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

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1 **Abstract**

2

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

20

21

22

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

24 1. Introduction

25

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

33

34 Traditionally, the EBA has been implicated as an early category-selective region in visual body
35 perception (Downing et al., 2001), responsible for the local processing of basic perceptual properties of
36 bodies (Peelen & Downing, 2007). However, the precise role of the EBA in visual body processing
37 remains contested (Downing & Peelen, 2011), with conflicting proposals for the function of this region
38 in representing identity (Hodzic, Muckli, Singer, & Stirn, 2009; Myers & Sowden, 2008), motor control
39 (Astafiev, Stanley, Shulman, & Corbetta, 2004; Kontaris, Wiggett, & Downing, 2009), emotion (Peelen
40 & Downing, 2007; van de Riet, Grèzes, & de Gelder, 2009), and action goals (Kühn, Keizer, Rombouts,
41 & Hommel, 2011; Pierno et al., 2009; Zimmermann, Verhagen, de Lange, & Toni, 2016) of bodies.
42 Interestingly, functional EBA activity has been shown to be modulated by the visual perspective of
43 whole bodies or body parts, irrespective of body identity (own/other body) (Chan, Peelen, & Downing,
44 2004; Saxe, Jamal, & Powell, 2006), with evidence of increased right EBA activation in response to
45 allocentric (typical view of others' bodies) perspectives of bodies compared with egocentric (typical
46 view of own body) perspectives (see also, Arzy, Thut, Mohr, Michel, & Blanke, 2006).

47

48 In addition, evidence has highlighted the role of the EBA in processing body morphology, such as
49 shape and size (Downing & Peelen, 2016; Urgesi, Calvo-Merino, Haggard, & Aglioti, 2007; Urgesi et
50 al., 2012). Importantly, the perception of body size in visual brain regions is likely to provide critical

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

65

66 Despite evidence highlighting the role of the EBA in processing visual perspective and body size
67 independently, it is yet to be understood how the combined processing of such visual inputs interact to
68 modulate functional EBA activity. In addition, fMRI studies which identify differences in neural
69 response to visual perspective have exclusively employed univariate analyses (Chan et al., 2004; Saxe
70 et al., 2006), therefore it is unclear whether changes in overall EBA activation also influences the pattern
71 of response in this region. Such changes in EBA activity in response to these combined physical
72 attributes may be key in influencing aesthetic evaluations made towards bodies (Cazzato et al., 2014),
73 particularly body image which encompasses perceptual and attitudinal components of one's own body
74 representation (de Vignemont, 2010). This research question is particularly important amongst those
75 who experience perceptual distortions of body size, such as individuals suffering with an eating disorder
76 (ED) (Mai et al., 2015; Mohr, Rickmeyer, Hummel, Ernst, & Grabhorn, 2016; Suchan et al., 2013).
77 Indeed, recent neuroimaging research has directly linked atypical visual processing and body
78 misperception within the EBA with disturbances in body image amongst ED patients (Suchan et al.,

79 2013; Suchan, Vocks, & Waldorf, 2015), with evidence of reduced functional (Uher et al., 2005) and
80 structural (Suchan et al., 2010) EBA activity amongst ED patients compared with healthy controls (see
81 also, Vocks et al., 2010, 2011). This suggests that alterations in EBA functioning, as a core region in
82 visual body processing, may be implicated in the perceptual component of body image disturbances
83 (Castellini et al., 2013; Groves, Kennett, & Gillmeister, 2017), facilitating its development and
84 maintenance within EDs (Urgesi et al., 2012). Crucially, it remains unclear whether such perceptual or
85 neural alterations are a cause or consequence of EDs (Frank, 2013; Hay & Sachdev, 2011; Stice, Marti,
86 & Rohde, 2010). Therefore, it is critical to undertake controlled experiments within the non-clinical,
87 healthy population to study brain regions that are implicated in EDs and investigate links between body
88 perception and ED vulnerability (Berg, Frazier, & Sherr, 2009; Eisenberg, Nicklett, Roeder, & Kirz,
89 2011; Preston & Ehrsson, 2014, 2016).

90

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

100

101 In brief, the present study investigated differences in functional EBA activity following
102 presentation of large and slim female bodies, viewed from egocentric and allocentric perspectives.
103 **Based upon previous research, we hypothesised that EBA activity will be increased for allocentric**
104 **perspectives compared with egocentric perspectives amongst healthy females. However, it was**
105 **expected that EBA neural response will be further modulated by the combined processing of both visual**
106 **perspective and body size.** In conjunction with the present hypotheses directed towards EBA activity,

107 we acknowledge that other neural regions may contribute to the perception and aesthetic evaluation of
108 bodies; therefore, an exploratory whole brain analysis was also run to assess whether any significant
109 activations were observed outside of our defined region of interest. In addition to univariate analyses,
110 we used multi-voxel pattern analysis (MVPA) to compare the pattern of neural response to each of our
111 four conditions. Moreover, we wished to investigate whether EBA activity is associated with non-
112 clinical ED psychopathology in healthy individuals, without the confounding issues surrounding a
113 clinical ED diagnosis. Finally, behavioural ratings of aesthetic and weight evaluations of all body
114 stimuli (recorded outside the scanner) were investigated in relation to EBA activity. If the EBA has a
115 functional role in higher-level, socio-cognitive evaluation of bodies in visual processing, it was
116 hypothesised that behavioural aesthetic and weight ratings would positively correlate with EBA
117 activity.

118 2. Methods

119 2.1 Participants

120 32 female participants, recruited from the University of York, completed a single 1-hour study
121 session. Data from two participants were excluded due to uncorrectable fMRI motion artefacts,
122 therefore data from 30 participants (Mean age = 19.40, $SD \pm 1.25$, range = 18-24) was analysed (see
123 Table 1). All participants were right-handed, with normal or corrected-to-normal vision and no current
124 or previous psychological or neurological disorders. All participants gave informed, written consent to
125 take part in the study. The study received ethical approval from York Neuroimaging Centre (YNiC)
126 Ethics Committee and was conducted in accordance with the Declaration of Helsinki.

127

128 2.2 Experimental Stimuli

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

146 established between groups ($t(8) = -11.66, p < .001$). Images were presented, and responses were
 147 recorded, using *PsychoPy2* (Peirce, 2007) for both the fMRI and behavioural experiment.

