ordinates ($N = 30$) of the peak left and right EBA voxel closely matched, bilaterally, with previously reported anatomical locations of the EBA (Downing et al., 2007; Myers & Sowden, 2008; Peelen & Downing, 2007) (see Fig. 2 and Supplementary Materials Table S1 for spatial MNI co-ordinates). ROIs were spatially normalized to an MNI152 standard brain template to create a mask for the left and right hemisphere, which were subsequently reverse normalised to single-subject functional space for univariate analysis.

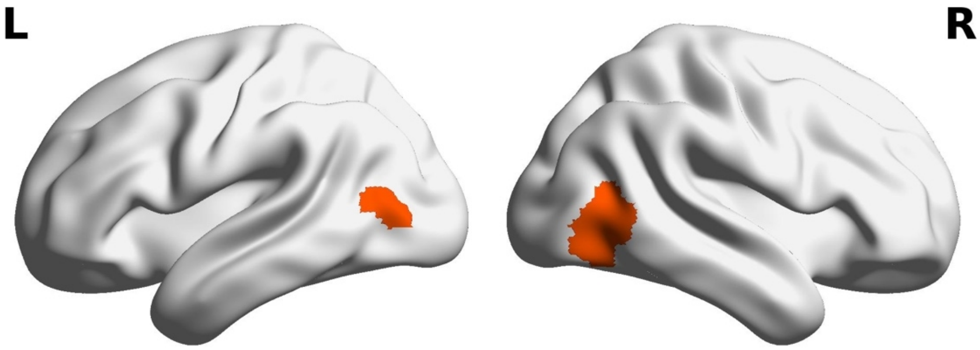

Fig. 2 - Region of interest established bilaterally using EBA localiser (*Bodies* > *Chairs* contrast). Z threshold > 3.1 with corrected cluster significance threshold ($p = 0.05$). *(L = Left; R = Right)

2.5.1.2 Univariate Analysis

For subsequent univariate analysis of experimental runs, percentage signal change was extracted independently from both left and right hemisphere masks within each of our conditions, using FEATquery in FSL toolbox. In addition, behavioural evaluation scores, participant BMI, and EDE-Q scores were independently entered as covariates into higher-level analysis at the group level, within selected conditions/contrasts. Moreover, an exploratory whole brain analysis was run using the same procedure as above, to investigate whether any effects were observed outside of our ROI analysis. Z statistic images were thresholded using clusters determined by Z > 3.1 (unless stated) and a (corrected) cluster significance threshold of $p = 0.05$ (Worsley, 2001).

2.5.1.3 Multi-Voxel Pattern Analysis

In order to investigate the similarity in the neural pattern of responses to visual perspective and body size, a subsequent multi-voxel pattern analysis (MVPA) was performed and restricted to the EBA masks established from the univariate analysis. Parameter estimates were correlated across all four block conditions using a between-run split (Run 1 & Run 2). Next, a multiple regression analysis was run to assess the relative contribution of visual perspective and body size towards the neural pattern of responses. For each of the two conditions, a binary regressor was generated which represented a model correlation matrix. A value of one (yellow) was assigned to elements where the relevant factor was shared, and a value of zero (red) was assigned to all other elements of the correlation matrix (see Fig. 5a and 5b). Therefore, the regressors represent the extreme cases in which the patterns of response are predicted by either visual perspective or body size. A multiple regression analysis was then applied to the fMRI data across the whole sample, which provided beta values and standard error terms for each regressor (i.e. visual perspective and body size). Regressors which differ significantly from zero, using one sample t-tests, suggest that such a variable can explain a significant amount of the variance in the MVPA correlations. Further, paired-samples t-tests were run to assess the differences in variance explained between regressors in the model. All regressors and outcomes were z-scored prior to the multiple regression analysis.

2.5.2 Behavioural Analysis

For aesthetic and weight evaluations, behavioural analysis was undertaken using SPSS (version 24.0). Mean rating scores were calculated for slim and large bodies, within both egocentric and allocentric perspectives, which were entered into a 2x2 repeated-measures ANOVA. Significant interactions were subsequently analysed using Bonferroni-corrected paired samples t-tests.

3. *Results*

3.1 Univariate analysis

3.1.1 fMRI Response - Visual Perspective

To first establish the role of visual perspective modulating neural activity within the EBA, percentage signal change was extracted for each hemisphere from our ROI masks, for egocentric and allocentric conditions, collapsed across body size (see Fig. 3). A 2 (Hemisphere: Left vs Right) x 2 (Perspective: Egocentric vs Allocentric) repeated measures ANOVA revealed a significant main effect of hemisphere (F (1, 29) = 15.38, $p < .001$, $\eta_p^2 = .35$), showing greater activation in the right EBA compared with the left EBA. Further, a significant main effect of perspective was observed (F (1, 29) = 8.57, $p = .007$, $\eta_p^2 = .23$), with Bonferroni-corrected paired-samples t-tests ($\alpha = .025$) revealing a significantly greater signal change to egocentric perspectives than allocentric perspectives, for both the left EBA (t (29) = 2.67, $p = .012$, $d = .49$) and right EBA (t (29) = 2.65, $p = .013$, $d = .48$). No interaction of hemisphere x perspective was observed (F (1,29) = 1.98, $p = .17$, $\eta_p^2 = .06$). Whilst not a hypothesised effect, a further 2x2 repeated measures ANOVA was performed to investigate the main effect of hemisphere and body size as well as their interaction. A main effect of hemisphere was observed, with no further significant interactions (see Supplementary Materials S2 for detailed analysis).

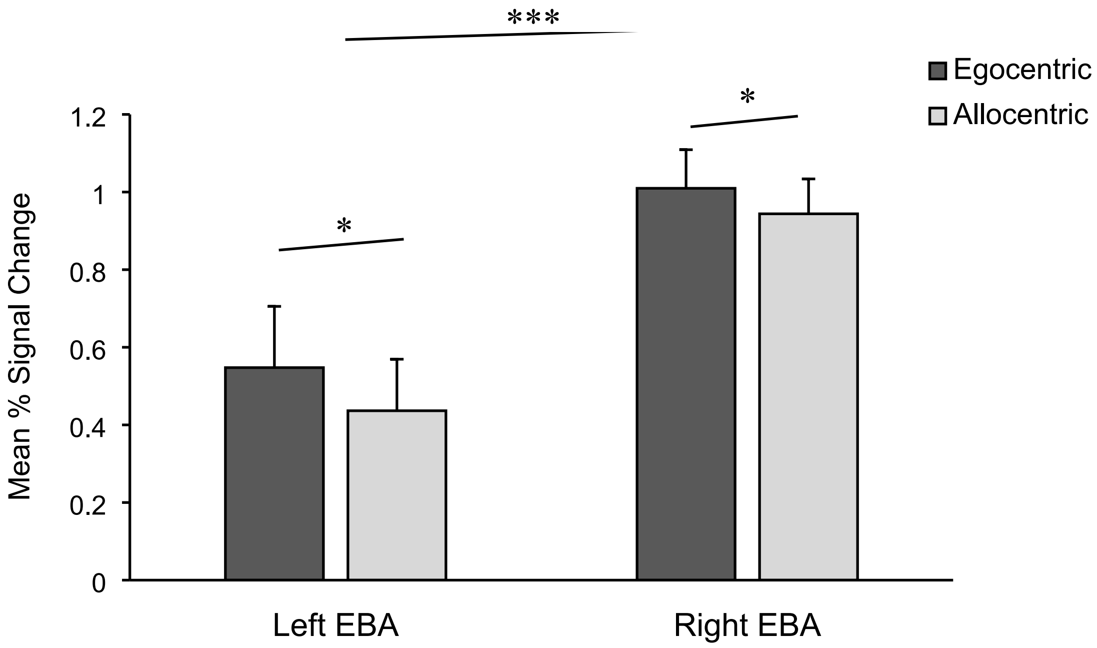

Fig. 3 - Average percentage signal change bilaterally for egocentric and allocentric perspectives, collapsed across body size. Error bars depict standard error of the mean. *= $p < .05$, ***= $p < .001$

3.1.2 fMRI Response – Visual Perspective vs Body Size

3.1.2.1 Left EBA

For EBA activity in the left hemisphere (see Fig. 4a), a 2 (Perspective: Egocentric vs Allocentric) x 2 (Body Size: Slim vs Large) repeated measures ANOVA revealed a significant main effect of perspective (F (1, 29) = 6.46, p = .017, η_p^2= .18). No significant main effect was found for body size (F (1,29) = 1.52, p = .227, η_p^2 = .05), however a significant interaction of perspective x body size was observed (F (1, 29) = 13.03, p = .001, η_p^2= .31). Bonferroni-corrected paired-samples t-tests (α = .0125) revealed a significantly larger signal change to egocentric compared with allocentric perspectives for slim bodies (t (29) = 4.51, p < .001, d = .82) but no difference was observed between perspectives for large bodies (t (29) = -.02, p = .986, d = .00). Further paired-samples t-tests revealed a significantly greater response to large bodies compared with slim bodies, from an allocentric perspective (t (29) = -3.82, p = .001, d = -.70) but no difference was observed between body sizes from an egocentric perspective (t (29) = 1.36, p = .185, d = .25). These results suggest that the amplitude of EBA activity does not respond uniformly to all bodies but is instead determined by the interaction between the type of body and the visual perspective in which it is perceived.

