RESEARCH ARTICLE

Body Image in Anorexia Nervosa: Body Size Estimation Utilising a Biological Motion Task and Eyetracking

Andrea Phillipou[1,2,3]*, Susan Lee Rossell[4,5,6], Caroline Gurvich[5], David Jonathan Castle[2,6,7], Nikolaus Friedrich Troje[8] & Larry Allen Abel[1]

[1]Department of Optometry & Vision Sciences, The University of Melbourne, Melbourne, Australia
[2]Department of Psychiatry, The University of Melbourne, Melbourne, Australia
[3]Department of Mental Health, The Austin Hospital, Melbourne, Australia
[4]Brain and Psychological Sciences Research Centre, Swinburne University of Technology, Melbourne, Australia
[5]Monash Alfred Psychiatry Research Centre, Melbourne, Australia
[6]Department of Psychiatry, St Vincent's Hospital, Melbourne, Australia
[7]Faculty of Health Sciences, Australian Catholic University, Melbourne, Australia
[8]Department of Psychology, Queen's University, Kingston, Canada

Abstract

Objective: Anorexia nervosa (AN) is a psychiatric condition characterised by a distortion of body image. However, whether individuals with AN can accurately perceive the size of other individuals' bodies is unclear.
Method: In the current study, 24 women with AN and 24 healthy control participants undertook two biological motion tasks while eyetracking was performed: to identify the gender and to indicate the walkers' body size.
Results: Anorexia nervosa participants tended to 'hyperscan' stimuli but did not demonstrate differences in how visual attention was directed to different body areas, relative to controls. Groups also did not differ in their estimation of body size.
Discussion: The hyperscanning behaviours suggest increased anxiety to disorder-relevant stimuli in AN. The lack of group difference in the estimation of body size suggests that the AN group was able to judge the body size of others accurately. The findings are discussed in terms of body image distortion specific to oneself in AN.

Received 2 June 2015; Revised 8 October 2015; Accepted 6 November 2015

Keywords

eating disorder; eye movements; scanpaths; visual attention

***Correspondence**

Dr Andrea Phillipou, Department of Mental Health, St Vincent's Hospital, Fitzroy, VIC 3065, Australia. Tel: 0061 3 9231 4577. Fax: 0061 3 9231 4802.
Email: ap@unimelb.edu.au

Published online 1 December 2015 in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/erv.2423

Anorexia nervosa (AN) is a psychiatric illness characterised by significantly low body weight and a fear of weight gain. A core feature of AN is a disturbance in the way in which an individual experiences their own body shape or weight, and this distortion of body image is indeed a diagnostic criterion for the disorder (American Psychiatric Association, 2013). However, whether individuals with AN have a perceptual disturbance that alters the experience of their own bodies is unclear. One of the main methods utilised to assess perceptual body image disturbances in AN is the use of body size estimation tasks. In relation to estimating the size of their own body, some investigators have reported that individuals with AN do not differ from healthy controls (HCs; Fernández, Probst, Meerman, & Vandereycken, 1994; Fernández-Aranda, Dahme, & Meermann, 1999; Probst, Vandereycken, Van Coppenolle, & Pieters, 1995, 1998), while other research suggests that people with AN significantly overestimate their own body size (Collins et al., 1987; Slade & Russell, 1973; Smeets & Kosslyn, 2001; Tovée, Emery, & Cohen–Tovée, 2000).

The estimation of other people's body size has been far less frequently investigated in AN as the disturbance in body perception has generally been held to be related solely to one's own body. However, in a study by Smeets (1999), where participants were required to select when a morphing video of a woman transitioned from thin–normal to fat–obese, AN participants perceived earlier transitions than HCs. In other words, what AN participants considered a thin, normal, overweight or obese body was thinner than

Contract/grant sponsor: Jack Brockhoff Foundation
Contract/grant number: 3410.
Contract/grant sponsor: Dick and Pip Smith Foundation.
Contract/grant sponsor: Australian Postgraduate Award.
Contract/grant sponsor: David Hay Memorial Fund Award.

what controls considered these body sizes to be. Furthermore, Tovée, Emery and Cohen-Tovée (2000) reported not only an overestimation of body size in AN but also a preference in AN participants to consider lower body mass as more attractive. This study also found that as the body mass index of the observer decreased, the overestimation of body size was accentuated.

The areas of the body upon which individuals with AN focus have also been found to differ from healthy individuals. During a free-viewing task where participants were presented with whole body stimuli, Watson, Werling, Zucker and Platt (2010) showed reduced attention to face regions in AN. Furthermore, Freeman et al. (1991) showed participants images of themselves photographed in a black leotard and reported that while HC participants spent relatively the same amount of time focusing on the four interest areas (the face, chest, abdomen and legs), individuals with AN spent more time looking at their legs and abdomen and less time looking at their face. Furthermore, the areas of the body that were of greater focus in AN corresponded to the areas of the body with which the patients were most dissatisfied. Jansen, Nederkoorn and Mulkens (2005) also found that participants with 'non-clinical' eating disorder symptomatology spent more time looking at their self-identified 'ugly' body parts than their self-identified 'beautiful' body parts, whereas individuals without eating disorder symptomatology were not found to show any difference in the amount of time focusing on their self-identified beautiful or ugly body parts.