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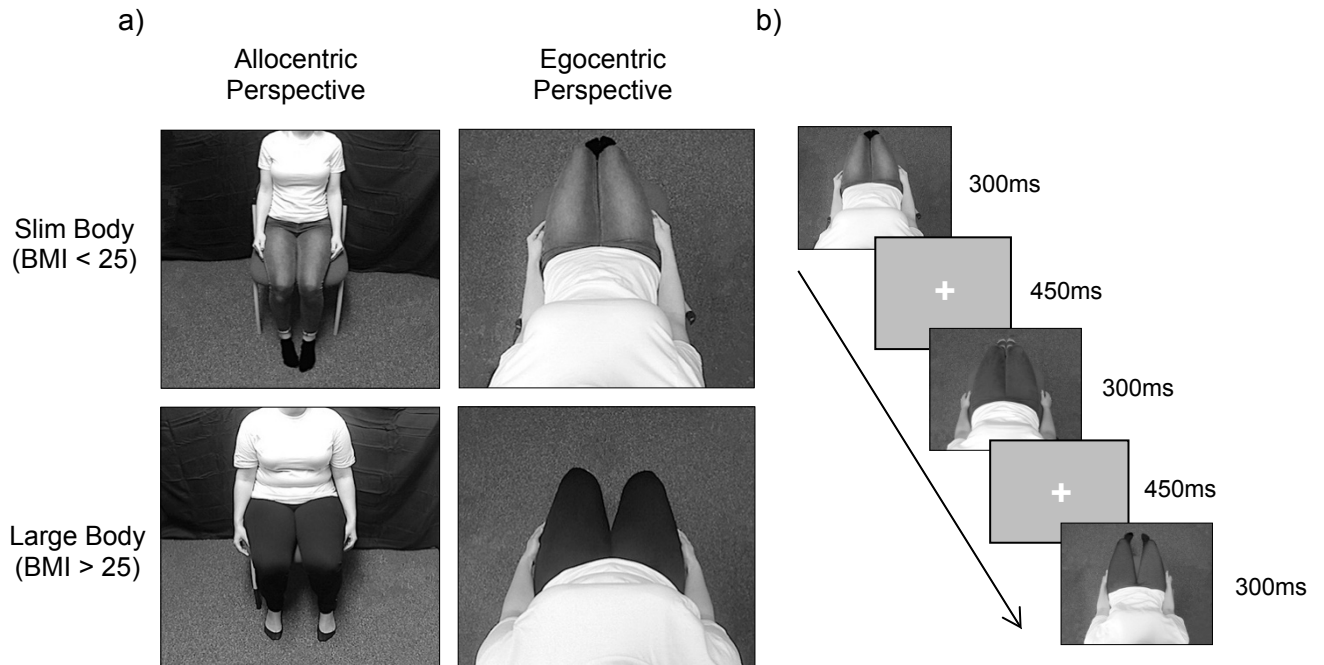
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161 **Fig. 1** - a) Sample stimuli from the experiment. Columns show the two visual perspectives
 162 (Allocentric/Egocentric), and rows show the two body sizes (Slim/Large). b) time series of experimental stimuli
 163 per block.

164

165 **2.3 fMRI Experiment**

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

175

176 **2.3.1 EBA Localizer**

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

189

190 **2.3.2 Experimental Task**

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

195

196 **2.4 Behavioural Measures**

197 **2.4.1 Aesthetic and Weight Evaluations**

198 Following the fMRI session, participants were asked to make aesthetic and weight evaluations
199 of each of the 20 stimuli presented in the fMRI experimental task, outside of the scanner. Stimuli were
200 presented in a randomized order within each block, with all blocks counterbalanced across participants
201 to control for any visual adaptation (Brooks, Mond, Stevenson, & Stephen, 2016). For aesthetic
202 evaluation blocks, stimuli were presented in the centre of the screen, with a prompt “Please rate the

203 *attractiveness of this model*” appearing at the top of the screen. Below the image, participants were
204 presented with a visual analogue scale (VAS), anchored by “*Very Unattractive*” and “*Very Attractive*”.
205 Weight evaluation blocks were identically presented, with the different prompt as “*Please rate the*
206 *weight of this model*”, anchored by “*Very Underweight*” and “*Very Overweight*” (Cazzato et al., 2014;
207 Cazzato, Siega, & Urgesi, 2012). Numeric values of the scale were not presented to participants, but
208 each VAS ranged from 0 to 100.

209

210 **2.4.2 Eating Disorder Examination Questionnaire (EDE-Q)**

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

227

228

229 **Table 1.** Total means and (standard deviations) of participant age, BMI and eating disorder
 230 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)

231

232

233 **2.5 Data analysis**

234 **2.5.1 fMRI analysis**

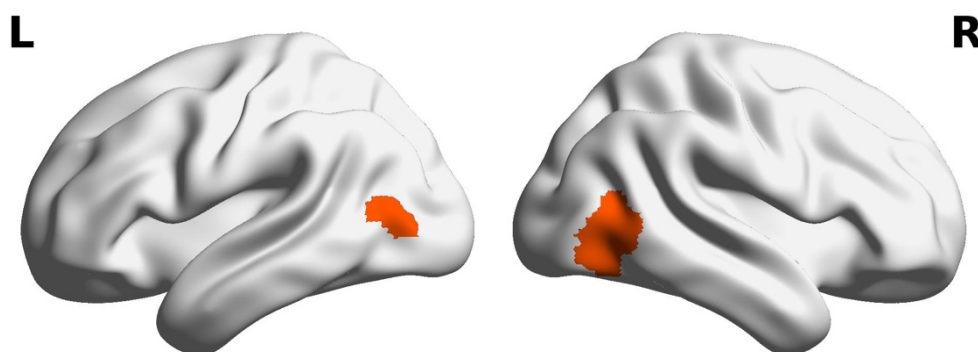
235 Univariate analysis of the fMRI data was undertaken using FEAT (FMRI Expert Analysis Tool)
 236 version 6.00 (<http://www.fmrib.ox.ac.uk/fsl>). The first 9 seconds (3 volumes) from all scans were
 237 discarded to avoid T1 saturation. MCFLIRT (FSL) motion correction, spatial smoothing (using a
 238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

244

245 **2.5.1.1 Region of Interest**

246 A region of interest (ROI) was established for participants in both the right and left hemisphere
 247 using an EBA localizer scan conducted immediately prior to the experimental run. Body-selective ROIs
 248 were defined by the *Bodies > Chairs* contrast (Downing, Wiggett, & Peelen, 2007), using the cluster of

249 contiguous voxels, at the group level, in extrastriate cortex. To account for multiple comparisons,
250 statistical thresholding was undertaken using clusters determined by $Z > 3.1$ with a corrected cluster
251 significance of $p = 0.05$ (Worsley, 2001). The group level spatial co-ordinates ($N = 30$) of the peak left
252 and right EBA voxel closely matched, bilaterally, with previously reported anatomical locations of the
253 EBA (Downing et al., 2007; Myers & Sowden, 2008; Peelen & Downing, 2007) (see Fig. 2 and
254 Supplementary Materials Table S1 for spatial MNI co-ordinates). ROIs were spatially normalized to an
255 MNI152 standard brain template to create a mask for the left and right hemisphere, which were
256 subsequently reverse normalised to single-subject functional space for univariate analysis.