3.1.2.2 Right EBA

For EBA activity in the right hemisphere (see Fig. 4b), a 2 (Perspective: Egocentric vs Allocentric) x 2 (Body Size: Slim vs Large) repeated measures ANOVA revealed a significant main effect of perspective (F (1, 29) = 4.79, p = .037, η_p^2 = .14). A main effect of body size was approaching significance (F (1, 29) = 4.13, p = .051, η_p^2 = .13), nevertheless a significant interaction of perspective x body size was observed (F (1, 29) = 16.88, p < .001, η_p^2 = .37). Bonferroni-corrected paired-samples t-tests (α = .0125) similarly revealed a significantly larger signal change to egocentric compared with allocentric perspectives for slim bodies (t (29) = 4.28, p < .001, d = .78) but no difference was observed between perspectives for large bodies (t (29) = -.73, p = .472, d = -.13). Further, paired-samples t-tests similarly revealed a significantly greater response to large bodies compared with slim bodies, from an allocentric perspective (t (29) = -5.87, p < .001, d = 1.07) but no difference was observed between body sizes from an egocentric perspective (*t* (29) = .91, *p* = .370, *d* = .17). These results show that the interaction between body size and visual perspective in modulating EBA amplitude is a bilateral effect, with an identical pattern shown between conditions compared with the left EBA (see Fig. 4).

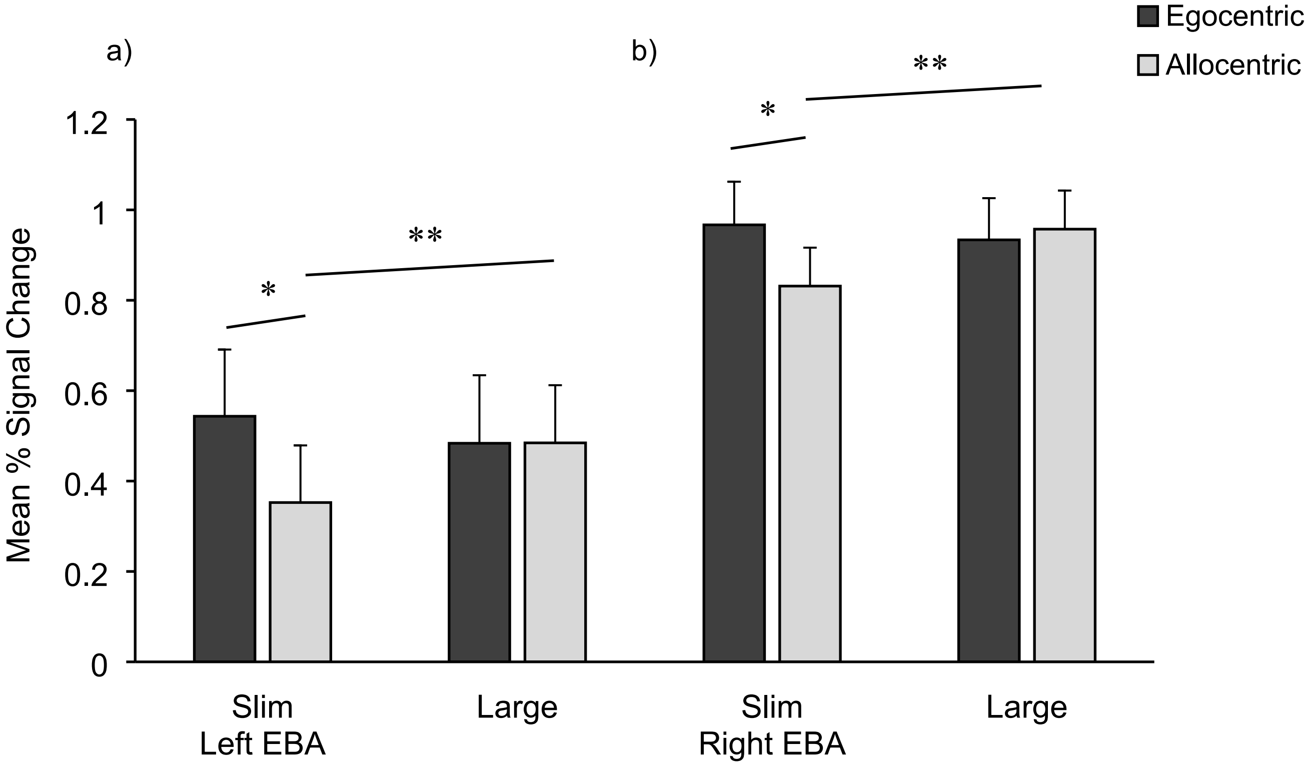

Fig. 4 - Mean percentage signal change in the a) left EBA and b) right EBA, for egocentric and allocentric perspectives of slim and large bodies. Error bars depict standard error of the mean (* = p < .05, ** = p < .01).

3.2 EBA activity and ED Psychopathology

To determine whether there was a relationship between functional EBA activity and ED psychopathology, EDE-Q subscale (Restraint, Eating Concern, Shape Concern, Weight Concern) and global scores were standardized (z-scored) across all participants and each used as a covariate in the group analysis of each of our four conditions, within our predefined ROI masks. No relationship was observed between EBA activity and EDE-Q subscale or global scores.

3.3 Whole Brain Analysis

An exploratory whole brain analysis was run to examine whether any significant activations were observed outside of our defined ROI analysis. In line with previous research identifying different brain regions (Mattavelli et al., 2014; Vatansever et al., 2017), statistical thresholding was lowered for exploratory purposes using clusters determined by $Z > 2.6$ with a corrected cluster significance of $p = 0.05$. Whole brain analyses were run on chosen contrasts based on the effects and interactions identified in the univariate ROI analysis (see Fig. 4), and effects identified in the behavioural analysis (see Section 3.5 & Fig. 6). As anticipated, significant activations were observed in occipital fusiform regions which include the fusiform body area (FBA). Moreover, significant activations were observed in areas associated with self-awareness (superior/inferior frontal gyrus) and multisensory construction of body image (right superior parietal lobule; Case, Wilson, & Ramachandran, 2012) (see Table 2). Anatomical localization was identified using the three-dimensional atlas of neuroanatomy (Duvernoy, 2012).

Finally, z-scored EDE-Q subscale and global scores were added as a covariate in a further exploratory whole brain analysis of each of our four conditions. However, no significant relationship was observed between brain regions and EDE-Q scores. Similarly, z-scored participant BMI was added as a covariate in exploratory whole brain analyses of each of our four conditions, with no significant relationship observed between brain regions and participant BMI.

Table 2. Whole brain analysis for the chosen contrasts, based on the significant effects of our univariate analysis within EBA masks, and on significant effects observed within behavioural analysis.

Contrast	**Anatomical Region**	**Hemisphere**	**MNI Co-ordinates**			**Cluster Size**	***p* value**
			X	**Y**	**Z**		
Slim Egocentric Body > Slim Allocentric Body	Temporal Occipital Fusiform Gyrus	Left	-36	-50	-22	2386	6.36E-13
	Occipital Fusiform Gyrus	Right	42	-62	-12	2042	1.49E-11
	Occipital Pole	Right	18	-94	6	1184	6.7E-11
	Superior Parietal Lobule	Left	-32	-54	54	1181	1.19E-07
	Occipital Pole	Left	-12	-96	6	476	0.0009
	Middle Temporal Gyrus	Right	62	-6	-28	297	0.0166
	Superior Parietal Lobule	Right	28	-46	36	244	0.0435
Large Allocentric Body > Slim Allocentric Body	Superior Occipital Gyrus	Left	-12	-94	-6	21347	0
	Temporal Occipital Fusiform Gyrus	Left	-38	-52	-24	5083	2.27E-23
	Inferior Frontal Gyrus	Left	-42	42	4	3354	1.79E-17
	Superior Frontal Gyrus	Left	-8	26	46	1408	2.33E-09
	Inferior Frontal Gyrus	Right	44	12	22	1124	5.96E-08
Large Allocentric Body > Large Egocentric Body	Occipital Fusiform Gyrus	Right	30	-88	-12	18826	0
	Inferior Frontal Gyrus	Right	46	14	24	9615	1.29E-37
	Lateral orbital gyrus	Left	-48	42	0	5931	5.6E-27
	Superior Temporal Gyrus	Right	56	-44	8	4685	6.63E-23

NB. For exploratory purposes, Z statistic images were thresholded using clusters determined by Z > 2.6 and a (corrected) cluster significance threshold of *p* = 0.05.

3.4 Multi-Voxel Pattern Analysis

Following our univariate analysis, a correlation-based multi-voxel pattern analysis (MVPA) was conducted using a between-run split (run 1 & run 2), to assess the similarity in the pattern of neural responses to visual perspective and body size. MVPA was performed at the individual level using the same left and right EBA masks from the univariate analysis. As expected, patterns of responses were higher for within-category correlations, compared with between-category correlations (see Fig. 5c & 5d).