In a more recent study, Hewig et al. (2008) presented male and female participants scoring high and low on the drive for thinness scale of the Eating Disorders Inventory (Garner, Olmstead, & Polivy, 1983) with male and female body images. Participants scoring high on the measure were found to make more fixations to and fixate longer on the waist, hips, arms and legs, and less at the face and head area. The authors suggest that the results reflect an attentional bias to areas that are associated with assessing body weight. Furthermore, the strength of the findings was dependent on the garments the models were wearing, with those in undershirts having the strongest effect, followed by those in underwear and swimwear, and nudes. These findings suggest that the clothing worn by models has an influence on which parts of the body people attend to. Therefore, it is necessary to control for these possible effects in studies of these phenomena. Furthermore, personal characteristics of the model may draw more attention to certain body parts that should also be controlled for. Rather than utilising drawings or computer-generated images of human figures, which can be unrealistic and distracting, a potential tool is the human body biological motion task, in which moving dots represent a human in motion.

Biological motion stimuli can be created to investigate a number of parameters including the identification of gender, age, emotion and body size. Furthermore, the task instruction given to participants can influence performance on the task as different aspects of the stimulus can be attended to. Biological motion tasks have been utilised in a variety of ways and have revealed atypical processing of these stimuli in a number of psychiatric conditions. Individuals with autism spectrum disorder have been found to show poorer emotion perception of biological motion stimuli (Parron et al., 2008), as have individuals with schizophrenia (Couture et al., 2010). When presented with happy, sad, afraid, angry and neutral biological motion stimuli, individuals currently ill with AN have been found to display poorer identification of sad stimuli, whereas individuals weight recovered from AN were not found to differ from healthy individuals in emotion identification (Zucker et al., 2013). In another biological motion study in eating disorders, Vocks, Legenbauer, Rüddel and Troje (2007) asked participants with bulimia nervosa (BN) and HCs to adjust biological motion stimuli to indicate their actual, felt and ideal body dimensions. Although individuals with BN did not differ from healthy individuals in the ideal and actual body size conditions, BN participants demonstrated larger body sizes in the felt condition.

The main aim of the study reported here was to utilise a human biological motion task to investigate body size estimation of others in AN. An additional aim was to investigate visual scanpath characteristics to biological motion stimuli in AN, as well as to ascertain whether task instructions modify visual scanpaths. Participants were therefore presented with a gender identification task (implicit task) and a body size estimation task (explicit task), while eyetracking was performed to investigate whether the explicit instruction to estimate body size changed how individuals with AN scan these stimuli. We hypothesised that individuals with AN would overestimate the size of the biological motion stimuli in comparison with healthy individuals (hypothesis 1). Given individuals with AN's preoccupation with body image, we also hypothesised that they would show greater visual attention to areas of the body related to body size estimation (i.e. hips) during the implicit task (hypothesis 2). Similarly to other clinical populations who show atypical scanpaths only during implicit processing, but not when given an explicit instruction (Delerue, Laprévote, Verfaillie, & Boucart, 2010), it was expected that areas of attentional focus would not differ from healthy individuals when an explicit task was undertaken (hypothesis 3). As hyperscanning is seen in response to disorder-relevant stimuli in related clinical populations such as social anxiety disorder (Horley, Williams, Gonsalvez, & Gordon, 2004) and is thought to be related to increased anxiety, it was predicted that AN participants would show hyperscanning (i.e. an increased number of fixations of shorter duration) in both tasks, particularly to heavier stimuli (hypothesis 4). It was also expected that the overestimation of body size, hyperscanning in both tasks and the increased attention to areas related to body size estimation during the implicit task would be greater to female than male stimuli as the relevance of these stimuli to the processing of body image in women with AN would be expected to be greater.

Materials and methods

Participants

Twenty-four individuals with AN and 25 HC participants completed the study. Technical eyetracking difficulties resulted in the eyetracking data of one HC being excluded, allowing analyses to be conducted on 24 AN and 24 HC participants. HCs were recruited through public advertisements, whereas AN participants were recruited through public advertisements, the Body Image and Eating Disorders Treatment and Recovery Service at the Austin and St Vincent's Hospitals, and The Melbourne Clinic (all in Melbourne, Australia).

All participants were English speaking, had no history of head injury that resulted in a loss of consciousness or neurological condition, no significant ocular pathology and normal (or corrected to normal) visual acuity. Controls were required to have no history of an eating disorder or other mental illness; they were also required to not be taking any medications apart from hormonal contraceptives (11 HC participants were taking this medication). AN participants were instructed to continue with their normal medications, which were as follows: selective serotonin reuptake inhibitors (10), atypical antipsychotics (10), benzodiazepines (5), serotonin–noradrenaline reuptake inhibitors (3), hormonal contraceptives (3), melatonergic antidepressants (2), noradrenergic and specific serotonergic antidepressant (1) and cyclopyrrolones (1).

The Mini International Neuropsychiatric Interview, 5.0.0 (Sheehan et al., 1998) was used to screen participants for major Axis I psychiatric disorders according to the Diagnostic and Statistical Manual of Mental Disorders. It was also used to confirm diagnoses of AN, with the exception of the amenorrhea criterion, which is no longer included in the current DSM-5. AN was required to be the primary diagnosis of the AN group. AN participants with comorbid psychiatric conditions, other than psychotic conditions, were not excluded as this would not have represented a typical AN sample.