263

264 **Fig. 2** - Region of interest established bilaterally using EBA localiser (*Bodies > Chairs* contrast). Z threshold $>$
265 3.1 with corrected cluster significance threshold ($p = 0.05$). *(L = Left; R = Right)

266

267 2.5.1.2 Univariate Analysis

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

276

277

278 **2.5.1.3 Multi-Voxel Pattern Analysis**

279 In order to investigate the similarity in the neural pattern of responses to visual perspective and
280 body size, a subsequent multi-voxel pattern analysis (MVPA) was performed and restricted to the EBA
281 masks established from the univariate analysis. Parameter estimates were correlated across all four
282 block conditions using a between-run split (Run 1 & Run 2). Next, a multiple regression analysis was
283 run to assess the relative contribution of visual perspective and body size towards the neural pattern of
284 responses. For each of the two conditions, a binary regressor was generated which represented a model
285 correlation matrix. A value of one (yellow) was assigned to elements where the relevant factor was
286 shared, and a value of zero (red) was assigned to all other elements of the correlation matrix (see Fig.
287 5a and 5b). Therefore, the regressors represent the extreme cases in which the patterns of response are
288 predicted by either visual perspective or body size. A multiple regression analysis was then applied to
289 the fMRI data across the whole sample, which provided beta values and standard error terms for each
290 regressor (i.e. visual perspective and body size). Regressors which differ significantly from zero, using
291 one sample t-tests, suggest that such a variable can explain a significant amount of the variance in the
292 MVPA correlations. Further, paired-samples t-tests were run to assess the differences in variance
293 explained between regressors in the model. All regressors and outcomes were z-scored prior to the
294 multiple regression analysis.

295

296 **2.5.2 Behavioural Analysis**

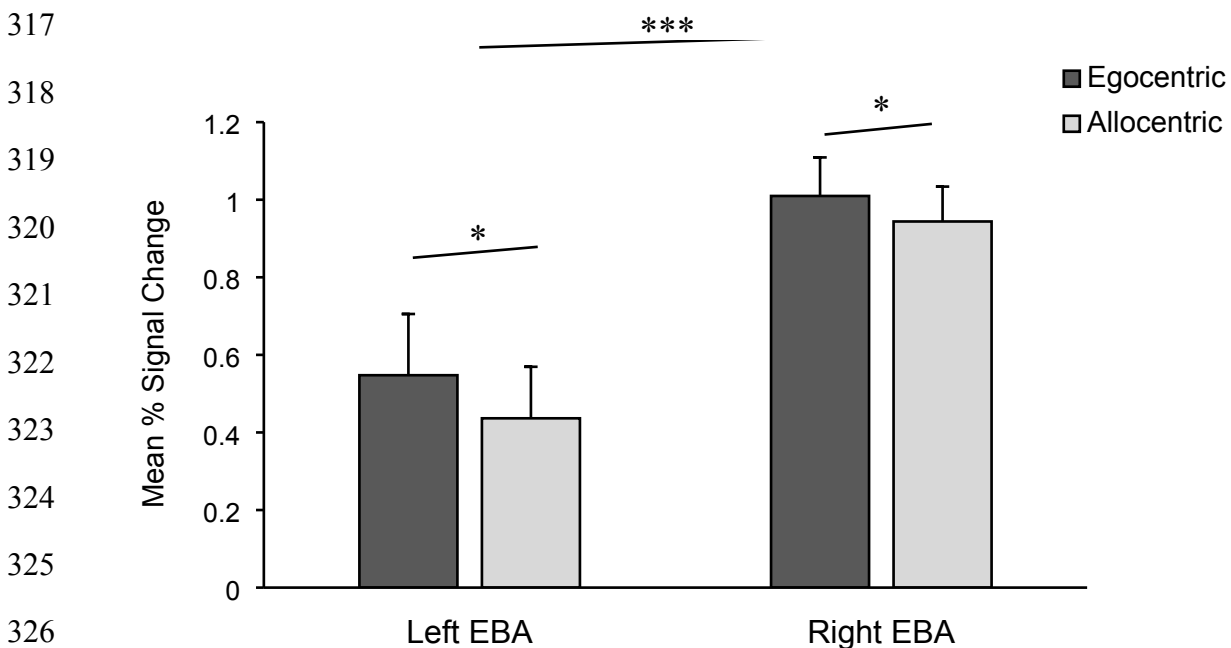
297 For aesthetic and weight evaluations, behavioural analysis was undertaken using SPSS (version
298 24.0). Mean rating scores were calculated for slim and large bodies, within both egocentric and
299 allocentric perspectives, which were entered into a 2x2 repeated-measures ANOVA. Significant
300 interactions were subsequently analysed using Bonferroni-corrected paired samples t-tests.

301 **3. Results**

302 **3.1 Univariate analysis**

303 **3.1.1 fMRI Response - Visual Perspective**

304 To first establish the role of visual perspective modulating neural activity within the EBA,
305 percentage signal change was extracted for each hemisphere from our ROI masks, for egocentric and
306 allocentric conditions, collapsed across body size (see Fig. 3). A 2 (Hemisphere: Left vs Right) x 2
307 (Perspective: Egocentric vs Allocentric) repeated measures ANOVA revealed a significant main effect
308 of hemisphere ($F(1, 29) = 15.38, p < .001, \eta_p^2 = .35$), showing greater activation in the right EBA
309 compared with the left EBA. Further, a significant main effect of perspective was observed ($F(1, 29)$
310 $= 8.57, p = .007, \eta_p^2 = .23$), with Bonferroni-corrected paired-samples t-tests ($\alpha = .025$) revealing a
311 significantly greater signal change to egocentric perspectives than allocentric perspectives, for both the
312 left EBA ($t(29) = 2.67, p = .012, d = .49$) and right EBA ($t(29) = 2.65, p = .013, d = .48$). No interaction
313 of hemisphere x perspective was observed ($F(1,29) = 1.98, p = .17, \eta_p^2 = .06$). **Whilst not a hypothesised**
314 **effect, a further 2x2 repeated measures ANOVA was performed to investigate the main effect of**
315 **hemisphere and body size as well as their interaction. A main effect of hemisphere was observed, with**
316 **no further significant interactions (see Supplementary Materials S2 for detailed analysis).**