Next, to establish the relative contribution of body size and visual perspective towards the neural pattern of responses, we subsequently ran a multiple regression analysis. Model correlation matrices were created to represent patterns of response which are exclusively predicted by the body size or visual perspective of body stimuli (see Fig. 5a & 5b). These models were then used as regressors in a multiple regression analysis of the fMRI data from our present sample (See Fig. 5e & 5f). A paired samples t-test revealed that visual perspective explained significantly more variance than body size for both the left EBA (t (29) = 3.86, $p < .001$) and right EBA (t (29) = 5.05, $p < .001$). Further, within the left EBA, one sample t-tests revealed that visual perspective explained a significant amount of the variance in the MVPA correlation matrix (t (29) = 4.15, $p < .001$), whilst body size did not (t (29) = .29, $p = .77$). However, within the right EBA, one sample t-tests revealed that both visual perspective (t (29) = 8.25, $p < .001$) and body size (t (29) = 3.35, $p < .01$) both explained a significant amount of the variance in the MVPA correlation matrix. Thus, the results show that the pattern of activity within the right EBA appears to represent bodies based on both visual perspective and the type of body which is perceived. Whilst the regression coefficient was non-significant for body size in the left EBA, this null result should be taken with caution as it may be due to a lack of statistical power as a result of a smaller ROI within the left hemisphere (see discussion below).

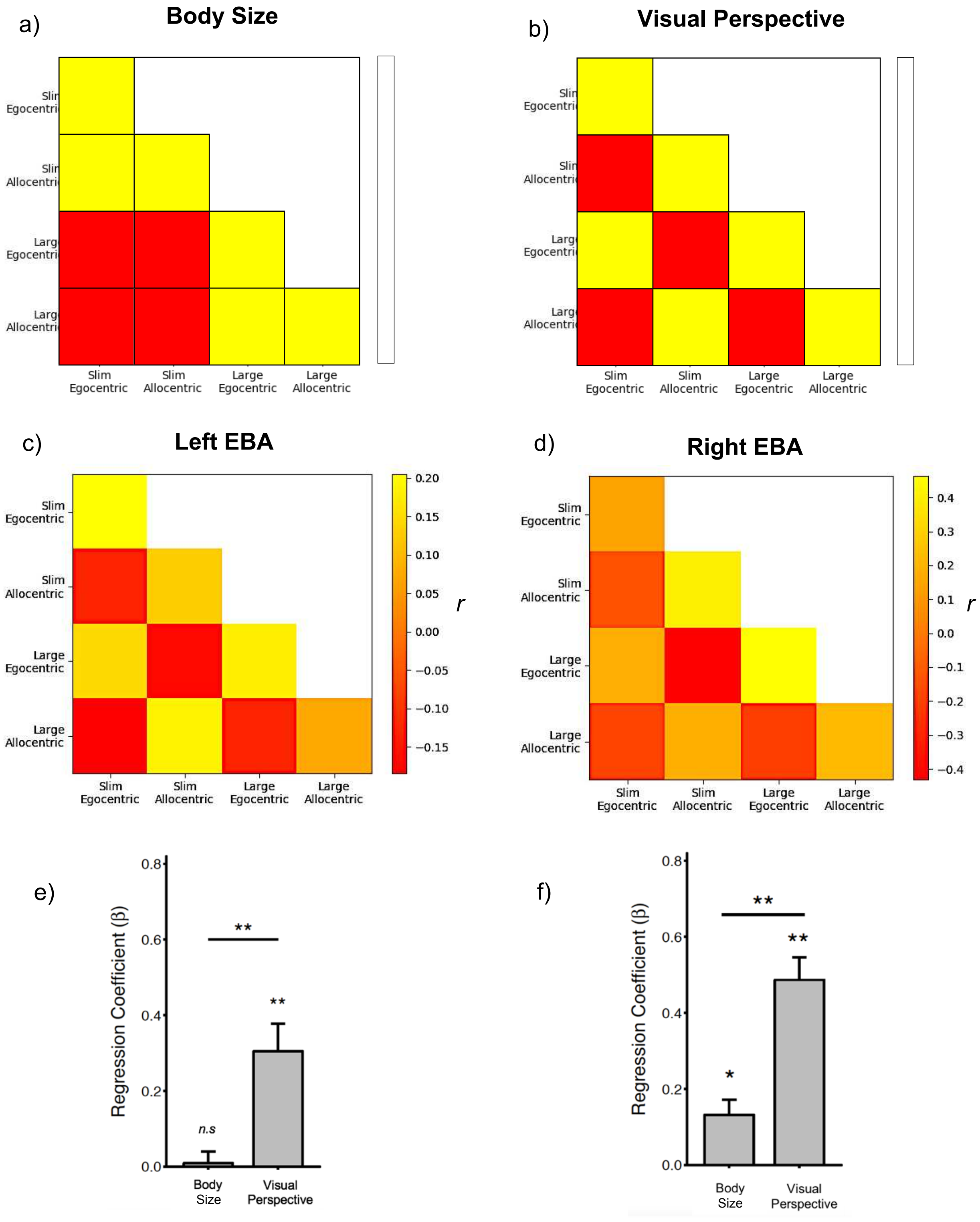

Fig. 5 - MVPA showing fMRI response patterns to body stimuli conditions. Binary models were created to represent the extreme cases where patterns of response are exclusively predicted by either the a) body size or b) visual perspective of body stimuli. Correlation matrix shows the similarity of neural patterns for within-category and between-category responses within the c) Left EBA mask and d) Right EBA mask. Correlations

were based on data from identical blocks between run 1 and run 2. These correlation matrices were compared against the binary models for both conditions using a multiple regression analysis, with regression coefficients shown for the e) Left EBA and f) Right EBA. Error bars depict standard error of the mean (*= $p < .01$, **= $p < .001$).

3.5 Behavioural Responses:

3.5.1 Aesthetic Evaluations:

Aesthetic evaluation ratings were compared between visual perspective and body size using a 2x2 repeated measures ANOVA (see Fig. 6a). There was a significant main effect of body size on ratings of attractiveness (F (1,29) = 98.03, p <.001, $\eta_p^2 = .77$), showing that participants rated slim bodies as significantly more attractive than large bodies. However, there was no significant main effect of visual perspective in ratings of attractiveness (F (1,29) = 3.99, p = .06, $\eta_p^2 = .12$). Nevertheless, there was a significant interaction between visual perspective and body size (F (1,29) = 24.07, p <.001, $\eta_p^2 =$ .45). Post hoc Bonferroni-corrected ($\alpha = .025$) paired samples t-tests revealed no significant difference in attractiveness ratings between perspectives for slim bodies (t (29) = -1.68, p = .105, d = -.31), but participants rated large bodies as significantly less attractive from allocentric perspectives compared with egocentric perspectives (t (29) = 4.72, p < .001, d = .86). These results suggest that visual perspective is more important in influencing subjective attractiveness ratings towards larger bodies, with slim bodies rated as equally attractive irrespective of visual perspective.

3.5.2 Weight Evaluations:

Weight evaluation ratings were also compared between visual perspective and body size using a 2x2 repeated measures ANOVA (see Fig. 6b). There was a significant main effect of body size on ratings of weight (F (1,29) = 282.15, p <.001, $\eta_p^2 = .91$), showing that participants rated large bodies to weigh significantly more than slim bodies. Further, there was a significant main effect of visual perspective in weight evaluations (F (1,31) = 13.48, p <.01, $\eta_p^2 = .32$), showing that participants rated bodies from allocentric perspectives as weighing significantly more than from egocentric perspectives. Finally, there was a significant interaction between visual perspective and body size (F (1,31) = 37.07, p <.001, $\eta_p^2 = .56$). Post hoc Bonferroni-corrected ($\alpha = .025$) paired samples t-tests revealed no significant difference in weight ratings between perspectives for slim bodies (*t* (29) = 1.86, *p* = .073, *d* = .34), but participants rated large bodies as significantly more overweight from allocentric perspectives compared with egocentric perspectives (*t* (29) = -5.91, *p* < .001, *d* = -1.08). Similarly, this suggests that visual perspective has more pronounced effect in influencing the subjective perceived weight of large bodies, yet such evaluations are statistically unaffected by visual perspective towards slim bodies.