Premorbid intelligence was estimated using the Wechsler Test of Adult Reading (Wechsler, 2001). Eating disorder symptomatology was investigated with the Eating Disorders Examination Questionnaire (EDE-Q; Fairburn, 2008), and body image with the figure rating scale (FRS; Stunkard, Sørensen, & Schulsinger, 1983; Table 1). The FRS is a 9-point rating scale of nine female schematic silhouettes ranging from thin to very obese. Participants are asked to indicate along the 9-point scale their *ideal* figure, the figure that best reflects how they *think* they look, the figure that best reflects how they *feel* most of the time, the figure they think is *preferred by men* and the figure they think is most *preferred by women*. Similarly to Thompson and Altabe (1991), discrepancy scores were calculated as follows: ideal minus think, ideal minus feel and think minus feel.

Biological motion task

The biological motion task used in this study was developed by the BioMotionLab at Queen's University, Ontario (Troje, 2002). The stimuli consist of point-light displays in which the movement of lights placed at major joints results in the appearance of a moving organism. All stimuli showed walkers presented in frontal view. The appearance of the walkers varied along two dimensions: they looked either clearly male (6 *SD* from the mean, Troje, 2002) or clearly female (−6 *SD*). In addition, the figures were varied according to apparent body weight in 13 steps that ranged from very slim to very heavy (range of ± 6 *SD*; examples of the types of stimuli used can be found at http://www.biomotionlab.ca/Demos/BMLwalker.html). The resulting 26 stimuli were presented twice each in a pseudorandom order, yielding a total of 52 trials, with the same stimulus never being presented twice in a row. Prior to the presentation of each stimulus, a 1° black fixation cross appeared in the centre of a white screen for 500 ms. The stimulus then followed for a period of 8000 ms, followed by a response screen. In the implicit (gender identification) task, participants were asked to respond by clicking on the gender of the previous stimulus. In the explicit (body size estimation) task, participants were required to click along a Likert scale ranging from 1 (*very underweight*) to 13 (*very overweight*). The response screen was presented until participants made their decision. The biological

Table 1 Participant information

	AN		HC		
	M	*SD*	*M*	*SD*	*p*
Age	23.07	6.88	22.72	3.25	0.824
Premorbid IQ	104.67	8.19	106.38	5.95	0.413
BMI	16.52	1.14	22.26	3.59	0.001
Illness duration	6.42	7.43	—	—	—
Age of illness onset	16.04	3.40	—	—	—
EDE-Q restraint	3.93	1.42	0.55	0.63	0.001
EDE-Q eating concern	3.78	1.24	0.25	0.32	0.001
EDE-Q shape concern	5.01	0.90	1.18	0.86	0.001
EDE-Q weight concern	4.50	1.41	0.67	0.84	0.001
EDE-Q global score	4.30	1.12	0.67	0.55	0.001
FRS ideal	2.08	0.93	3.13	0.80	0.001
FRS think	4.88	1.75	3.96	1.16	0.038
FRS feel	7.04	1.68	4.00	1.02	0.001
FRS male prefer	3.42	1.06	3.25	0.79	0.541
FRS female prefer	2.58	0.97	2.46	0.72	0.616
FRS ideal—think	−2.96	2.37	−0.83	1.05	0.001
FRS ideal—feel	−4.96	1.97	−0.88	1.03	0.001
FRS think—feel	−2.17	1.37	−0.04	0.46	0.001

AN, anorexia nervosa; HC, healthy control; premorbid IQ, standardised Wechsler Test of Adult Reading Score; BMI, body mass index; EDE-Q, Eating Disorders Examination Questionnaire; FRS, figure rating scale; age, age of illness onset and illness duration are reported in years.

motion stimuli were presented at a frame rate of 25 Hz at 640×480 pixels, equalling approximately 5×16 cm, or $3° \times 10°$ of visual angle at viewing distance of 90 cm, varying slightly depending on the body size of the walker. The implicit task was presented first so that participants were not explicitly aware that the different stimuli corresponded to different body sizes and so that they would be somewhat familiar with the different stimuli for the next task, which required them to estimate the body size.

Stimuli were presented through SR Research's Experiment Builder programme, and eyetracking was recorded using a remote view eyetracker, the EyeLink1000 (SR Research, Ontario, Canada), monocularly at 1000 Hz. Data were analysed with SR Research's analysis programme, DataViewer. Stimuli were grouped into weight categories for analysis (i.e. thin, thin-mid, mid, mid-heavy and heavy). Average fixation count, fixation duration and saccade amplitude were calculated for each body size category. Discrete areas of interest (AOIs) were created and included the head, shoulders, hips, knees, feet and arms. To investigate the proportion of fixations and fixation durations to salient features (the AOIs) and non-salient features, two spatial–temporal parameters were calculated: the feature fixation index (FFI) and the feature duration index (FDI; Williams, Loughland, Gordon, & Davidson, 1999). The FFI is derived by dividing the number of fixations to salient features minus the number of fixations to non-salient features by the total number of fixations. The FDI is derived in the same manner. Indices range from -1 to $+1$, with positive values indicating more fixations or longer durations to salient features and negative values indicating more visual attention to non-salient features. Average fixation count and dwell times (total time fixating on an interest area during a trial) to each AOI were also calculated for each body size category.