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

329

330 **3.1.2 fMRI Response – Visual Perspective vs Body Size**

331 **3.1.2.1 Left EBA**

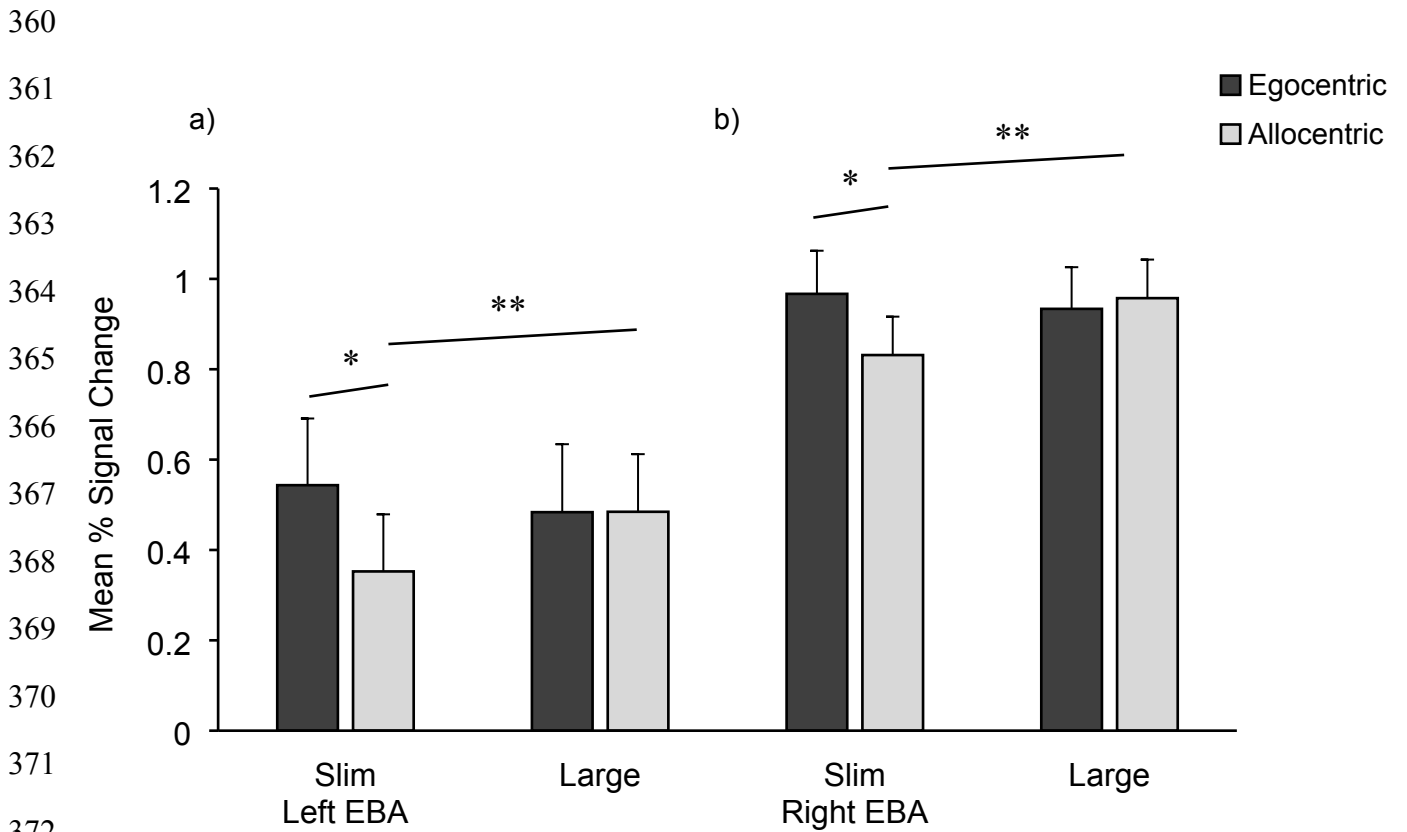
332 For EBA activity in the left hemisphere (see Fig. 4a), a 2 (Perspective: Egocentric vs
333 Allocentric) x 2 (Body Size: Slim vs Large) repeated measures ANOVA revealed a significant main
334 effect of perspective ($F(1, 29) = 6.46, p = .017, \eta_p^2 = .18$). No significant main effect was found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

345

346 **3.1.2.2 Right EBA**

347 For EBA activity in the right hemisphere (see Fig. 4b), a 2 (Perspective: Egocentric vs
348 Allocentric) x 2 (Body Size: Slim vs Large) repeated measures ANOVA revealed a significant main
349 effect of perspective ($F(1, 29) = 4.79, p = .037, \eta_p^2 = .14$). A main effect of body size was approaching
350 significance ($F(1, 29) = 4.13, p = .051, \eta_p^2 = .13$), nevertheless a significant interaction of perspective
351 x body size was observed ($F(1, 29) = 16.88, p < .001, \eta_p^2 = .37$). Bonferroni-corrected paired-samples
352 t-tests ($\alpha = .0125$) similarly revealed a significantly larger signal change to egocentric compared with
353 allocentric perspectives for slim bodies ($t(29) = 4.28, p < .001, d = .78$) but no difference was observed
354 between perspectives for large bodies ($t(29) = -.73, p = .472, d = -.13$). Further, paired-samples t-tests
355 similarly revealed a significantly greater response to large bodies compared with slim bodies, from an
356 allocentric perspective ($t(29) = -5.87, p < .001, d = 1.07$) but no difference was observed between body

357 sizes from an egocentric perspective ($t(29) = .91, p = .370, d = .17$). These results show that the
 358 interaction between body size and visual perspective in modulating EBA amplitude is a bilateral effect,
 359 with an identical pattern shown between conditions compared with the left EBA (see Fig. 4).



373

374 **Fig. 4** - Mean percentage signal change in the a) left EBA and b) right EBA, for egocentric and
 375 allocentric perspectives of slim and large bodies. Error bars depict standard error of the mean (* = $p <$
 376 $.05$, ** = $p < .01$).

377

378 **3.2 EBA activity and ED Psychopathology**

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

384

385 **3.3 Whole Brain Analysis**

386 An exploratory whole brain analysis was run to examine whether any significant activations
387 were observed outside of our defined ROI analysis. In line with previous research identifying different
388 brain regions (Mattavelli et al., 2014; Vatansever et al., 2017), statistical thresholding was lowered for
389 exploratory purposes using clusters determined by $Z > 2.6$ with a corrected cluster significance of $p =$
390 0.05 . Whole brain analyses were run on chosen contrasts based on the effects and interactions identified
391 in the univariate ROI analysis (see Fig. 4), and effects identified in the behavioural analysis (see Section
392 3.5 & Fig. 6). As anticipated, significant activations were observed in occipital fusiform regions which
393 include the fusiform body area (FBA). Moreover, significant activations were observed in areas
394 associated with self-awareness (superior/inferior frontal gyrus) and multisensory construction of body
395 image (right superior parietal lobule; Case, Wilson, & Ramachandran, 2012) (see Table 2). Anatomical
396 localization was identified using the three-dimensional atlas of neuroanatomy (Duvernoy, 2012).

