



# Fat or fiction? Effects of body size, eating pathology, and sex upon the body schema of an undergraduate population



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## ABSTRACT

Although there is a growing consensus that women with anorexia nervosa have a distorted body schema, the origins of this disturbance remain uncertain. The present investigation examined the effects of body size, eating pathology, and sex upon the body schema of an at-risk, undergraduate population. In Study 1, 98 participants mentally simulated their passage through apertures. When aperture width was manipulated, narrow and broad women over- and under-estimated their spatial requirements for passage, respectively. This relationship was exacerbated by dietary restraint. When aperture height was manipulated, short and tall men over- and under-estimated their spatial requirements for passage, respectively. Study 2 ( $N = 32$ ) replicated the association between women's veridical and internally-represented widths, although no significant effects of eating pathology were observed. Our findings suggest that body schema enlargement is not necessarily pathological, and may be driven by normal perceptual biases and internalised sociocultural body ideals.

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## 1. Introduction

We interact with the outside world with extraordinary ease because of our capacity to detect possibilities for action, and respond with the appropriate motor behaviour, without consciously monitoring our bodies (Gallagher & Cole, 1995; Gibson, 1979). Visual perception alerts us to environmental constraints, while motion and the maintenance of posture occur without the need for conscious awareness (Gallagher & Cole, 1995). The act of navigating our surroundings is therefore experienced as close-to-automatic (Gallagher, 2005). For example, when traversing a busy street we intuitively turn our bodies to slide through a narrow gap in the crowd. We move skilfully around upcoming obstacles without calculating their distance from our body or planning gait alterations. Such piloting of the body through space is achieved via the body schema (de Vignemont, 2010; Head & Holmes, 1911; Maravita & Iriki, 2004; Wolpert, Goodbody, & Husain, 1998).

The body schema is an internal, three-dimensional representation of one's body and its biomechanical properties used primarily for the spatial organisation of action (Haggard & Wolpert, 2005; Head & Holmes, 1911; Morasso, Casadio, Mohan, Rea, & Zenzeri,

2015). It can be differentiated from the body image, which comprises the cognitive, affective, and perceptual dimensions of bodily awareness (Cash & Green, 1986; Gallagher, 2005). Through the integration of multimodal sensory inputs, the body schema stores and continuously updates information on the size and shape of the body surface, while tracking the location of the body and its segments as we move (Haggard & Wolpert, 2005; Morasso et al., 2015). It is attuned to possibilities for action, and automatically takes measure of the fit between the behaviourally pertinent properties of one's body and its immediate surroundings (Morasso et al., 2015). The body schema therefore guides posture and motion to subserve intentional action, whether simulated or overt, without the requirement of reflective awareness (de Vignemont, 2010; Gallagher & Cole, 1995; Morasso et al., 2015).

The accuracy of the body schema is largely dependent upon the integrity of the parietal lobes (Daprati, Sirigu, & Nico, 2010; Holmes & Spence, 2004; Wolpert et al., 1998). Following right parietal damage, neglect of the left side of egocentric space, a rightward shift of the subjective body midline, and misattributed ownership of the contralesional limbs are commonly experienced (Adair & Barrett, 2008; Nico et al., 2010). In contrast, left parietal lesions can cause impairments in action attribution and difficulties in planning and executing complex gestures (Daprati et al., 2010; Sirigu, Daprati, Pradat-Diehl, Franck, & Jeannerod, 1999). Therefore, the right and left parietal cortices are, respectively, specialised in providing a

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spatial description of incoming sensations and an internal model of motoric behaviour.

It has been suggested that parietal dysfunction underlies the anomalous experience of the body in anorexia nervosa (AN) (Grunwald, Ettrich, Assmann, Dähne, & Gertz, 2002; Guardia et al., 2010, 2012; Nico et al., 2010). Individuals with AN characteristically report feeling fat, deny the seriousness of their low body weight, and visually overestimate their body size (American Psychiatric Association, 2013; Cash & Deagle, 1997; Cornelissen, Bester, Cairns, Tovée, & Cornelissen, 2015; Cornelissen, Johns, & Tovée, 2013; Slade & Russell, 1973). Nico et al. (2010) compared women with AN, patients with left and right parietal lesions, and healthy controls on a task that probed implicit body representation. When judging whether an approaching visual stimulus would contact their bodies, women with AN and patients with right parietal lesions both demonstrated a significant rightward shift of their left body boundary. This finding is in line with the role that the parietal cortex plays in maintaining the body schema, and implies that internally stored information on the body's configuration is disturbed in AN.

