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# The influence of personal BMI on body size estimations and sensitivity to body size change in anorexia spectrum disorders

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ABSTRACT

In this cross-sectional study, we investigated the influence of personal BMI on body size estimation in 42 women who have symptoms of anorexia (referred to henceforth as anorexia spectrum disorders, ANSD), and 100 healthy controls. Low BMI control participants over-estimate their size and high BMI controls under-estimate, a pattern which is predicted by a perceptual phenomenon called contraction bias. In addition, control participants' sensitivity to size change declines as their BMI increases as predicted by Weber's law. The responses of women with ANSD are very different. Low BMI participants who have ANSD are extremely accurate at estimating body size and are very sensitive to changes in body size in this BMI range. However, as BMI rises in the ANSD participant group, there is a rapid increase in over-estimation concurrent with a rapid decline in sensitivity to size change. We discuss the results in the context of signal detection theory.



## Introduction

Anorexia nervosa (AN) is a serious psychological and physiological condition, which occurs predominantly in the female population. Current therapeutic regimes have only a limited success in treating this condition (Treasure, Claudino, & Zucker, 2010), where the long-term mortality rate has been estimated to be as high as 10% (Berkman, Lohr, & Bulik, 2007). To be able to treat this condition more effectively, we need a better understanding of its central features. Diagnostic criteria for AN include a distorted evaluation of personal body size (American Psychiatric Association, 2013), and this is also a key element of psychological models of the disorder (Cash & Deagle, 1997; Fairburn, Cooper, & Shafran, 2003). Body image distortion has been shown to be one of the most persistent of all the eating disorder symptoms, the severity of which seems to predict the long term outcome for patients (Fairburn et al., 2003; Pike, 1998). Furthermore, persistence of body image distortion has been shown to predict the rate of relapse (Channon & DeSilva, 1985; Slade & Russell, 1973) which has been estimated to be as high as 35% (Casper, Halmi, Goldberg, Eckert, & Davis, 1979). While there is evidence to suggest that women with AN under-estimate their body size (Meermann, 1983), or even show performance in size estimation tasks equivalent to non eating-disordered controls (Fernández, Probst, Meermann, & Vandereycken, 1994; Meermann, 1983), most studies have found that patients with AN overestimate their body size (Gardner & Bokenkamp, 1996; Probst, Vandereycken, Van Coppenolle, & Pieters, 1998; Slade & Russell, 1973; Tovée, Benson, Emery, Mason, & Cohen-Tovée, 2003). The disturbance in body size estimation is thought to comprise two components; a perceptual/sensory component and an attitudinal/cognitive component (Cash & Deagle, 1997). The perceptual component is described as an inability to accurately estimate body size. The attitudinal component of body image disturbance consists of dissatisfaction with body shape combined with negative attitudes to weight and shape. Moreover, there is evidence that these effects may be specific to judgements about bodies, and do not generalise to other objects such as vases (McCabe, Ricciardelli, & Ridge, 2006; Slade & Russell, 1973).

Classical psychophysics has been used to try and separate the contributions to body size estimation made by perceptual 'sensory' factors (in this case, the smallest change in body shape that the participant can detect, indexed by the difference limen, DL) and attitudinal 'non-sensory factors' (the subjective body size criterion, or bias, adopted by the participant, indexed by the point of subjective equality, PSE). For example, using the method of

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constant stimuli, in combination with the video distorting technique, Gardner and Bokenkamp (1996) reported that women with AN were more likely to over-estimate their size than non-eating disordered controls, as indexed by a higher PSE on average. On the other hand, analyses of the same data showed that the smallest difference in stimulus size (DL) that anorexic participants could reliably detect was no different from controls (i.e., both female controls and women with AN were equally sensitive at discriminating between different sized versions of their bodies). Because of this dissociation between PSE and DL, Gardner and Bokenkamp (1996) suggested that body size over-estimation is entirely due to attitudinal, non-sensory factors (see also: Gardner & Moncrieff, 1988; Mussap, McCabe, & Ricciardelli, 2008).

Recently, however, Cornelissen, Johns, & Tovée (2013) came to a different conclusion. They re-analysed a previous study in which women with AN and controls were asked to estimate their own body size by manipulating an image of themselves using a body morphing program (Tovée et al., 2003). The software allowed participants to match their perception of the size of their individual body parts with what they saw on screen by manipulating slider controls. These had the effect of changing the width and shape of those body parts. It is possible to calculate the BMI of these self-manipulated bodies from their perimeter area ratios (Cornelissen et al., 2013). As a result, Cornelissen et al. could compare directly the participants' estimates of their own BMIs with their actual BMIs. They found that the inaccuracies in body size estimation could largely be explained by a known perceptual error in magnitude estimation called contraction bias (Poulton, 1989). Critically, as shown in Fig. 1A, the relationship between estimated BMI and actual BMI appeared to be exactly the same for participants with anorexia and controls; there were no differences in the pattern of contraction bias between the two groups. This figure is a schematic representation of the results from Cornelissen et al. (2013) in which women with AN and controls used an interactive software program to estimate body size. The line of equality (i.e., perfect accuracy) is shown by the dotted black line. The control participants (whose response distribution is indicated by the cross-hatched region) varied in BMI between 14.7 and 36.8 and the women with AN (indicated by the grey region) varied in BMI between 11.5 and 18.4. The solid black line represents the regression of estimated BMI on actual BMI and has the same slope and intercept for women with AN and controls.