397

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

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

Contrast	Anatomical Region	Hemisphere	MNI Co-ordinates			Cluster Size	<i>p</i> 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

406
 407 **NB.** For exploratory purposes, Z statistic images were thresholded using clusters determined by $Z > 2.6$ and
 408 a (corrected) cluster significance threshold of $p = 0.05$.
 409

410 **3.4 Multi-Voxel Pattern Analysis**

411

412 Following our univariate analysis, a correlation-based multi-voxel pattern analysis (MVPA)
413 was conducted using a between-run split (run 1 & run 2), to assess the similarity in the pattern of neural
414 responses to visual perspective and body size. MVPA was performed at the individual level using the
415 same left and right EBA masks from the univariate analysis. As expected, patterns of responses were
416 higher for within-category correlations, compared with between-category correlations (see Fig. 5c &
417 5d).

418

419 Next, to establish the relative contribution of body size and visual perspective towards the
420 neural pattern of responses, we subsequently ran a multiple regression analysis. Model correlation
421 matrices were created to represent patterns of response which are exclusively predicted by the body size or
422 visual perspective of body stimuli (see Fig. 5a & 5b). These models were then used as regressors in a
423 multiple regression analysis of the fMRI data from our present sample (See Fig. 5e & 5f). A paired
424 samples t-test revealed that visual perspective explained significantly more variance than body size for
425 both the left EBA ($t(29) = 3.86, p < .001$) and right EBA ($t(29) = 5.05, p < .001$). Further, within the
426 left EBA, one sample t-tests revealed that visual perspective explained a significant amount of the
427 variance in the MVPA correlation matrix ($t(29) = 4.15, p < .001$), whilst body size did not ($t(29) = .29,$
428 $p = .77$). However, within the right EBA, one sample t-tests revealed that both visual perspective ($t(29)$
429 $= 8.25, p < .001$) and body size ($t(29) = 3.35, p < .01$) both explained a significant amount of the
430 variance in the MVPA correlation matrix. Thus, the results show that the pattern of activity within the
431 right EBA appears to represent bodies based on both visual perspective and the type of body which is
432 perceived. Whilst the regression coefficient was non-significant for body size in the left EBA, this null
433 result should be taken with caution as it may be due to a lack of statistical power as a result of a smaller
434 ROI within the left hemisphere (see discussion below).

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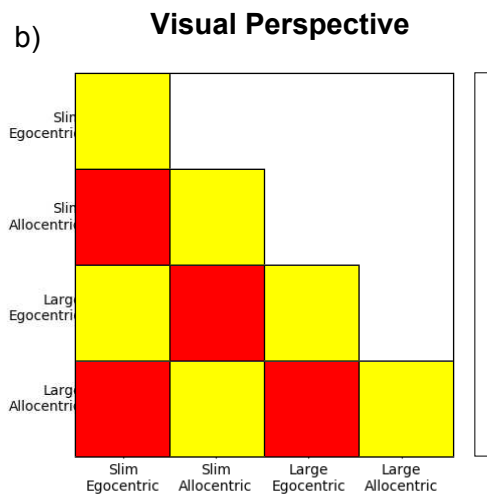
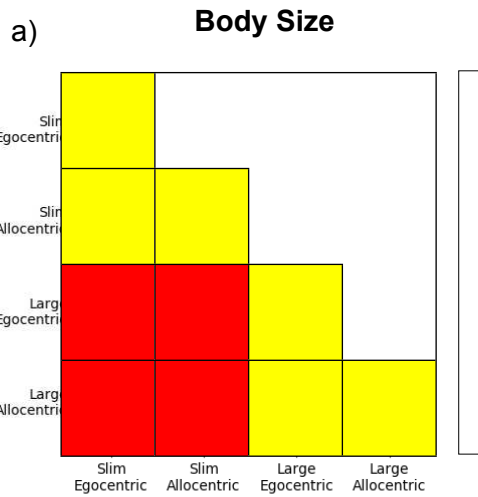
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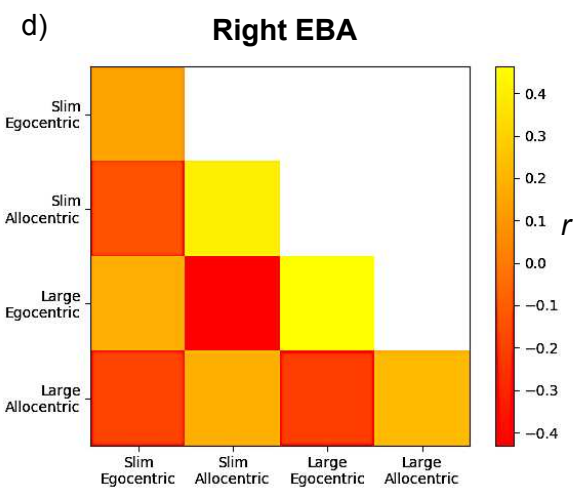
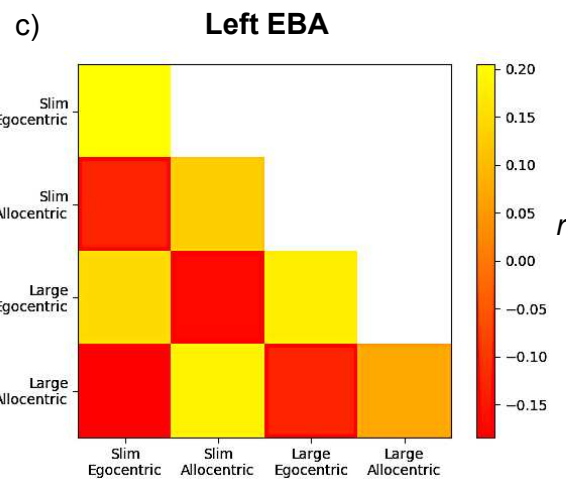
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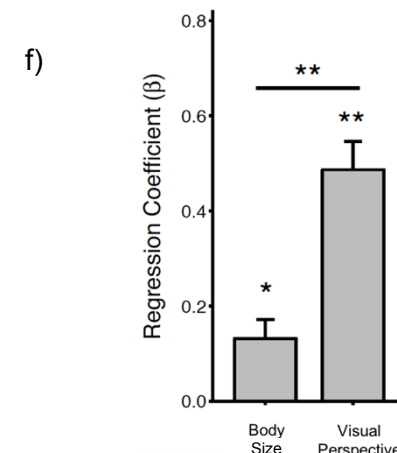
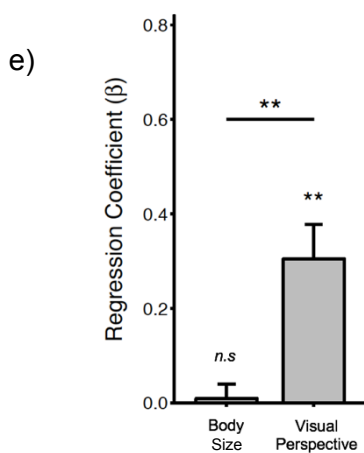
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Fig. 5 - MVPA showing fMRI response patterns to body stimuli conditions. Binary models were created to represent the extreme cases where patterns of response are exclusively predicted by either the a) body size or b) visual perspective of body stimuli. 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

471 were based on data from identical blocks between run 1 and run 2. These correlation matrices were compared
472 against the binary models for both conditions using a multiple regression analysis, with regression
473 coefficients shown for the e) Left EBA and f) Right EBA. Error bars depict standard error of the mean (*=
474 $p < .01$, **= $p < .001$).