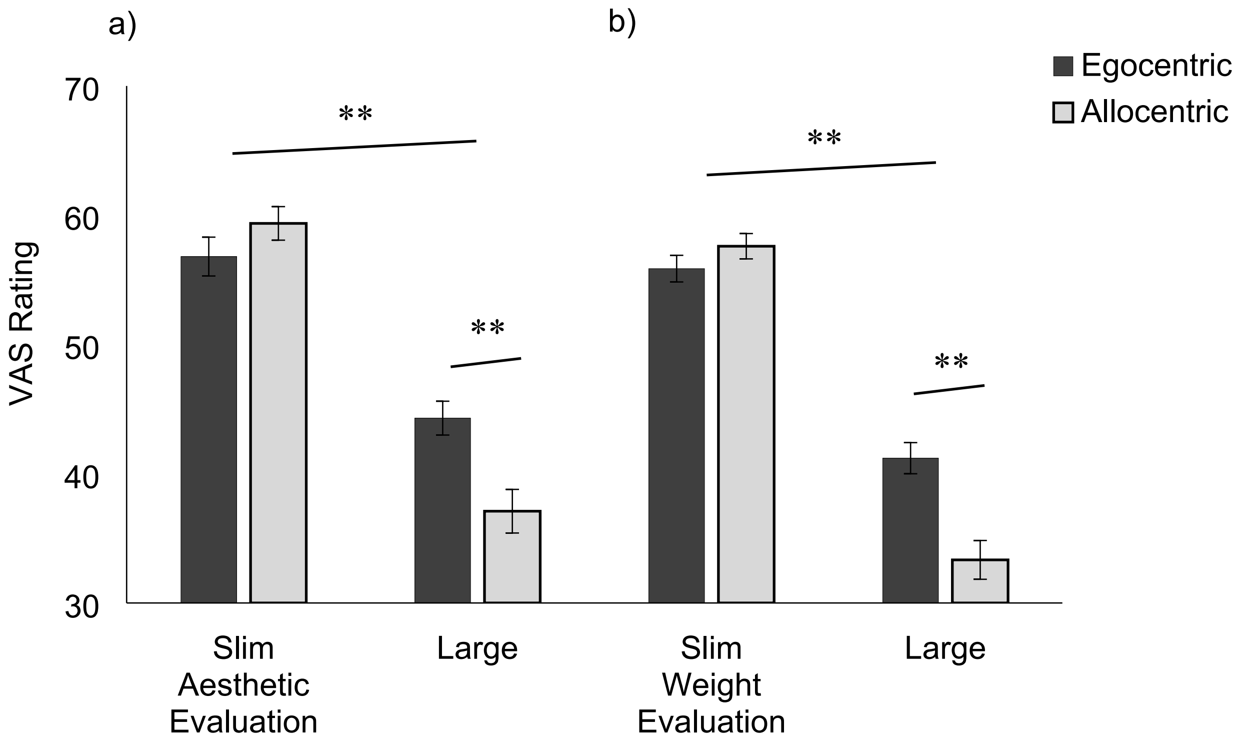

Fig. 6 - Mean VAS rating (0-100) for a) aesthetic and b) weight evaluations of slim and large body stimuli, from egocentric and allocentric perspectives. Error bars depict standard error of the mean (**= *p* < .001). NB. Weight Evaluation VAS ratings are reversed scored for the purposes of the above figure, to represent the similarity in the pattern of responses between behavioural evaluations.

3.6 Relationship between fMRI and Behavioural Responses

To determine whether there was a relationship between EBA activity and aesthetic or weight evaluations of body stimuli, difference scores were first calculated between behavioural evaluation ratings, which reflected the appropriate fMRI contrasts based on the behavioural analysis (see Fig. 6). Values were z-scored across all participants and used as covariates in the group analysis of contrasts

Slim Allocentric > Slim Egocentric and Large Allocentric > Large Egocentric, within our predefined ROI mask. However, EBA activity showed no significant relationships with aesthetic or weight behavioural responses.

Finally, a whole brain analysis was run to explore whether any regions outside our defined ROI showed a relationship between fMRI and behavioural responses. Similarly, for exploratory purposes, statistical thresholding was lowered, using clusters determined by Z > 2.6, with a corrected cluster significance of $p = 0.05$. Results showed a significant relationship between *Large Allocentric > Large Egocentric* contrast and corresponding attractiveness ratings in the right superior frontal gyrus within prefrontal cortex (see Fig. 7 and Supplementary Materials Table S3 for spatial MNI co-ordinates). Crucially, the above contrast showed no significant relationship in any brain regions with the corresponding weight evaluations, suggesting that the effects of aesthetic evaluations may be independent of perceived body weight. Overall, this suggests that such socio-cognitive evaluations made towards bodies may not occur in the EBA, but are instead made in higher-order, prefrontal regions of the brain.

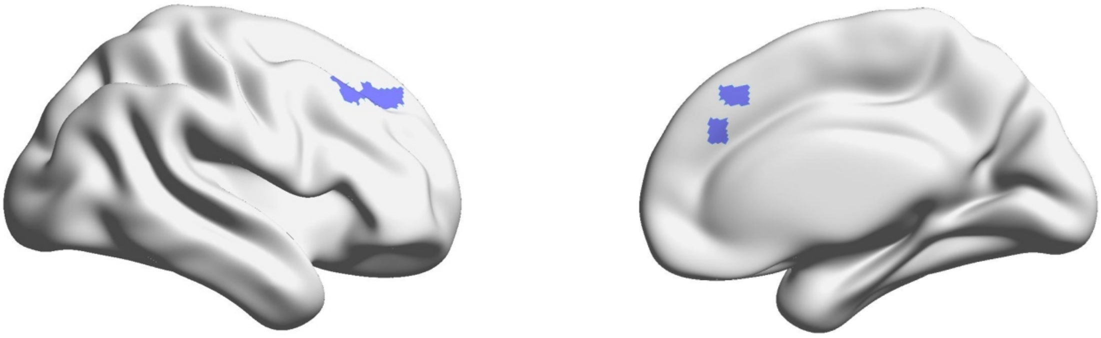

Fig. 7 - Whole brain correlation analysis between *Large Allocentric Body > Large Egocentric Body* contrast and corresponding behavioural attractiveness ratings (Right Hemisphere). Z threshold > 2.6 with corrected cluster significance threshold ($p = 0.05$).

4. Discussion

The aim of the present study was to investigate whether the combined processing of visual perspective and body size modulated neural response in the body-selective EBA brain region. Univariate results revealed an interaction between such physical body attributes, shown by greater EBA activity, bilaterally, when viewing all bodies from an egocentric perspective compared with allocentric perspective. Additionally, EBA activity was increased in response to larger bodies compared with slim bodies when viewed from an allocentric, but not egocentric perspective. Furthermore, multi-voxel pattern analysis (MVPA) highlighted distinct neural patterns in response to different conditions of body stimuli, with subsequent multiple regression analysis showing that EBA activity could be predicted by visual perspective and body size independently. Such findings highlight an interactive effect between multiple physical attributes in modulating EBA activity in visual body processing, with selective patterns of neural response shown to different categories of body information, rather than an absolute neural response to all human bodies. Finally, an interaction between the visual perspective and size of perceived bodies was supported following behavioural aesthetic and weight evaluations of bodies. Such evaluations had no significant relationship with EBA activity; however, aesthetic, but not weight evaluations of large bodies viewed from different perspectives related to activation in prefrontal cortex, which is implicated in socio-cognitive assessments of bodies. This relationship between higher-order, prefrontal regions and aesthetic evaluations suggests that visual perspective can play a crucial role in influencing such subjective aesthetic assessments, independently of the perceived size or weight of the body.

Previous research has found greater neural activation in the EBA in response to allocentric views of human bodies compared with egocentric views (Chan et al., 2004; Saxe et al., 2006). The present study supports the argument that EBA response is functionally modulated by the perceived visual perspective of bodies, however, our results highlight that the role of the EBA is more complex than discriminating between visual perspective alone. Within our univariate analysis we found greater neural activation, bilaterally, to egocentric viewpoints compared with allocentric in response to slim bodies only, with no discrimination between visual perspective in response to large bodies. Such findings may be associated with an increased sense of body identity within egocentric conditions. Indeed, whilst evidence has argued that the EBA is selective in response to images of the self vs. others' bodies (De Bellis, Trojano, Errico, Grossi, & Conson, 2017; Myers & Sowden, 2008), such effects which highlight the effect of body identity within this region remains equivocal (Chan et al., 2004; Downing & Peelen, 2011; Hodzic et al., 2009). Therefore, with evidence that one's own body ownership is optimally coded within egocentric reference frames (Maselli & Slater, 2013), we speculate that a possible explanation for such increased neural amplitude in response to slim bodies from an egocentric visual perspective may be associated with greater congruency between the perceived body and participants' own body identity (Hu et al., 2016).

Together, the sensitivity of the EBA to also discriminate between body size, and the interaction between such perceptual properties means that it is of little surprise that there are differences between previous research and the present results, given the combined processing of physical attributes in the present study. Indeed, the use of body stimuli which investigates the interaction between body size and visual perspective is novel, and is in contrast to previous research which has used gender neutral (Chan et al., 2004) or body-part specific (Saxe et al., 2006) stimuli when highlighting greater activation to allocentric vs. egocentric visual perspectives. Moreover, our study has a much-improved sample size (*N*=30) compared with previous studies (*N*=10) which have examined the influence of visual perspective on EBA activity (Chan et al., 2004; Saxe et al., 2006). Specifically, previous research has most commonly used localiser tasks which utilise allocentric perspectives of headless bodies (e.g. Chan et al., 2004), in order to localise their EBA region of interest. Therefore, with a small sample size, we speculate that greater activity to allocentric compared with egocentric perspectives in previous research may be influenced by the close congruency between allocentric conditions matching the localiser condition. However, within the present study, we used the same localiser task as previous research, yet our sample size (N=30) ensured that we had sufficient power to observe the interactive effect of multiple physical attributes within our study design. Our findings support the literature in highlighting the importance of visual perspective as a critical factor in modulating EBA activity (Chan et al., 2004; Saxe et al., 2006; Arzy et al., 2006), yet extend upon previous work by demonstrating a bilateral sensitivity to other physical body attributes in addition to - and in combination with - visual perspective. Consequently, future studies must consider how multiple body-related properties interact to modulate neural EBA response, which will provide a more real-world assessment of how individuals perceive bodies in everyday life.