Statistical analysis

Performance on the biological motion tasks was compared between groups with mixed-design analyses of variance (ANOVAs), following normality checking and the removal of outliers. SPSS version 21 (SPSS, Chicago, IL, USA) was used, and α was set at 0.05. Further descriptions of the ANOVAs are presented in the succeeding texts, and for brevity, only interactions with group will be commented on.

Results

Figure rating scale

Results of the FRS indicated that figures participants' *felt* they looked like were significantly larger, and *ideal* figures were significantly thinner in AN. The figures participants' *thought* they looked like were also significantly larger in AN, despite significantly lower body mass indices in the AN group. AN participants' *ideal* figures were significantly thinner than the figures they *thought* and *felt* they looked, relative to controls. The figures AN participants reported they *felt* they looked like were also significantly heavier than the figures they *thought* they looked like, compared with the HC group (Table 1).

Biological motion task

Behavioural

A between groups ANOVA revealed that groups did not differ in gender discrimination in the implicit task [$F(1, 11) = 0.47$, $p = 0.510$].

For the explicit biological motion task, a body size discrimination score was determined by subtracting the participants' responses by the correct scores for each body size (Table 2). A 2 (group) × 5 (body size category) × 2 (gender) mixed design ANOVA was conducted on the explicit biological motion task for this body size discrimination score (hypothesis 1). A significant main effect of body size category was found [$F(1.50, 70.61) = 525.10$, $p < 0.001$] with body size estimation decreasing (underestimating) as the stimulus size increased. A significant main effect of gender of the walker [$F(1, 47) = 12.90$, $p = 0.001$] was also found with overestimation of male stimuli. A significant interaction between body size category and gender was also found [$F(2.11, 99.01) = 12.94$, $p < 0.001$]. No significant main effect of group and no other significant interactions were found.

Eyetracking

Scanpath characteristics

Two (group) × 5 (body size category) × 2 (gender) × 2 (task) mixed design ANOVAs were carried out for average fixation count, fixation duration and saccade amplitude separately (hypothesis 4; Supporting Information Table S1).

For fixation count, a significant main effect of group was found with AN participants making more fixations than HCs [$F(1, 46) = 6.72$, $p = 0.013$]. Significant interactions were also found between body size category and task [$F(3.25, 149.5) = 3.58$, $p = 0.013$], and between body size category, gender and group [$F(4, 184) = 2.65$, $p = 0.035$; Figure 1]. Within-subjects contrasts revealed a significant difference between mid-heavy body sizes between male and female stimuli in AN participants relative to HCs [$F(1, 46) = 9.41$, $p = 0.004$]. Fixation count for AN participants was increased to mid-heavy male stimuli, relative to female stimuli. Fixation count to male and female stimuli did not differ to the mid-heavy body size category in HCs.

For fixation duration, significant main effects were found for body size category [$F(2.87, 132) = 4.65$, $p = 0.005$] with longer fixation durations to both thin and heavy stimuli than other body sizes. A significant main effect was also found for task [$F(1, 46) = 16.2$, $p < 0.001$] with longer fixations during the implicit task, and a significant main effect for group, with AN participants displaying shorter fixation durations than HCs, was also found [$F(1, 46) = 5.60$, $p = 0.022$]. No significant interactions were revealed.

For saccade amplitude, significant main effects were found for body size category [$F(2.69, 124) = 3.54$, $p = 0.020$] with larger saccade amplitudes to thin and thin-mid body sizes, and gender [$F(1, 46) = 4.39$, $p = 0.042$] with larger saccade amplitudes to male stimuli. There was also a significant main effect for group, with AN participants making saccades of smaller amplitude than HCs [$F(1, 46) = 5.89$, $p = 0.019$]. A significant interaction was also revealed for task by group: saccadic amplitudes remained similar from the implicit to explicit tasks in AN but decreased between

Table 2 Body size discrimination scores

	AN				HC			
	Female stimuli		Male stimuli		Female stimuli		Male Stimuli	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Thin	1.66	1.46	2.88	1.31	1.20	1.46	2.44	1.74
Thin-mid	0.41	1.46	1.53	1.22	0.90	1.34	1.12	1.55
Mid	−1.12	1.29	−0.15	1.30	−1.30	1.17	−0.43	1.24
Mid-heavy	−2.08	1.28	−2.08	1.28	−2.23	1.47	−2.25	1.43
Heavy	−3.35	1.80	−3.35	1.40	−3.94	1.88	−3.42	1.27

AN, anorexia nervosa; HC, healthy control.
Discrimination scores over and under 0 indicate overestimation and underestimation of body sizes, respectively.

tasks in HCs [$F(1, 46) = 5.70$, $p = 0.021$; Figure 2]. Further analyses revealed a significant group difference during the implicit task, with AN participants making smaller saccades than HC participants [$F(1, 46) = 12.6$, $p < 0.001$]. However, groups were not found to differ in saccade amplitude during the explicit task.