475

476 **3.5 Behavioural Responses:**

477 **3.5.1 Aesthetic Evaluations:**

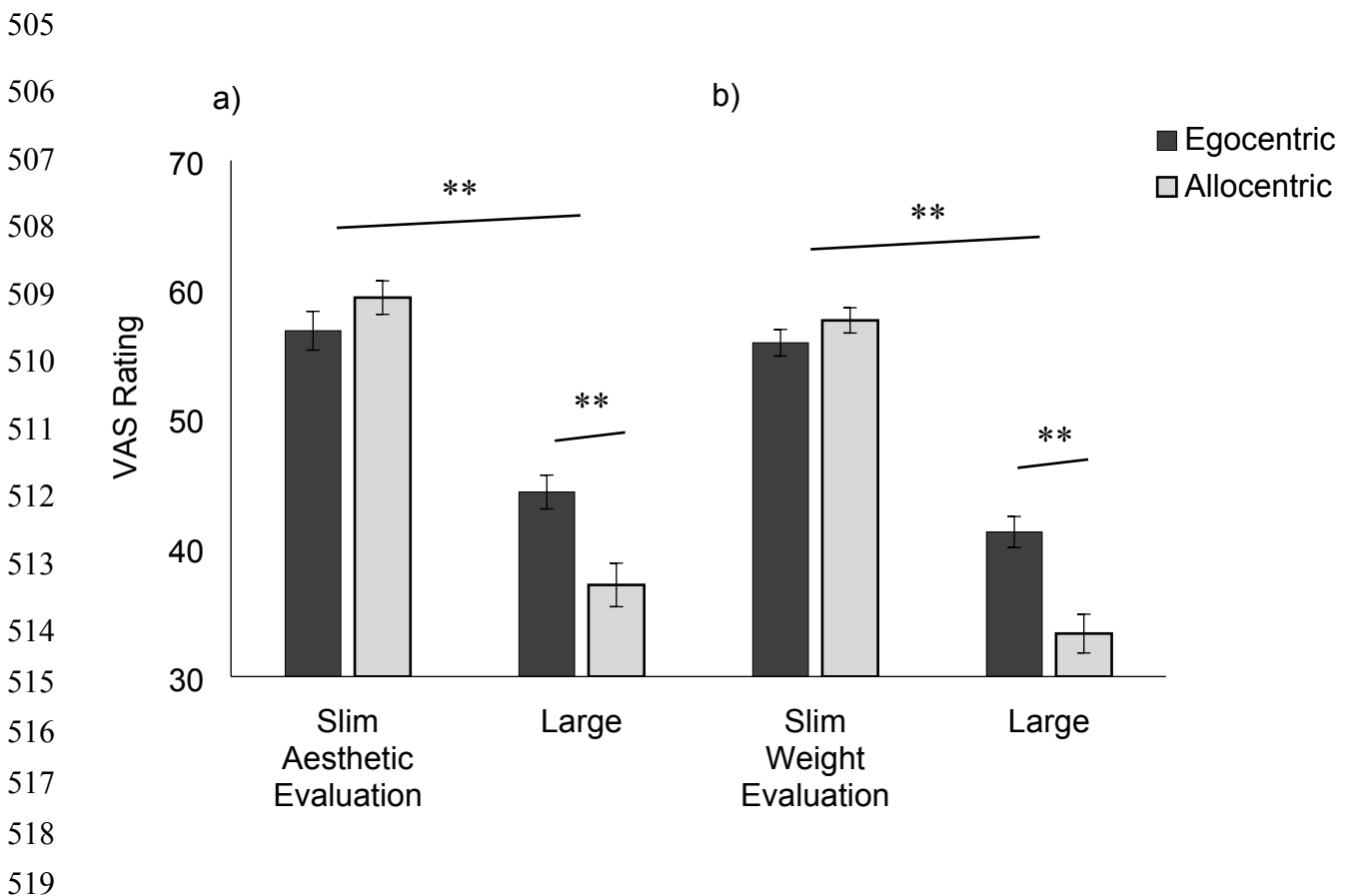
478 Aesthetic evaluation ratings were compared between visual perspective and body size using a
479 2x2 repeated measures ANOVA (see Fig. 6a). There was a significant main effect of body size on
480 ratings of attractiveness ($F(1,29) = 98.03, p < .001, \eta_p^2 = .77$), showing that participants rated slim
481 bodies as significantly more attractive than large bodies. However, there was no significant main effect
482 of visual perspective in ratings of attractiveness ($F(1,29) = 3.99, p = .06, \eta_p^2 = .12$). Nevertheless, there
483 was a significant interaction between visual perspective and body size ($F(1,29) = 24.07, p < .001, \eta_p^2 =$
484 $.45$). Post hoc Bonferroni-corrected ($\alpha = .025$) paired samples t-tests revealed no significant difference
485 in attractiveness ratings between perspectives for slim bodies ($t(29) = -1.68, p = .105, d = -.31$), but
486 participants rated large bodies as significantly less attractive from allocentric perspectives compared
487 with egocentric perspectives ($t(29) = 4.72, p < .001, d = .86$). These results suggest that visual
488 perspective is more important in influencing subjective attractiveness ratings towards larger bodies,
489 with slim bodies rated as equally attractive irrespective of visual perspective.

490

491 **3.5.2 Weight Evaluations:**

492 Weight evaluation ratings were also compared between visual perspective and body size using
493 a 2x2 repeated measures ANOVA (see Fig. 6b). There was a significant main effect of body size on
494 ratings of weight ($F(1,29) = 282.15, p < .001, \eta_p^2 = .91$), showing that participants rated large bodies to
495 weigh significantly more than slim bodies. Further, there was a significant main effect of visual
496 perspective in weight evaluations ($F(1,31) = 13.48, p < .01, \eta_p^2 = .32$), showing that participants rated
497 bodies from allocentric perspectives as weighing significantly more than from egocentric perspectives.
498 Finally, there was a significant interaction between visual perspective and body size ($F(1,31) = 37.07,$
499 $p < .001, \eta_p^2 = .56$). Post hoc Bonferroni-corrected ($\alpha = .025$) paired samples t-tests revealed no

500 significant difference in weight ratings between perspectives for slim bodies ($t(29) = 1.86, p = .073, d$
 501 $= .34$), but participants rated large bodies as significantly more overweight from allocentric perspectives
 502 compared with egocentric perspectives ($t(29) = -5.91, p < .001, d = -1.08$). Similarly, this suggests that
 503 visual perspective has more pronounced effect in influencing the subjective perceived weight of large
 504 bodies, yet such evaluations are statistically unaffected by visual perspective towards slim bodies.