Our univariate analyses revealed a significant interaction between visual perspective and body size in modulating EBA activity, yet research has highlighted that caution must be taken when interpreting neural response using this analysis alone (e.g. Peelen & Downing, 2007), as it is unclear whether changes in overall neural amplitude affects the pattern of response in this region. Therefore, in addition to our univariate results, our MVPA strengthened and extended our findings by discriminating distinct, selective patterns of neural EBA activity between each of our four conditions. Indeed, multiple regression analysis showed EBA responses were significantly predicted by both visual perspective and body size independently, within the right EBA. Whilst neural response was also significantly predicted by visual perspective in the left EBA, body size did not significantly predict activity in this hemisphere. However, this null result should be treated with caution, and may be a statistical power issue given the reduced neural response in the left compared with right EBA. Indeed, such findings are in line with previous fMRI research which shows greater selectivity for bodies in the right EBA (Downing et al., 2001; Downing, Peelen, Wiggett, & Tew, 2006), particularly amongst females (Aleong & Paus, 2010). Thus, the use of MVPA provides a robust technique in identifying dissociable patterns of activity within extrastriate cortex, supporting the argument that the EBA can discriminate between both the visual perspective and size of perceived bodies.

Aesthetic and weight behavioural evaluations similarly showed interactions between visual perspective and body size in the present study, which supports our neuroimaging evidence in highlighting the complex interplay between the visual properties of multiple physical attributes in body perception. Consistent with the cultural ‘thin-ideal’ body amongst females (Ahern, Bennett, &

Hetherington, 2008; Myers, Ridolfi, Crowther, & Ciesla, 2012), participants gave lower weight evaluations and higher attractive evaluations to slim bodies compared with large bodies. Importantly, the influence of visual perspective towards such behavioural ratings was dependent on the type of body that was being evaluated. We found no difference between visual perspectives in influencing weight or aesthetic ratings made towards slim bodies. However, an interesting finding revealed that large bodies were rated as significantly more overweight, and significantly less attractive, when viewed from an allocentric perspective compared with an egocentric perspective. We speculate that such differences in weight evaluations between perspectives may be due to occlusion of body parts which inform perception of weight, when viewed from an egocentric perspective. For example, rolls of fat on one's stomach or the width of one's shoulders are more readily perceivable from an allocentric perspective than an egocentric perspective. Therefore, an allocentric perspective is likely to provide more balanced representation of an individual's body morphology. Indeed, this supports research which highlights that overweight individuals underestimate their body size (Robinson, 2017), which may relate to their lack of allocentric perspective of their own body. Together, these findings suggest that social evaluations made towards bodies are modulated by the combined contribution of visual perspective and size of the perceived body. Such an interaction between the visual properties of bodies may have important implications in influencing one's own body image, particularly amongst those with EDs or obesity, as individuals may exhibit changes in their own body satisfaction depending on the perspective in which their body is perceived (Cazzato et al., 2012).

Despite interactions observed in neural and behavioural responses independently, we did not observe a direct relationship between EBA activity and aesthetic or weight evaluations of bodies. Indeed, the pattern of interactions between the physical attributes were not mirrored neurally and behaviourally. Whilst there was a significant difference in neural activation between visual perspectives for slim bodies, behavioural responses revealed a significant difference in both aesthetic and weight evaluations between perspectives for large bodies. The different patterns of responses observed within these two tasks may suggest that such socio-cognitive evaluations of bodies do not occur in the EBA, but instead occur in brain regions associated with higher-order reasoning (Downing & Peelen, 2011; Taylor, Wiggett, & Downing, 2007). This is supported by our whole brain analysis, which revealed a significant relationship between the superior frontal gyrus (SFG) in prefrontal cortex and aesthetic evaluations of large bodies viewed from different visual perspectives. This region is associated with cognitive processes including self-awareness and introspection (Goldberg, Harel, & Malach, 2006), supporting the argument that higher-order regions are engaged when making such cognitive evaluations of bodies (Greven, Downing, & Ramsey, 2018). The relationship shown within this particular contrast is critical, as individuals were perceiving the same bodies but simply from different visual perspectives. It is speculated that such activation within the SFG in this instance reflects the functional integration between the bottom-up visual properties of large bodies and subsequent top-down impression formation in body perception (Ramsey, 2018). Indeed, observed activation in the SFG specifically in response to large bodies may reflect a more extreme social evaluation in contrast with slim bodies (Greven et al., 2018). Importantly, this finding suggests that the subjective aesthetic appraisal of bodies can be modulated based on the viewpoint in which it is perceived, when all other physical attributes (i.e. body size) are identical. Specifically, whilst the above effect was observed between prefrontal regions and aesthetic evaluations, no significant relationships were observed between any brain regions with behavioural weight evaluations in the identical contrast. This reinforces the argument that such aesthetic evaluations are being made independently of perceived body size or weight.

Previous research has shown that disruption to extrastriate cortex directly influences aesthetic evaluations of bodies (Calvo-Merino et al., 2010), but not weight estimations (Cazzato et al., 2014, 2016) amongst healthy individuals, which suggests that the EBA may have an important, dynamic role in higher-order processing of human bodies (David et al., 2007). However, whilst we do not find evidence of EBA involvement in such higher-order assessments of bodies, our findings suggest that the EBA is sensitive enough to discriminate between the subtleties of body morphology (i.e. body size/shape). Therefore, in addition to our whole brain analysis revealing prefrontal activation, we argue that the EBA may instead act as a core region at the early stage of body processing within a distributed network, which extracts important information for higher-order brain regions when making subsequent socio-cognitive assessments of bodies (Amoruso, Couto, & Ibáñez, 2011; Greven et al., 2018). Future research which investigates the functional connectivity of the EBA within a wider, distributed network is essential, using techniques such as psychophysiological interaction (PPI) analyses (Greven et al., 2018) to examine the distinct communication between brain networks during body perception. Indeed, the present study focused primarily on neural response in the EBA given the converging evidence of its implicated role within body image (Cazzato et al., 2014) and its disturbances (Suchan et al., 2010; Uher et al., 2005).

However, our whole brain analysis also revealed significant activations in regions within the superior/inferior frontal gyrus, associated with higher-order cognitive processes, and the fusiform gyrus, which includes the fusiform body area (FBA). Such FBA activation is unsurprising given its role within human body perception (Peelen & Downing, 2005; Schwarzlose et al., 2005), however, such findings must be considered in the context of the different contributions between the EBA and FBA towards visual body processing. Indeed, whilst activation in the EBA showed different neural amplitude in response to localised physical attributes towards bodies in the present study, there is evidence to suggest that the FBA is more responsive to the visual appearance of the global properties of whole bodies (Downing & Peelen, 2016; Taylor et al., 2007). Such considerations are important in determining how each region contributes independently and collectively towards the perception and evaluation of perceived bodies based on their shape and visual perspective. Therefore, future research could use both the EBA and FBA as seed regions to investigate functional connectivity within a wider neural network which is responsible for the social evaluation of bodies.

Alternatively, no direct relationship between EBA and behavioural responses may be due to the design of the task undertaken by participants in the present study. Recent research has found dissociable EBA responses when participants were asked to make an explicit social inference of bodies, but not when those bodies were viewed in an identity recognition task (Greven et al., 2018). Thus, whilst EBA activity was modulated between the four conditions within the current study, further investigation of functional integration in body perception could be undertaken by adapting the design of the present task within future research. Specifically, participants could be exposed to a longer stimulus duration of slim vs. large bodies viewed from egocentric vs. allocentric perspectives, followed by explicit evaluation ratings of bodies made *within* the scanner. This would be designed to directly investigate the functional interplay between the perceptual properties of perceived bodies and its relationship with non-visual, higher-order representations following intentional, explicit evaluation of bodies. Such empirical work would help to better understand the neural trajectory between perceptual and cognitive-affective components of body image (Ramsey, 2018).

Despite previous research finding relationships between neural responses and non-clinical ED psychopathology in body-related fMRI research (Preston & Ehrsson, 2016), our results showed that EBA response was not functionally modulated by ED psychopathology in our sample of healthy females. Such findings may suggest that alterations in EBA functioning may be a consequence of clinical EDs rather than a predisposing risk factor (Hay & Sachdev, 2011). Indeed, additional analyses in the present study showed that participant BMI did not modulate EBA response in any conditions, which may suggest that such EBA alterations in clinical populations are not simply a consequence of changes in body weight. Thus, with increasing research looking to identify potential biomarkers of EDs (Groves et al., 2017), it is important that future research investigates neural functioning of body-related areas such as the EBA in relation to non-clinical ED psychopathology.