Consistent with perceiving their bodies as wider than in reality, might patients with AN also have an enlarged body schema? To answer this question, Guardia et al. (2010, 2012) conducted a series of motor imagery studies in which women with and without AN imagined walking through projected apertures of variable widths. Participants with AN judged that they would rotate their shoulders to ensure successful passage for relatively wider apertures than controls. Furthermore, the amount of space they deemed necessary for passage was positively correlated with disease duration (Guardia et al., 2010), AN symptomatology (Guardia et al., 2012), and body dissatisfaction (Guardia et al., 2010, 2012). Keizer et al. (2013) subsequently filmed the postural adjustments of women as they walked through apertures. In keeping with the findings of Guardia et al. (2010, 2012), women with AN rotated for openings up to 40.0% wider than their measured shoulder widths; however, their motor performance was not significantly related to disease duration or body image. Thus, there is a growing consensus that the motor performance of women with AN is guided by an unduly large internal representation of body width (see also Metral et al., 2014). The origins of this body schema disturbance, however, have not been conclusively determined.

Interestingly, the representations of body size held by non-clinical women and their true physical dimensions are not in perfect correspondence either (Guardia et al., 2010, 2012; Keizer et al., 2013). As observed by Keizer et al. (2013), controls rotated for apertures up to 25.0% wider than their measured shoulder widths. They also visually overestimated their body size by 23.5%, although no significant relationship was observed between their estimations of shoulder width and motor performance. It must be noted that controls were recruited from an undergraduate population, where up to 67.2% of women suffer from subthreshold eating disorders (Berg, Frazier, & Sherr, 2009; Krahn, Kurth, Gomberg, & Drewnowski, 2005; Mintz & Betz, 1988). As controls displayed abnormalities of body representation similar to, albeit less pronounced than, those of their clinical counterparts, this raises the possibility that body schema enlargement is a marker of susceptibility to AN.

It is also possible that body schema enlargement is not pathological, but is a function of one's body size. Cornelissen et al. (2013) examined the perceptual components of body image amongst women with and without AN. There, participants adjusted a misshapen image of themselves to reflect their subjective bodily dimensions. Irrespective of participants' clinical states, the mis-estimation of body size was linearly predicted by body mass index (BMI). Women with low and high BMIs over- and underestimated their sizes, respectively, a pattern which is predicted the normal perceptual phenomenon of contraction bias (Poulton, 1989). As the body image and body schema interact dynamically during

intentional action (Rosetti, Rode, Farnè, & Rosetti, 2005), a similar relationship may exist between one's anthropometric measurements and sensorimotor representation of body size. Providing some support for this theory, Guardia et al. (2010, 2012) and Keizer et al. (2013) found that women with AN overestimated their spatial requirements for passage through apertures to a greater magnitude than controls, notwithstanding their significantly narrower measured shoulder widths. Although highly informative, in each of these studies participants were dichotomised into clinical and control groups, while body schema distortion was expressed as a ratio of aperture width to shoulder width. Therefore, the precise relationship between body size, eating pathology, and the body schema is currently unknown.

As AN is a complex psychiatric condition with the highest mortality rate of all mental illnesses (Harris & Barraclough, 1998), it is important to develop a comprehensive understanding of its cardinal features. One such feature is the disturbed experience of body size and shape (American Psychiatric Association, 2013); however, there is a surprising paucity of literature examining the sensorimotor representation of the body and the factors tied to its integrity. Therefore, the present study was designed to broaden our understanding of the body schema, and to investigate the correlates and predictors of its distortion, within a population at an elevated risk for developing AN. To do so, we conducted two motor imagery experiments inspired by the action-anticipation paradigm of Guardia et al. (2010). In a critical extension to the current literature, apertures that varied in their horizontal, vertical, and sagittal dimensions were utilised. Moreover, aperture size was based upon each individual's pertinent anthropometric measurements, while consistent incremental changes were used across participants. This sophisticated new methodology allowed a precise quantitative measurement of the body schema, and the extent to which it deviated from participants' objective body sizes, across the three principal axes of the body.

## 2. Study 1

In Study 1, participants mentally simulated their frontal passage through apertures that varied in their horizontal and vertical dimensions. They subsequently judged, without executing the action, whether they could successfully pass without modifying their gait or posture. Using established psychophysical techniques, the size of participants' internal sensorimotor representations of body width and height could then be determined.

A primary objective of Study 1 was to explore whether body schema distortion could be predicted by AN psychopathology. Participants were therefore drawn from an undergraduate population, where there is significant variability in problematic eating behaviours and body attitudes (e.g., Berg et al., 2009). Given the highly skewed sex distribution of AN (Hoek, 2006; Striegel Weissman & Bulik, 2007), undergraduates of both sexes were recruited and their differences examined. If nonclinical AN psychopathology disturbs the body schema, participants' sensorimotor representations of body width should become progressively enlarged as a result of increased symptom severity. As the anomalous experience of the body in AN does not appear to encompass one's stature (Keizer, van Elburg, Helms, & Dijkerman, 2016; Slade & Russell, 1973), no association between AN psychopathology and the sensorimotor representation of body height was anticipated.

Study 1 also sought to determine the relationship between participants' sensorimotor representations of body size and their objective physical dimensions. If body schema disturbances are driven by contraction bias, participants at the lower and upper ends of the width and height spectrums should over- and underestimate their spatial requirements for passage, respectively.

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