Contraction bias arises when one uses a standard reference or template for a particular kind of object against which to estimate the size of other examples of that object. The estimate is most accurate when estimating the size of an object of a similar size to the reference, but becomes increasingly inaccurate as the magnitude of the difference between the reference and the object increases. When this happens, the observer estimates that the object is closer in size to the reference than it actually is. As a result an object smaller in size than the reference will be over-estimated and an object larger will be under-estimated. Thus, if we use a "reference body" based on an average of all the bodies we have seen in our life to make our judgements of body size (Winkler & Rhodes, 2005), individuals with very thin bodies will over-estimate their own body size, and individuals with very large bodies will under-estimate their body size (illustrated in Fig. 1A). An earlier study by Kuskowska-Wolk and Rössner (1989) reported results on self-estimation of body size that is also consistent with a contraction bias explanation. In addition, Cornelissen et al. (2013) also found an independent, modulating effect of psychological factors, as illustrated in Fig. 1A. The thick dashed black line represents the increase in intercept for the regression of estimated BMI on actual BMI as psychological concern about body shape and weight increase (i.e., the regression line moves up the *Y*-axis as concerns increase). The contraction bias explanation predicts that for both controls and women with AN, the accuracy of their body size estimation will be driven by the BMI of the participants. Cornelissen et al. report that this is the case, but the BMI values of the women with AN in the study by Tovée et al. (2003) all actually fell within a relatively narrow range of 6.9 BMI units (11.5–18.4). Most of the variation in BMI in this study is based on the responses of the control participants who ranged in BMI between 14.7 and 36.8 (22.1 BMI units). Cornelissen et al.'s (2013) assumption is that with a wider BMI range (including recovering patients to expand the range), the responses of the women with AN should follow the same pattern as the control participants. This is illustrated in Fig. 1B, where the white arrow shows how the regression of estimated BMI on actual BMI in these women should track up along the same regression line as in Fig. 1A when BMI increases. In short, this model predicts that as BMI increases in women with AN, so body size over-estimation should *decrease*.

Alternatively, it is entirely possible that psychological factors represent a stronger driving force behind body size over-estimation in women with AN than they do for controls. If so, this could lead to a different outcome. Consistent with this possibility, an individual's body size (as indexed by BMI) is known to be strongly correlated with body dissatisfaction (Gardner, Brown, & Boice, 2012; Stice & Shaw, 2002; Striegel-Moore et al., 2004). Women with AN who have achieved a very low BMI might be expected to have relatively low body size concerns, but during the recovery process as their weight increases, their body size concerns would rise in parallel. Therefore, an alternative outcome for women with AN is that as their

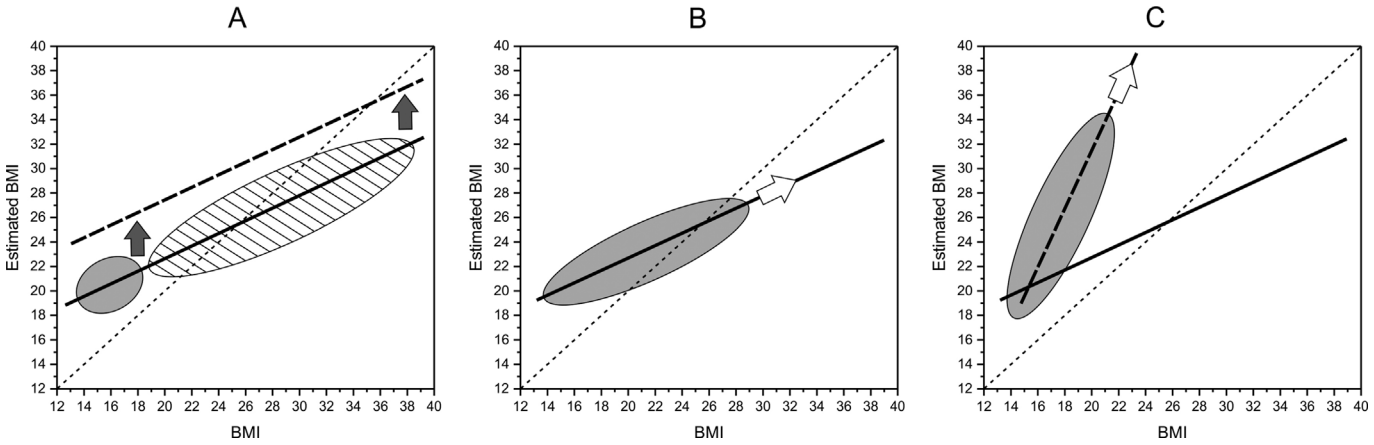


**Fig. 1.** (A) Schematic representation of the results from Cornelissen et al. (2013). (B) The pattern of body size estimation predicted by the contraction bias model in women with AN, or recovering from AN (i.e., in an eating disordered group with a wider BMI range). (C) The pattern of body size over-estimation predicted by increasing psychological concerns, rather than contraction bias. See text for details.