Behavioural research has highlighted the importance of visual perspective in its role within body ownership (Jenkinson & Preston, 2017; Preston, Kuper-Smith, & Ehrsson, 2015). Direct comparison between first-person (egocentric) and third-person (allocentric) perspectives using multisensory illusion paradigms have yielded clear findings of greatest body ownership (feelings as if the viewed body is your own body) when synchronous sensory input is coded from an egocentric reference frame within peripersonal space (Maselli & Slater, 2013; Petkova, Khoshnevis, & Ehrsson, 2011). This highlights the intrinsic, robust role of visual perspective with the physical self in human body perception. Moreover, whilst previous research has argued that the EBA does not play a role in discriminating between self and others (Chan et al., 2004), the perception of one's *own* body compared with another’s is important to consider in relation to changes in one’s body image. Indeed, body image disturbances amongst ED patients show alterations specifically in the perception of one’s own body, but not of others (Castellini et al., 2013; Mai et al., 2015; Sachdev, Mondraty, Wen, & Gulliford, 2008). Thus, as participants in the present study only viewed images of others’ bodies, future studies should explore the effect of visual perspective with the perception and evaluation of one’s own body (e.g. Ganesh, van Schie, Cross, de Lange, & Wigboldus, 2015) compared with another’s body, in relation to non-clinical ED psychopathology.

In conclusion, our results showed that the EBA plays a key role in discriminating between both visual perspective and body size in visual body perception. More specifically, EBA activity was functionally modulated by the interaction between such physical attributes, with distinct neural patterns shown bilaterally across each condition. Behavioural assessments of aesthetic and weight evaluations support the argument of an interaction between the visual perspective and size of perceived bodies, although such evaluations had no significant relationship with EBA activity. Instead, differences in aesthetic evaluations of large bodies related to activity within prefrontal cortex. Together, our findings argue that the role of the EBA in visual body processing is more complex than a simple category-selective region and represents human bodies in a more integrative manner in which it simultaneously considers multiple physical attributes of bodies. We argue that the differences observed in neural response may act as an important early step in communicating such processing to higher-order, frontal brain regions which are associated with aesthetic evaluation of bodies.

Acknowledgements

We are grateful to Poppy Bryant, Rosie Hall, Amy Ralton, Theo Karapanagiotidis, and David Coggan for their help and contribution at various stages of this project. All authors report no conflicts of interest. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Ahern, A. L., Bennett, K. M., & Hetherington, M. M. (2008). Internalization of the Ultra-Thin Ideal: Positive Implicit Associations with Underweight Fashion Models are Associated with Drive for Thinness in Young Women. *Eating Disorders*, *16*(4), 294–307. https://doi.org/10.1080/10640260802115852

Aleong, R., & Paus, T. (2010). Neural Correlates of Human Body Perception. *Journal of Cognitive Neuroscience*, *22*(3), 482–495. https://doi.org/https://doi.org/10.1162/jocn.2009.21211

Amoruso, L., Couto, B., & Ibáñez, A. (2011). Beyond extrastriate body area (EBA) and fusiform body area (FBA): context integration in the meaning of actions. *Frontiers in Human Neuroscience*, *5*(November), 1–3. https://doi.org/10.3389/fnhum.2011.00124

Andersson, J. L. R., Jenkinson, M., & Smith, S. M. (2007). Non-linear optimisation. FMRIB technical report TR07JA1. *In Practice*, (June), 16. Retrieved from http://fsl.fmrib.ox.ac.uk/analysis/techrep/tr07ja1/tr07ja1.pdf

Arzy, S., Thut, G., Mohr, C., Michel, C. M., & Blanke, O. (2006). Neural Basis of Embodiment: Distinct Contributions of Temporoparietal Junction and Extrastriate Body Area. *Journal of Neuroscience*, *26*(31), 8074–8081. https://doi.org/10.1523/JNEUROSCI.0745-06.2006

Astafiev, S. V., Stanley, C. M., Shulman, G. L., & Corbetta, M. (2004). Extrastriate body area in human occipital cortex responds to the performance of motor actions. *Nature Neuroscience*, *7*(5), 542–548. https://doi.org/10.1038/nn1241

Berg, K. C., Frazier, P., & Sherr, L. (2009). Change in eating disorder attitudes and behavior in college women: Prevalence and predictors. *Eating Behaviors*, *10*(3), 137–142. https://doi.org/10.1016/j.eatbeh.2009.03.003

Berg, K. C., Peterson, C. B., Frazier, P., & Crow, S. J. (2012). Psychometric evaluation of the eating disorder examination and eating disorder examination-questionnaire: A systematic review of the literature. *International Journal of Eating Disorders*, *45*(3), 428–438. https://doi.org/10.1002/eat.20931

Brooks, K. R., Mond, J. M., Stevenson, R. J., & Stephen, I. D. (2016). Body Image Distortion and Exposure to Extreme Body Types: Contingent Adaptation and Cross Adaptation for Self and Other. *Frontiers in Neuroscience*, *10*(July), 334. https://doi.org/10.3389/FNINS.2016.00334

Calvo-Merino, B., Urgesi, C., Orgs, G., Aglioti, S. M., & Haggard, P. (2010). Extrastriate body area underlies aesthetic evaluation of body stimuli. *Experimental Brain Research*, *204*(3), 447–456. https://doi.org/10.1007/s00221-010-2283-6

Carey, M., Kupeli, N., Knight, R. E., Troop, N., Jenkinson, P. M., & Preston, C. E. J. (2019). Eating Disorder Examination Questionnaire (EDE-Q): norms and psychometric properties in UK females and males. *Psychological Assessment*.

Case, L. K., Wilson, R. C., & Ramachandran, V. S. (2012). Diminished size–weight illusion in anorexia nervosa: evidence for visuo-proprioceptive integration deficit. *Experimental Brain Research*, *217*(1), 79–87. https://doi.org/10.1007/s00221-011-2974-7

Castellini, G., Polito, C., Bolognesi, E., D'Argenio, A., Ginestroni, A., Mascalchi, M., … Ricca, V. (2013). Looking at my body. similarities and differences between anorexia nervosa patients and controls in body image visual processing. *European Psychiatry*, *28*(7), 427–435. https://doi.org/10.1016/j.eurpsy.2012.06.006

Cazzato, V., Mele, S., & Urgesi, C. (2014). Gender differences in the neural underpinning of perceiving and appreciating the beauty of the body. *Behavioural Brain Research*, *264*, 188–196. https://doi.org/10.1016/j.bbr.2014.02.001

Cazzato, V., Mele, S., & Urgesi, C. (2016). Different contributions of visual and motor brain areas during liking judgments of same- and different-gender bodies. *Brain Research*, *1646*, 98–108.

https://doi.org/10.1016/j.brainres.2016.05.047

Cazzato, V., Mian, E., Serino, A., Mele, S., & Urgesi, C. (2015). Distinct contributions of extrastriate body area and temporoparietal junction in perceiving one’s own and others’ body. *Cognitive, Affective & Behavioral Neuroscience*, *15*(1), 211–228. https://doi.org/10.3758/s13415-014-0312-9

Cazzato, V., Siega, S., & Urgesi, C. (2012). “What women like”: Influence of motion and form on esthetic body perception. *Frontiers in Psychology*, *3*(JUL), 1–10. https://doi.org/10.3389/fpsyg.2012.00235

Chan, A. W.-Y., Peelen, M. V, & Downing, P. E. (2004). The effect of viewpoint on body representation in the extrastriate body area. *Neuroreport*, *15*(15), 2407–2410. https://doi.org/10.1097/00001756-200410250-00021

Cross, E. S., Kirsch, L., Ticini, L. F., & Schütz-Bosbach, S. (2011). The impact of aesthetic evaluation and physical ability on dance perception. *Frontiers in Human Neuroscience*, *5*(September), 1–10. https://doi.org/10.3389/fnhum.2011.00102

David, N., Cohen, M. X., Newen, A., Bewernick, B. H., Shah, N. J., Fink, G. R., & Vogeley, K. (2007). The extrastriate cortex distinguishes between the consequences of one’s own and others’ behavior. *NeuroImage*, *36*(3), 1004–1014. https://doi.org/10.1016/j.neuroimage.2007.03.030

De Bellis, F., Trojano, L., Errico, D., Grossi, D., & Conson, M. (2017). Whose hand is this? Differential responses of right and left extrastriate body areas to visual images of self and others’ hands. *Cognitive, Affective, & Behavioral Neuroscience*, (2004). https://doi.org/10.3758/s13415-017-0514-z

de Vignemont, F. (2010). Body schema and body image-Pros and cons. *Neuropsychologia*, *48*(3), 669–680. https://doi.org/10.1016/j.neuropsychologia.2009.09.022

Di Dio, D. C., Macaluso, E., & Rizzolatti, G. (2007). The golden beauty: Brain response to classical and renaissance sculptures. *PLoS ONE*, *2*(11). https://doi.org/10.1371/journal.pone.0001201