Areas of interest

A 2 (group) × 5 (body size category) × 6 (body area) × 2 (gender) × 2 (task) mixed design ANOVA was undertaken for fixation count and dwell time to AOIs (hypothesis 3; Supporting Information Tables S2 and S3). For fixation count to salient stimuli, significant main effects included gender [$F(1, 44) = 7.98$, $p = 0.007$], body size category [$F(2.75, 121) = 26.22$, $p < 0.001$] with increased fixations to larger body sizes, and body area [$F(1.97, 86.8) = 63.44$, $p < 0.001$] with more fixations to the hips than any region and fewest to the head. Significant interactions were found between task, body size category and gender [$F(4, 176) = 3.99$, $p = 0.004$], task and body area [$F(2.09, 91.7) = 3.42$, $p = 0.035$], body size category and body area [$F(6.15, 271) = 19.6$, $p < 0.001$], gender and body area [$F(2.31, 102) = 29.59$, $p < 0.001$] and body size category, gender and body area [$F(7.57, 333) = 4.10$, $p < 0.001$]. There was no significant main effect of group or any significant group interactions.

For dwell time to salient stimuli, there were significant main effects of body size category [$F(2.95, 129) = 17.60$, $p < 0.001$] with increased dwell times to AOIs of larger body sizes, and body area [$F(2.21, 97.4) = 74.78$, $p < 0.001$] with increased dwell times to the hip and shoulder regions and decreased dwell times to the head. There were also significant interactions between body size category and body area [$F(7.17, 315) = 16.6$, $p < 0.001$], gender and body area [$F(2.27, 99.9) = 21.8$, $p < 0.001$] and body size category, gender and body area [$F(8.67, 381) = 3.07$, $p = 0.002$]. There was no significant main effect of group or any significant group interactions.

We also conducted 2 (group) × 5 (size category) × 2 (task) mixed design ANOVAs on the FFI and FDI (Supporting Information Table S4). For the FFI, there was a significant main effect of body size category [$F(3.30, 145) = 13.8$, $p < 0.001$] with more fixations to non-salient rather than salient features of heavy stimuli compared with thin stimuli, and a significant interaction between task and body size category [$F(4, 176) = 3.17$, $p = 0.015$] was found for the FFI, but no significant main effect of group or

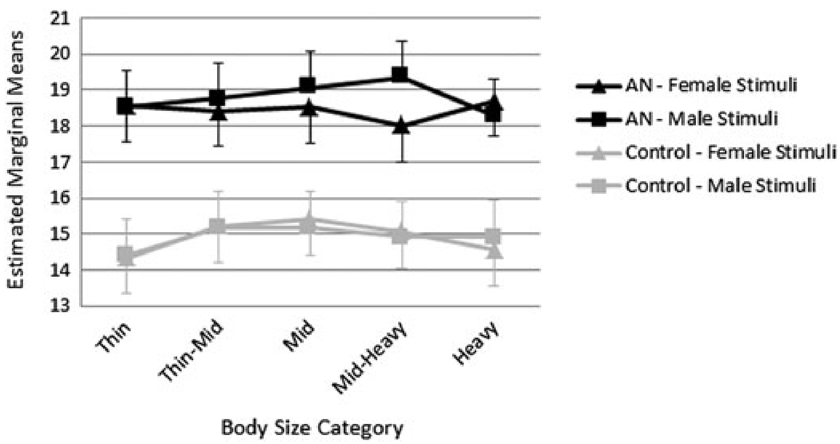

Figure 1. Fixation count for anorexia nervosa (AN) and control groups for each gender and body size category of biological motion stimuli over the implicit and explicit biological motion tasks (error bars = standard error)

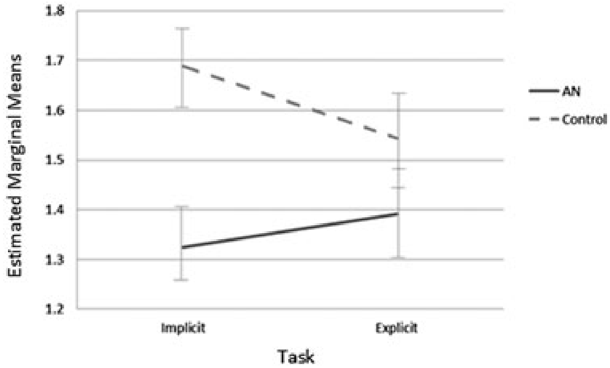

Figure 2. Saccadic amplitude for anorexia nervosa (AN) and control groups for the implicit and explicit biological motion tasks (error bars = standard error)

group interactions. For the FDI, a significant main effect of body size category was found [$F(3.06,\ 134) = 7.89,\ p < 0.001$] with greater attention to non-salient features of mid-size stimuli, but there were no other main effects, or significant interactions.

Discussion

The aim of this study was to investigate body size estimation of others in AN. Additional aims were to investigate visual scanpath characteristics to biological motion stimuli in AN and to ascertain whether task instructions modify visual scanpaths. Overall, the findings of this study suggest that irrespective of stimulus gender, individuals with AN are as accurate as controls in their estimates of body size and visually attended to the same areas of the bodies but differed in their ocular motor behaviour, displaying hyperscanning (increased fixations of shorter duration) during both implicit and explicit tasks.