520 **Fig. 6** - Mean VAS rating (0-100) for a) aesthetic and b) weight evaluations of slim and large body
 521 stimuli, from egocentric and allocentric perspectives. Error bars depict standard error of the mean (**=
 522 $p < .001$). **NB. Weight Evaluation VAS ratings are reversed scored for the purposes of the above figure,**
 523 **to represent the similarity in the pattern of responses between behavioural evaluations.**

524 3.6 Relationship between fMRI and Behavioural Responses

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

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

533

534 Finally, a whole brain analysis was run to explore whether any regions outside our defined ROI
535 showed a relationship between fMRI and behavioural responses. Similarly, for exploratory purposes,
536 statistical thresholding was lowered, using clusters determined by $Z > 2.6$, with a corrected cluster
537 significance of $p = 0.05$. Results showed a significant relationship between *Large Allocentric > Large*
538 *Egocentric* contrast and corresponding attractiveness ratings in the right superior frontal gyrus within
539 prefrontal cortex (see Fig. 7 and Supplementary Materials Table S3 for spatial MNI co-ordinates).

540 Crucially, the above contrast showed no significant relationship in any brain regions with the
541 corresponding weight evaluations, suggesting that the effects of aesthetic evaluations may be
542 independent of perceived body weight. Overall, this suggests that such socio-cognitive evaluations
543 made towards bodies may not occur in the EBA, but are instead made in higher-order, prefrontal regions
544 of the brain.

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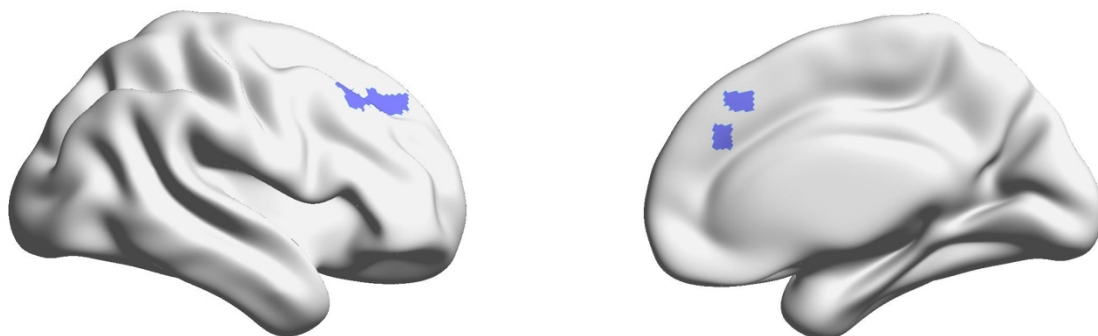
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553 **Fig. 7** - Whole brain correlation analysis between *Large Allocentric Body > Large Egocentric Body* contrast
554 and corresponding behavioural attractiveness ratings (Right Hemisphere). Z threshold > 2.6 with corrected
555 cluster significance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

556 4. Discussion

557

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

577

578 Previous research has found greater neural activation in the EBA in response to allocentric
579 views of human bodies compared with egocentric views (Chan et al., 2004; Saxe et al., 2006). The
580 present study supports the argument that EBA response is functionally modulated by the perceived
581 visual perspective of bodies, however, our results highlight that the role of the EBA is more complex
582 than discriminating between visual perspective alone. Within our univariate analysis we found greater
583 neural activation, bilaterally, to egocentric viewpoints compared with allocentric in response to slim

584 bodies only, with no discrimination between visual perspective in response to large bodies. Such
585 findings may be associated with an increased sense of body identity within egocentric conditions.
586 Indeed, whilst evidence has argued that the EBA is selective in response to images of the self vs. others'
587 bodies (De Bellis, Trojano, Errico, Grossi, & Conson, 2017; Myers & Sowden, 2008), such effects
588 which highlight the effect of body identity within this region remains equivocal (Chan et al., 2004;
589 Downing & Peelen, 2011; Hodzic et al., 2009). Therefore, with evidence that one's own body ownership
590 is optimally coded within egocentric reference frames (Maselli & Slater, 2013), we speculate that a
591 possible explanation for such increased neural amplitude in response to slim bodies from an egocentric
592 visual perspective may be associated with greater congruency between the perceived body and
593 participants' own body identity (Hu et al., 2016).

594

595 Together, the sensitivity of the EBA to also discriminate between body size, and the interaction
596 between such perceptual properties means that it is of little surprise that there are differences between
597 previous research and the present results, given the combined processing of physical attributes in the
598 present study. Indeed, the use of body stimuli which investigates the interaction between body size and
599 visual perspective is novel, and is in contrast to previous research which has used gender neutral (Chan
600 et al., 2004) or body-part specific (Saxe et al., 2006) stimuli when highlighting greater activation to
601 allocentric vs. egocentric visual perspectives. Moreover, our study has a much-improved sample size
602 ($N=30$) compared with previous studies ($N=10$) which have examined the influence of visual
603 perspective on EBA activity (Chan et al., 2004; Saxe et al., 2006). Specifically, previous research has
604 most commonly used localiser tasks which utilise allocentric perspectives of headless bodies (e.g. Chan
605 et al., 2004), in order to localise their EBA region of interest. Therefore, with a small sample size, we
606 speculate that greater activity to allocentric compared with egocentric perspectives in previous research
607 may be influenced by the close congruency between allocentric conditions matching the localiser
608 condition. However, within the present study, we used the same localiser task as previous research, yet
609 our sample size ($N=30$) ensured that we had sufficient power to observe the interactive effect of multiple
610 physical attributes within our study design. Our findings support the literature in highlighting the
611 importance of visual perspective as a critical factor in modulating EBA activity (Chan et al., 2004; Saxe

612 et al., 2006; Arzy et al., 2006), yet extend upon previous work by demonstrating a bilateral sensitivity
613 to other physical body attributes in addition to - and in combination with - visual perspective.
614 Consequently, future studies must consider how multiple body-related properties interact to modulate
615 neural EBA response, which will provide a more real-world assessment of how individuals perceive
616 bodies in everyday life.

617

618 Our univariate analyses revealed a significant interaction between visual perspective and body
619 size in modulating EBA activity, yet research has highlighted that caution must be taken when
620 interpreting neural response using this analysis alone (e.g. Peelen & Downing, 2007), as it is unclear
621 whether changes in overall neural amplitude affects the pattern of response in this region. Therefore, in
622 addition to our univariate results, our MVPA strengthened and extended our findings by discriminating
623 distinct, selective patterns of neural EBA activity between each of our four conditions. Indeed, multiple
624 regression analysis showed EBA responses were significantly predicted by both visual perspective and
625 body size independently, within the right EBA. Whilst neural response was also significantly predicted
626 by visual perspective in the left EBA, body size did not significantly predict activity in this hemisphere.
627 However, this null result should be treated with caution, and may be a statistical power issue given the
628 reduced neural response in the left compared with right EBA. Indeed, such findings are in line with
629 previous fMRI research which shows greater selectivity for bodies in the right EBA (Downing et al.,
630 2001; Downing, Peelen, Wiggett, & Tew, 2006), particularly amongst females (Aleong & Paus, 2010).
631 Thus, the use of MVPA provides a robust technique in identifying dissociable patterns of activity within
632 extrastriate cortex, supporting the argument that the EBA can discriminate between both the visual
633 perspective and size of perceived bodies.