Downing, P. E., Jiang, Y., Shuman, M., & Kanwisher, N. (2001). A cortical area selective for visual processing of the human body. *Science (New York, N.Y.)*, *293*(5539), 2470–2473. https://doi.org/10.1126/science.1063414

Downing, P. E., & Peelen, M. V. (2011). The role of occipitotemporal body-selective regions in person perception. *Cognitive Neuroscience*, *2*(3–4), 186–203. https://doi.org/10.1080/17588928.2011.582945

Downing, P. E., & Peelen, M. V. (2016). Body selectivity in occipitotemporal cortex: Causal evidence. *Neuropsychologia*, *83*, 138–148. https://doi.org/10.1016/j.neuropsychologia.2015.05.033

Downing, P. E., Peelen, M. V, Wiggett, A. J., & Tew, B. D. (2006). The role of the extrastriate body area in action perception. *Social Neuroscience*, *1*(1), 52–62. https://doi.org/10.1080/17470910600668854

Downing, P. E., Wiggett, A. J., & Peelen, M. V. (2007). Functional magnetic resonance imaging investigation of overlapping lateral occipitotemporal activation using multi-voxel pattern analysis. *J Neurosci*, *27*(1), 226–233. https://doi.org/10.1523/JNEUROSCI.3619-06.2007

Duvernoy, H. M. (2012). *The human brain: surface, three-dimensional sectional anatomy with MRI, and blood supply*. Springer Science & Business Media.

Eisenberg, D., Nicklett, E. J., Roeder, K., & Kirz, N. E. (2011). Eating disorder symptoms among college students: prevalence, persistence, correlates, and treatment-seeking. *Journal of American College Health : J of ACH*, *59*(8), 700–707. https://doi.org/10.1080/07448481.2010.546461

Fairburn, C. G., & Beglin, S. (1994). Assessment of eating disorders: interview or self- report questionnaire? *Int J Eat Disord*, *16*(4), 363–370. https://doi.org/10.1002/1098-108X(199412)16:4

Frank, G. K. W. (2013). Altered Brain Reward Circuits in Eating Disorders: Chicken or Egg? *Current Psychiatry Reports*, *15*(10), 396. https://doi.org/10.1007/s11920-013-0396-x

Ganesh, S., van Schie, H. T., Cross, E. S., de Lange, F. P., & Wigboldus, D. H. J. (2015). Disentangling neural processes of egocentric and allocentric mental spatial transformations using whole-body photos of self and other. *NeuroImage*, *116*, 30–39. https://doi.org/10.1016/j.neuroimage.2015.05.003

Goldberg, I. I., Harel, M., & Malach, R. (2006). When the Brain Loses Its Self: Prefrontal Inactivation during Sensorimotor Processing. *Neuron*, *50*(2), 329–339. https://doi.org/10.1016/j.neuron.2006.03.015

Greven, I. M., Downing, P. E., & Ramsey, R. (2018). Neural networks supporting social evaluation of bodies based on body shape. *Social Neuroscience*, *00*(00), 1–17. https://doi.org/10.1080/17470919.2018.1448888

Groves, K., Kennett, S., & Gillmeister, H. (2017). Evidence for ERP biomarkers of eating disorder symptoms in women. *Biological Psychology*, *123*, 205–219. https://doi.org/10.1016/j.biopsycho.2016.12.016

Groves, K., Kennett, S., & Gillmeister, H. (2018). Affective responses to body stimuli: comparing male and female bodies with cropped heads and masked faces. *Journal of Cognitive Psychology*, *30*(7), 754–770. https://doi.org/10.1080/20445911.2018.1518962

Hay, P. J., & Sachdev, P. (2011). Brain dysfunction in anorexia nervosa: cause or consequence of under-nutrition? *Current Opinion in Psychiatry*, *24*, 251–256. https://doi.org/10.1097/YCO.0b013e3283453775

Hodzic, A., Muckli, L., Singer, W., & Stirn, A. (2009). Cortical responses to self and others. *Human Brain Mapping*, *30*(3), 951–962. https://doi.org/10.1002/hbm.20558

Hu, C., Di, X., Eickhoff, S. B., Zhang, M., Peng, K., Guo, H., & Sui, J. (2016). Distinct and common aspects of physical and psychological self-representation in the brain: A meta-analysis of self-bias in facial and self-referential judgements. *Neuroscience and Biobehavioral Reviews*, *61*, 197–207. https://doi.org/10.1016/j.neubiorev.2015.12.003

Jenkinson, M., Bannister, P., Brady, M., & Smith, S. (2002). Improved optimization for the robust and accurate linear registration and motion correction of brain images. *NeuroImage*, *17*(2), 825–841. https://doi.org/10.1016/S1053-8119(02)91132-8

Jenkinson, M., & Smith, S. (2001). A global optimisation method for robust affine registration of brain images. *Medical Image Analysis*, *5*(2), 143–156. https://doi.org/10.1016/S1361-8415(01)00036-6

Jenkinson, P. M., & Preston, C. (2017). The ‘ not-so-strange ’ body in the mirror : A principal components analysis of direct and mirror self-observation. *Consciousness and Cognition*, *48*, 262–272. https://doi.org/10.1016/j.concog.2016.12.007

Kontaris, I., Wiggett, A. J., & Downing, P. E. (2009). Dissociation of extrastriate body and biological-motion selective areas by manipulation of visual-motor congruency. *Neuropsychologia*, *47*(14), 3118–3124. https://doi.org/10.1016/j.neuropsychologia.2009.07.012

Kühn, S., Keizer, A. W., Rombouts, S. A. R. B., & Hommel, B. (2011). The functional and neural mechanism of action preparation: Roles of EBA and FFA in voluntary action control. *Journal of Cognitive Neuroscience*, *23*(1), 214–220. https://doi.org/10.1162/jocn.2010.21418

Mai, S., Gramann, K., Herbert, B. M., Friederich, H. C., Warschburger, P., & Pollatos, O. (2015). Electrophysiological evidence for an attentional bias in processing body stimuli in bulimia nervosa. *Biological Psychology*, *108*, 105–114. https://doi.org/10.1016/j.biopsycho.2015.03.013

Maselli, A., & Slater, M. (2013). The building blocks of the full body ownership illusion. *Frontiers in Human Neuroscience*, *7*(March), 83. https://doi.org/10.3389/fnhum.2013.00083

Mattavelli, G., Sormaz, M., Flack, T., Asghar, A. U. R., Fan, S., Frey, J., … Andrews, T. J. (2014). Neural responses to facial expressions support the role of the amygdala in processing threat. *Social Cognitive and Affective Neuroscience*, *9*(11), 1684–1689. https://doi.org/10.1093/scan/nst162

Mohr, H. M., Rickmeyer, C., Hummel, D., Ernst, M., & Grabhorn, R. (2016). Altered Visual Adaptation to Body Shape in Eating Disorders: Implications for Body Image Distortion. *Perception*. https://doi.org/10.1177/0301006616633385

Myers, A., & Sowden, P. T. (2008). Your hand or mine? The extrastriate body area. *NeuroImage*, *42*(4), 1669–1677. https://doi.org/10.1016/j.neuroimage.2008.05.045

Myers, T. A., Ridolfi, D. R., Crowther, J. H., & Ciesla, J. A. (2012). The impact of appearance-focused social comparisons on body image disturbance in the naturalistic environment: The roles of thin-ideal internalization and feminist beliefs. *Body Image*, *9*(3), 342–351. https://doi.org/10.1016/j.bodyim.2012.03.005

Peelen, M. V, & Downing, P. E. (2005). Selectivity for the human body in the fusiform gyrus. *Journal of Neurophysiology*, *93*(1), 603–608. https://doi.org/10.1152/jn.00513.2004

Peelen, M. V, & Downing, P. E. (2007). The neural basis of visual body perception. *Nature Reviews. Neuroscience*, *8*(8), 636–648. https://doi.org/10.1038/nrn2195

Peirce, J. W. (2007). PsychoPy—Psychophysics software in Python. *Journal of Neuroscience Methods*, *162*(1–2), 8–13. JOUR. https://doi.org/http://dx.doi.org/10.1016/j.jneumeth.2006.11.017

Peterson, C. B., Crosby, R. D., Wonderlich, S. A., Joiner, T., Crow, S. J., Mitchell, J. E., … Grange,

D. le. (2007). Psychometric Properties of the Eating Disorder Examination-Questionnaire: Factor Structure and Internal Consistency. *The International Journal of Eating Disorders*, *40*(2), 386–389. https://doi.org/10.1002/eat

Petkova, V. I., Khoshnevis, M., & Ehrsson, H. H. (2011). The Perspective Matters! Multisensory Integration in Ego-Centric Reference Frames Determines Full-Body Ownership. *Frontiers in Psychology*, *2*(March), 1–7. https://doi.org/10.3389/fpsyg.2011.00035

Pierno, A. C., Tubaldi, F., Turella, L., Grossi, P., Barachino, L., Gallo, P., & Castiello, U. (2009). Neurofunctional modulation of brain regions by the observation of pointing and grasping actions. *Cerebral Cortex*, *19*(2), 367–374. https://doi.org/10.1093/cercor/bhn089