The finding of intact body size estimation in the current study is contrary to those reported by Smeets (1999) and Tovée, Emery and Cohen–Tovée (2000) who found that AN participants overestimated body size of human stimuli relative to healthy individuals. The current findings suggest that the perception of physical body size does not always differ between healthy individuals and those with AN. The divergence from past research may reflect an influence of physical characteristics of real human stimuli on body size perception. Our findings from the FRS, however, support the notion that individuals with AN may perceive their own physical size as larger, as the figure they thought they looked like was significantly larger than controls, despite having significantly lower body mass indices. Furthermore, a discrepancy between how AN participants thought and felt they looked was also apparent, with AN participants reporting feeling larger than they thought they appeared; a discrepancy that was not evident for healthy individuals. This finding may suggest a deficit in multisensory integration in AN, as has been reported in studies assessing differences between perceived and actual size and weight in AN (Case, Wilson, & Ramachandran, 2012; Guardia et al., 2012). Alternatively, these results suggest that a distortion in the way the body is *felt* may be a more significant problem for individuals with AN than the way the body is *visually perceived*. Given the lack of difference found in the perception of others' body size, further research utilising biological motion stimuli in the same manner as Vocks, Legenbauer, Rüddel and Troje (2007), where participants with BN were required to set the stimulus to reflect their actual, felt and ideal bodies, would be valuable to investigate in AN. This would allow for the investigation of own body size perception in AN, without the confounds associated with distorting own body stimuli that can result in unrealistic and distracting images.

As hypothesised, groups were found to differ in scanpath behaviours. Specifically, AN participants tended to hyperscan stimuli. Scanning behaviours were, however, not found to differ depending on the gender or the body size of the stimulus alone but were found to differ between body size categories of the two genders between groups. This was demonstrated by an increased rate of fixations to mid-heavy male stimuli in relation to female stimuli in AN, a relationship that was not evident in controls. Crucially, the AN group was found to demonstrate hyperscanning overall during both biological motion tasks. As hyperscanning of stimuli is often associated with anxiety (Horley et al., 2004), the tendency for individuals with AN to show these behaviours when presented with human body biological motion stimuli may reflect increased anxiety to disorder-relevant stimuli. Hyperscanning of face stimuli has similarly been reported by our group in the same sample of AN participants (Phillipou et al., 2015). Although this may suggest that individuals with AN also find face stimuli anxiety provoking, it may suggest deficits in brain areas related to saccade inhibition that result in the over-firing of saccades. Relatedly, our recent research has indicated reduced saccade inhibition during attempted fixation in AN (Phillipou, Rossell, Castle, Gurvich, & Abel, 2014). However, whether hyperscanning behaviours in AN are present when observing non-anxiety provoking stimuli has not been examined and should be investigated in future research.

The hyperscanning behaviours reported in the current study may also suggest an increased tendency to focus on details in AN; this is further supported by the finding of smaller saccadic amplitudes during the implicit biological task. Perfectionism and a preoccupation with details are often reported in AN (Bastiani, Rao, Weltzin, & Kaye, 1995; Halmi et al., 2000; Tokley & Kemps, 2007), and individuals with AN tend to focus on details and lose sight of the 'big picture'. This is evident on tasks of central coherence where individuals with AN have demonstrated superior performance on tasks requiring local processing and poorer performance on tasks requiring global processing (Gillberg, Råstam, Wentz, & Gillberg, 2007; Lopez et al., 2008; Tokley & Kemps, 2007).

Having said this, saccadic amplitudes did not differ between groups during the explicit task. Although the AN group had similar saccade amplitudes during both tasks, the HC group's saccade amplitudes decreased between implicit and explicit tasks, resulting in similar saccade amplitudes between groups during explicit processing. Scanning behaviours are typically found to differ depending on task instruction in both healthy and clinical populations (Delerue et al., 2010; Yarbus, 1967). In schizophrenia, differences in scanpath characteristics change in the same direction as HCs between passive and active tasks (Delerue et al., 2010). This was, however, not found in the current study for saccade amplitude. Saccadic amplitude was found to remain stable in AN participants from the implicit to explicit tasks but decreased between tasks in the control group to similar values of patients. Therefore, this result may reflect more local processing in healthy individuals during the explicit task. Furthermore, as the AN group displayed similar saccadic amplitudes between task conditions, and their saccadic amplitudes were similar to that of controls during explicit processing, it may suggest that the AN patients engage in scanning behaviours relevant for body size evaluation irrespective of task instruction.

Although differences in scanning behaviours were apparent between groups, in our study, AN participants did not differ from healthy individuals in the body areas attended to. AN participants and HCs did not differ in the number of fixations or the amount of time spent fixating on different body regions in either biological motion task. This finding may also be related to the intact estimation of body size to the biological motion stimuli in AN. As participants were visually attending to the same areas of the stimuli as healthy individuals, it may suggest that they were attending to appropriate areas to make a body size judgement, a behaviour that may not persist when examining one's own body in AN. Freeman et al. (1991) reported increased visual attention to areas related to weight estimation such as the legs and abdomen in AN to images of one's own body. Although Freeman et al. (1991) did not investigate body size estimation of oneself, other investigations have suggested an overestimation of own body size in AN (Collins et al., 1987; Slade & Russell, 1973; Smeets & Kosslyn, 2001; Tovée et al., 2000). Therefore, the overestimation of body size commonly reported in AN may be related to increased visual attention to areas related to body weight estimation. Further investigations of visual scanpaths to own-body biological motion stimuli, as described previously, would also be beneficial for this reason.