634

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

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

658

659 Despite interactions observed in neural and behavioural responses independently, we did not
660 observe a direct relationship between EBA activity and aesthetic or weight evaluations of bodies.
661 Indeed, the pattern of interactions between the physical attributes were not mirrored neurally and
662 behaviourally. Whilst there was a significant difference in neural activation between visual perspectives
663 for slim bodies, behavioural responses revealed a significant difference in both aesthetic and weight
664 evaluations between perspectives for large bodies. The different patterns of responses observed within
665 these two tasks may suggest that such socio-cognitive evaluations of bodies do not occur in the EBA,

666 but instead occur in brain regions associated with higher-order reasoning (Downing & Peelen, 2011;
667 Taylor, Wiggett, & Downing, 2007). This is supported by our whole brain analysis, which revealed a
668 significant relationship between the superior frontal gyrus (SFG) in prefrontal cortex and aesthetic
669 evaluations of large bodies viewed from different visual perspectives. This region is associated with
670 cognitive processes including self-awareness and introspection (Goldberg, Harel, & Malach, 2006),
671 supporting the argument that higher-order regions are engaged when making such cognitive evaluations
672 of bodies (Greven, Downing, & Ramsey, 2018). The relationship shown within this particular contrast
673 is critical, as individuals were perceiving the same bodies but simply from different visual perspectives.
674 It is speculated that such activation within the SFG in this instance reflects the functional integration
675 between the bottom-up visual properties of large bodies and subsequent top-down impression formation
676 in body perception (Ramsey, 2018). Indeed, observed activation in the SFG specifically in response to
677 large bodies may reflect a more extreme social evaluation in contrast with slim bodies (Greven et al.,
678 2018). Importantly, this finding suggests that the subjective aesthetic appraisal of bodies can be
679 modulated based on the viewpoint in which it is perceived, when all other physical attributes (i.e. body
680 size) are identical. Specifically, whilst the above effect was observed between prefrontal regions and
681 aesthetic evaluations, no significant relationships were observed between any brain regions with
682 behavioural weight evaluations in the identical contrast. This reinforces the argument that such aesthetic
683 evaluations are being made independently of perceived body size or weight.

684

685 Previous research has shown that disruption to extrastriate cortex directly influences aesthetic
686 evaluations of bodies (Calvo-Merino et al., 2010), but not weight estimations (Cazzato et al., 2014,
687 2016) amongst healthy individuals, which suggests that the EBA may have an important, dynamic role
688 in higher-order processing of human bodies (David et al., 2007). However, whilst we do not find
689 evidence of EBA involvement in such higher-order assessments of bodies, our findings suggest that the
690 EBA is sensitive enough to discriminate between the subtleties of body morphology (i.e. body
691 size/shape). Therefore, in addition to our whole brain analysis revealing prefrontal activation, we argue
692 that the EBA may instead act as a core region at the early stage of body processing within a distributed
693 network, which extracts important information for higher-order brain regions when making subsequent

694 socio-cognitive assessments of bodies (Amoruso, Couto, & Ibáñez, 2011; Greven et al., 2018). Future
695 research which investigates the functional connectivity of the EBA within a wider, distributed network
696 is essential, using techniques such as psychophysiological interaction (PPI) analyses (Greven et al.,
697 2018) to examine the distinct communication between brain networks during body perception. Indeed,
698 the present study focused primarily on neural response in the EBA given the converging evidence of its
699 implicated role within body image (Cazzato et al., 2014) and its disturbances (Suchan et al., 2010; Uher
700 et al., 2005).

701

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

715

716 Alternatively, no direct relationship between EBA and behavioural responses may be due to
717 the design of the task undertaken by participants in the present study. Recent research has found
718 dissociable EBA responses when participants were asked to make an explicit social inference of bodies,
719 but not when those bodies were viewed in an identity recognition task (Greven et al., 2018). Thus,
720 whilst EBA activity was modulated between the four conditions within the current study, further
721 investigation of functional integration in body perception could be undertaken by adapting the design

722 of the present task within future research. Specifically, participants could be exposed to a longer
723 stimulus duration of slim vs. large bodies viewed from egocentric vs. allocentric perspectives, followed
724 by explicit evaluation ratings of bodies made *within* the scanner. This would be designed to directly
725 investigate the functional interplay between the perceptual properties of perceived bodies and its
726 relationship with non-visual, higher-order representations following intentional, explicit evaluation of
727 bodies. Such empirical work would help to better understand the neural trajectory between perceptual
728 and cognitive-affective components of body image (Ramsey, 2018).

729

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

740

741 Behavioural research has highlighted the importance of visual perspective in its role within
742 body ownership (Jenkinson & Preston, 2017; Preston, Kuper-Smith, & Ehrsson, 2015). Direct
743 comparison between first-person (egocentric) and third-person (allocentric) perspectives using
744 multisensory illusion paradigms have yielded clear findings of greatest body ownership (feelings as if
745 the viewed body is your own body) when synchronous sensory input is coded from an egocentric
746 reference frame within peripersonal space (Maselli & Slater, 2013; Petkova, Khoshnevis, & Ehrsson,
747 2011). This highlights the intrinsic, robust role of visual perspective with the physical self in human
748 body perception. Moreover, whilst previous research has argued that the EBA does not play a role in
749 discriminating between self and others (Chan et al., 2004), the perception of one's *own* body compared

750 with another's is important to consider in relation to changes in one's body image. Indeed, body image
751 disturbances amongst ED patients show alterations specifically in the perception of one's own body,
752 but not of others (Castellini et al., 2013; Mai et al., 2015; Sachdev, Mondraty, Wen, & Gulliford, 2008).
753 Thus, as participants in the present study only viewed images of others' bodies, future studies should
754 explore the effect of visual perspective with the perception and evaluation of one's own body (e.g.
755 Ganesh, van Schie, Cross, de Lange, & Wigboldus, 2015) compared with another's body, in relation to
756 non-clinical ED psychopathology.

757

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

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- 1016

Supplementary Material

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

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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 ($F(1, 29) = 15.64, p < .001, \eta^2 = .35$), showing greater activation in the right EBA compared with the left EBA. No main effect of body size was observed ($F(1, 29) = 3.18, p = .085, \eta^2 = .10$). Furthermore, no interaction of hemisphere x body size was observed ($F(1,29) = .28, p = .60, \eta^2 = .01$).

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.