Preston, C., & Ehrsson, H. H. (2014). Illusory Changes in Body Size Modulate Body Satisfaction in a Way That Is Related to Non-Clinical Eating Disorder Psychopathology. *PLoS ONE*, *9*(1), e85773. https://doi.org/10.1371/journal.pone.0085773

Preston, C., & Ehrsson, H. H. (2016). Illusory obesity triggers body dissatisfaction responses in the insula and anterior cingulate cortex. *Cerebral Cortex*, 1–11. https://doi.org/10.1093/cercor/bhw313

Preston, C., Kuper-Smith, B. J., & Ehrsson, H. H. (2015). Owning the body in the mirror: The effect of visual perspective and mirror view on the full-body illusion. *Scientific Reports*, *5*, 18345. https://doi.org/10.1038/srep18345

Ramsey, R. (2018). Neural Integration in Body Perception. *Journal of Cognitive Neuroscience*, *30*(10), 1442–1451. https://doi.org/10.1162/jocn_a_01299

Robinson, E. (2017). Overweight but unseen: a review of the underestimation of weight status and a visual normalization theory. *Obesity Reviews*, *18*(10), 1200–1209. https://doi.org/10.1111/obr.12570

Sachdev, P., Mondraty, N., Wen, W., & Gulliford, K. (2008). Brains of anorexia nervosa patients process self-images differently from non-self-images: An fMRI study. *Neuropsychologia*, *46*(8), 2161–2168. https://doi.org/10.1016/j.neuropsychologia.2008.02.031

Saxe, R., Jamal, N., & Powell, L. (2006). My body or yours? The effect of visual perspective on cortical body representations. *Cerebral Cortex*, *16*(2), 178–182. https://doi.org/10.1093/cercor/bhi095

Schwarzlose, R. F., Baker, C. I., & Kanwisher, N. (2005). Separate Face and Body Selectivity on the Fusiform Gyrus. *Journal of Neuroscience*, *25*(47), 11055–11059. https://doi.org/10.1523/jneurosci.2621-05.2005

Stice, E., Marti, N., & Rohde, P. (2010). Prevalence, Incidence, Impairment, and Course of the Proposed DSM-5 Eating Disorder Diagnoses in an 8-Year Prospective Community Study of Young Women. *Ratio*, *36*(3), 490–499. https://doi.org/10.1124/dmd.107.016501.CYP3A4-Mediated

Suchan, B., Bauser, D. S., Busch, M., Schulte, D., Grönemeyer, D., Herpertz, S., & Vocks, S. (2013). Reduced connectivity between the left fusiform body area and the extrastriate body area in anorexia nervosa is associated with body image distortion. *Behavioural Brain Research*, *241*(1), 80–85. https://doi.org/10.1016/j.bbr.2012.12.002

Suchan, B., Busch, M., Schulte, D., Grönermeyer, D., Herpertz, S., & Vocks, S. (2010). Reduction of gray matter density in the extrastriate body area in women with anorexia nervosa. *Behavioural Brain Research*, *206*(1), 63–67. https://doi.org/10.1016/j.bbr.2009.08.035

Suchan, B., Vocks, S., & Waldorf, M. (2015). Alterations in activity, volume, and connectivity of body-processing brain areas in anorexia nervosa: A review. *European Psychologist*, *20*(1), 27–33. https://doi.org/10.1027/1016-9040/a000213

Taylor, J. C., Wiggett, A. J., & Downing, P. E. (2007). Functional MRI analysis of body and body part representations in the extrastriate and fusiform body areas. *Journal of Neurophysiology*, *98*(3), 1626–1633. https://doi.org/10.1152/jn.00012.2007

Uher, R., Murphy, T., Friederich, H. C., Dalgleish, T., Brammer, M. J., Giampietro, V., … Treasure, J. (2005). Functional neuroanatomy of body shape perception in healthy and eating-disordered women. *Biological Psychiatry*, *58*(12), 990–997. https://doi.org/10.1016/j.biopsych.2005.06.001

Urgesi, C., Calvo-Merino, B., Haggard, P., & Aglioti, S. M. (2007). Transcranial Magnetic Stimulation Reveals Two Cortical Pathways for Visual Body Processing. *Journal of Neuroscience*, *27*(30), 8023–8030. https://doi.org/10.1523/JNEUROSCI.0789-07.2007

Urgesi, C., Fornasari, L., Perini, L., Canalaz, F., Cremaschi, S., Faleschini, L., … Brambilla, P. (2012). Visual body perception in anorexia nervosa. *International Journal of Eating Disorders*, *45*(4), 501–511. https://doi.org/10.1002/eat.20982

van de Riet, W., Grèzes, J., & de Gelder, B. (2009). Specific and common brain regions involved in the perception of faces and bodies and the representation of their emotional expressions. *Social Neuroscience*, *4*(2), 101–120. https://doi.org/10.1080/17470910701865367

Vatansever, D., Bzdok, D., Wang, H. T., Mollo, G., Sormaz, M., Murphy, C., … Jefferies, E. (2017). Varieties of semantic cognition revealed through simultaneous decomposition of intrinsic brain connectivity and behaviour. *NeuroImage*, *158*(January), 1–11. https://doi.org/10.1016/j.neuroimage.2017.06.067

Vocks, S., Busch, M., Schulte, D., Grönermeyer, D., Herpertz, S., & Suchan, B. (2010). Effects of body image therapy on the activation of the extrastriate body area in anorexia nervosa: An fMRI study. *Psychiatry Research - Neuroimaging*, *183*(2), 114–118. https://doi.org/10.1016/j.pscychresns.2010.05.011

Vocks, S., Schulte, D., Busch, M., Groenemeyer, D., Herpertz, S., & Suchan, B. (2011). Changes in neuronal correlates of body image processing by means of cognitive-behavioural body image therapy for eating disorders: a randomized controlled fMRI study. *Psychological Medicine*, *41*(8), 1651–1663. https://doi.org/10.1017/S0033291710002382

Worsley, K. J. (2001). Functional MRI: An introduction to methods. *Functional MRI: An Introduction to Methods*, 251–270. https://doi.org/10.1093/acprof

Zimmermann, M., Verhagen, L., de Lange, F. P., & Toni, I. (2016). The Extrastriate Body Area Computes Desired Goal States during Action Planning,,. *ENeuro*, *3*(2), 1–13. https://doi.org/10.1523/ENEURO.0020-16.2016

Supplementary Material

Distinct Neural Response to Visual Perspective and Body Size in the Extrastriate Body Area

Mark Carey [1*], Ruth Knight [1], and Catherine Preston [1]

[1] *Department of Psychology, University of York, York, United Kingdom*

Supplementary Material

S1: Regions of Interest

Functional Localizer

Body-selective ROIs for EBA masks were defined by the bodies minus chairs contrast (Downing et al., 2007), with Z statistic images thresholded using clusters determined by $Z > 3.1$ and a (corrected) cluster significance threshold of $p = 0.05$.

Table S1: MNI co-ordinates of the peak voxel with each ROI for left and right EBA

Anatomical Region	**MNI Co-ordinates**			**Cluster Size**	**Z Max**	***p* value**
	X	**Y**	**Z**			
Left EBA	-52	-78	6	218	5.37	0.000955
Right EBA	50	-70	0	736	5.39	3.64e-09

Supplementary Material

S2: fMRI Response – Body Size

To establish the role of body size modulating neural activity within the EBA, percentage signal change was extracted for each hemisphere from our ROI masks, for slim and large body conditions, collapsed across visual perspective. A 2 (Hemisphere: Left vs Right) x 2 (Body Size: Slim vs Large) repeated measures ANOVA revealed a significant main effect of hemisphere (F (1, 29) = 15.64, $p < .001$, $\eta p^2 = .35$), showing greater activation in the right EBA compared with the left EBA. No main effect of body size was observed (F (1, 29) = 3.18, $p = .085$, $\eta p^2 = .10$). Furthermore, no interaction of hemisphere x body size was observed (F (1,29) = .28, $p = .60$, $\eta p^2 = .01$).

Supplementary Material

S3: Whole Brain Analysis: Relationship between fMRI and Behavioural Responses

Exploratory whole brain analysis for Large Allocentric > Large Egocentric contrast with corresponding behavioural attractiveness difference rating added into the model as a covariate. fMRI data processing was carried out using FEAT (FMRI Expert Analysis Tool) Version 6.00, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl). Z statistic images were thresholded using clusters determined by Z > 2.6 and a (corrected) cluster significance threshold of *p* = 0.05.

Table S3: Contrast: *Large Allocentric Body > Large Egocentric Body with corresponding behavioural covariate (attractiveness ratings)*

Anatomical Region	**Hemisphere**	**MNI Co-ordinates**			**Cluster Size**	**Z Max**	***p* value**
		X	**Y**	**Z**			
Superior frontal gyrus	Right	32	22	46	361	3.8	0.00247

Supplementary Material

References:

Duvernoy, H. M. (2012). *The human brain: surface, three-dimensional sectional anatomy with MRI, and blood supply*. Springer Science & Business Media.