Conclusions

Together, these results suggest that individuals with AN are able to estimate the physical size of human body biological motion stimuli as accurately as healthy individuals. This implies that although individuals with AN may perceive themselves as larger, their perception of body size for other individuals is intact. Therefore, a distorted perception of body size may be specific to oneself in the condition. Furthermore, although AN participants fixated the same body areas when observing these stimuli, scanpath behaviours differed from HCs. Individuals with AN were found to hyperscan stimuli relative to HCs, which may reflect a preoccupation with detail or increased anxiety induced by disorder-relevant stimuli in AN. A number of reports have suggested a relationship between anxiety and AN (Kaye, Bulik, Thornton, Barbarich, & Masters, 2004; Phillipou, Rossell, Castle, Gurvich, & Abel, 2014), and the findings of the current study may provide further support for this association. Furthermore, as the current study indicates a potential role of anxiety related to body stimuli, future research examining scanning behaviour to own body stimuli may provide information about increased anxiety to self-body stimuli in AN. Additionally, these scanning behaviours may be monitored over the course of treatment to investigate improvements in scanning behaviour, which may be indicative of reduced anxiety to disorder-relevant stimuli and, correspondingly, improved body image in AN.

Acknowledgements

This research was supported by the Jack Brockhoff Foundation (L. A., S. R., D. C. and A. P., grant number: 3410), the Dick and Pip Smith Foundation (A. P., L. A., S. R. and D. C.), an Australian Postgraduate Award (A. P.) and the David Hay Memorial Fund Award (A. P.). The authors would like to thank Charlotte Keating for administering the clinical interview. The authors would also like to thank Chia Huang, Richard Newton, Lynley Gervasoni, Michelle Snell, Helen Shepherd, Philippa Harrison and Felicity Lawrence for their assistance in recruiting participants. Finally, the authors would like to thank everyone who took the time to participate in the study.

References

American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders 5. Washington, DC: American Psychiatric Association.

Bastiani, A. M., Rao, R., Weltzin, T., & Kaye, W. H. (1995). Perfectionism in anorexia nervosa. *International Journal of Eating Disorders*, *17*(2), 147–152.

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.

Collins, J. K., Beumont, P. J. V., Touyz, S. W., Krass, J., Thompson, P., & Philips, T. (1987). Variability in body shape perception in anorexic, bulimic, obese, and control subjects. *International Journal of Eating Disorders*, *6*(5), 633–638.

Couture, S. M., Penn, D. L., Losh, M., Adolphs, R., Hurley, R., & Piven, J. (2010). Comparison of social cognitive functioning in schizophrenia and high functioning autism: More convergence than divergence. *Psychological Medicine*, *40*(4), 569–579.

Delerue, C., Laprévote, V., Verfaillie, K., & Boucart, M. (2010). Gaze control during face exploration in schizophrenia. *Neuroscience Letters*, *482*(3), 245–249.

Fairburn, C. G. (2008). Cognitive behavior therapy and eating disorders. New York, NY: Guilford Press.

Fernández, F., Probst, M., Meerman, R., & Vandereycken, W. (1994). Body size estimation and body dissatisfaction in eating disorder patients and normal controls. *International Journal of Eating Disorders*, *16*(3), 307–310.

Fernández-Aranda, F., Dahme, B., & Meermann, R. (1999). Body image in eating disorders and analysis of its relevance: A preliminary study. *Journal of Psychosomatic Research*, *47*(5), 419–428.

Freeman, R., Touyz, S., Sara, G., Rennie, C., Gordon, E., & Beumont, P. (1991). In the eye of the beholder: Processing body shape information in anorexic and bulimic patients. *International Journal of Eating Disorders*, *10*(6), 709–714.

Garner, D. M., Olmstead, M. P., & Polivy, J. (1983). Development and validation of a multidimensional eating disorder inventory for anorexia nervosa and bulimia. *International Journal of Eating Disorders*, *2*(2), 15–34.

Gillberg, I. C., Råstam, M., Wentz, E., & Gillberg, C. (2007). Cognitive and executive functions in anorexia nervosa ten years after onset of eating disorder. *Journal of Clinical and Experimental Neuropsychology*, *29*(2), 170–178.

Guardia, D., Conversy, L., Jardri, R., Lafargue, G., Thomas, P., Dodin, V., et al. (2012). Imagining one's own and someone else's body actions: Dissociation in anorexia nervosa. *PLoS ONE*, *7*(8), e43241.

Halmi, K. A., Sunday, S. R., Strober, M., Kaplan, A., Woodside, D. B., Fichter, M., et al. (2000). Perfectionism in anorexia nervosa: Variation by clinical subtype, obsessionality, and pathological eating behavior. *American Journal of Psychiatry*, *157*(11), 1799–1805.

Hewig, J., Cooper, S., Trippe, R. H., Hecht, H., Straube, T., & Miltner, W. H. R. (2008). Drive for thinness and attention toward specific body parts in a nonclinical sample. *Psychosomatic Medicine*, *70*(6), 729–736.

Horley, K., Williams, L. M., Gonsalvez, C., & Gordon, E. (2004). Face to face: Visual scanpath evidence for abnormal processing of facial expressions in social phobia. *Psychiatry Research*, *127*(1–2), 43–53.

Jansen, A., Nederkoorn, C., & Mulkens, S. (2005). Selective visual attention for ugly and beautiful body parts in eating disorders. *Behaviour Research and Therapy*, *43*(2), 183–196.

Kaye, W. H., Bulik, C. M., Thornton, L., Barbarich, N., & Masters, K. (2004). Comorbidity of anxiety disorders with anorexia and bulimia nervosa. *American Journal of Psychiatry*, *161*(12), 2215–2221.

Lopez, C., Tchanturia, K., Stahl, D., Booth, R., Holliday, J., & Treasure, J. (2008). An examination of the concept of central coherence in women with anorexia nervosa. *International Journal of Eating Disorders*, *41*(2), 143–152.

Parron, C., Da Fonseca, D., Santos, A., Moore, D., Monfardini, E., & Deruelle, C. (2008). Recognition of biological motion in children with autistic spectrum disorders. *Autism*, *12*(3), 261–274.

Phillipou, A., Abel, L. A., Castle, D. J., Hughes, M. E., Gurvich, C., Nibbs, R. G., et al. (2015). Self perception and facial emotion perception of others in anorexia nervosa. *Frontiers in Psychology*, *6*, 1181.

Phillipou, A., Rossell, S. L., Castle, D. J., Gurvich, C., & Abel, L. A. (2014). Square wave jerks and anxiety as distinctive biomarkers for anorexia nervosa. *Investigative Ophthalmology & Visual Science*, *55*(12), 8366–8370.

Probst, M., Vandereycken, W., Van Coppenolle, H., & Pieters, G. (1995). Body size estimation in eating disorder patients: Testing the video distortion method on a life-size screen. *Behaviour Research and Therapy*, *33*(8), 985–990.

Probst, M., Vandereycken, W., Van Coppenolle, H., & Pieters, G. (1998). Body size estimation in anorexia nervosa patients: The significance of overestimation. *Journal of Psychosomatic Research*, *44*(3), 451–456.

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., et al. (1998). The Mini-International Neuropsychiatric Interview (MINI): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *Journal of Clinical Psychiatry*, *59*, 22–33.

Slade, P. D., & Russell, G. F. M. (1973). Awareness of body dimensions in anorexia nervosa: Cross-sectional and longitudinal studies. *Psychological Medicine*, *3*(02), 188–199.

Smeets, M. A. M. (1999). Body size categorization in anorexia nervosa using a morphing instrument. *International Journal of Eating Disorders*, *25*(4), 451–455.

Smeets, M. A. M., & Kosslyn, S. M. (2001). Hemispheric differences in body image in anorexia nervosa. *International Journal of Eating Disorders*, *29*(4), 409–416.

Stunkard, A. J., Sørensen, T., & Schulsinger, F. (1983). Use of the Danish adoption register for the study of obesity and thinness. *Association for Research in Nervous and Mental Disease*, *60*, 115–120.

Thompson, J. K., & Altabe, M. N. (1991). Psychometric qualities of the figure rating scale. *International Journal of Eating Disorders*, *10*(5), 615–619.

Tokley, M., & Kemps, E. (2007). Preoccupation with detail contributes to poor abstraction in women with anorexia nervosa. *Journal of Clinical and Experimental Neuropsychology*, *29*(7), 734–741.

Tovée, M. J., Emery, J. L., & Cohen–Tovée, E. M. (2000). The estimation of body mass index and physical attractiveness is dependent on the observer's own body mass index. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *267*(1456), 1987–1997.

Troje, N. F. (2002). Decomposing biological motion: A framework for analysis and synthesis of human gait patterns. *Journal of Vision*, *2*(5), 371–387.

Vocks, S., Legenbauer, T., Rüddel, H., & Troje, N. F. (2007). Static and dynamic body image in bulimia nervosa: Mental representation of body dimensions and biological motion patterns. *International Journal of Eating Disorders*, *40*(1), 59–66.

Watson, K. K., Werling, D. M., Zucker, N. L., & Platt, M. L. (2010). Altered social reward and attention in anorexia nervosa. *Frontiers in Psychology*, *1*(36), 1–8.

Wechsler, D. (2001). Wechsler Test of Adult Reading: WTAR: Psychological Corporation.

Williams, L. M., Loughland, C. M., Gordon, E., & Davidson, D. (1999). Visual scanpaths in schizophrenia: Is there a deficit in face recognition? *Schizophrenia Research*, *40*(3), 189–199.

Yarbus, A. L. (1967). Eye movements and vision. Plenum press. New York, NY: USA.

Zucker, N. L., Moskovich, A., Bulik, C. M., Merwin, R., Gaddis, K., Losh, M., et al. (2013). Perception of affect in biological motion cues in anorexia nervosa. *International Journal of Eating Disorders*, *46*(1), 12–22.

Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site.

