



Body size and shape misperception and visual adaptation: An overview of an emerging research paradigm

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Abstract

Although body size and shape misperception (BSSM) is a common feature of *anorexia nervosa*, *bulimia nervosa* and *muscle dysmorphia*, little is known about its underlying neural mechanisms. Recently, a new approach has emerged, based on the long-established non-invasive technique of perceptual adaptation, which allows for inferences about the structure of the neural apparatus responsible for alterations in visual appearance. Here, we describe several recent experimental examples of BSSM, wherein exposure to “extreme” body stimuli causes visual aftereffects of biased perception. The implications of these studies for our understanding of the neural and cognitive representation of human bodies, along with their implications for clinical practice are discussed.

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Introduction

Body size and shape misperception (BSSM) is a key component of body image disturbance¹ and a known risk factor for the development of the eating disorders (EDs) *anorexia nervosa* (AN) and *bulimia nervosa* (BN).^{2,3} Although not all individuals with EDs experience BSSM, many sufferers perceive themselves to be larger – usually fatter – than they are in reality. As psychotherapy targeting body image disturbance, such as cognitive behaviour therapy,⁴ is a core component of first-line treatments for EDs, elucidating its perceptual bases may inform the improvement of such treatment. While estimates of the population prevalence of BSSM – the perceptual component of body image disturbance – are lacking, it is clear that body dissatisfaction – the attitudinal component – is common in the general population. This is particularly true among women, with 33%–39% reporting moderate to marked levels of dissatisfaction.^{5,6} In men, by contrast, BSSM is more likely to be manifest in an underestimation, of muscularity in particular,⁷ with around 15% of males reporting moderate to marked dissatisfaction.⁵ When taken to an extreme, clinical presentations of BSSM and associated psychopathology are similar in males and females.^{7,8}

Attempts to understand BSSM have focused on socio-cognitive processes linking the incidence of this phenomenon with the prevalence of idealised images (thin females and muscular males) in the mass media, the role of social comparison⁹ and social pressure to be thin¹⁰ or muscular.⁷ While these approaches may provide insight into when an individual might experience

dissatisfaction regarding their body size or shape, they were not designed to address the question of how the figure is perceived, or why misperceptions might occur. Here we give an overview of recent efforts to elucidate these processes using the psychophysical paradigm of visual adaptation.

Visual adaptation

The social comparison explanation for size overestimation involves a central role for visual inspection of images of bodies of a particular shape or size, either in the traditional media, or more recently on social media platforms. To psychophysicists – experimental psychologists who specialise in elucidating the mechanisms that mediate the relationship between objective sensory stimuli and the subjective experience of perception – this may sound rather familiar. Since Aristotle, it has been known that extended viewing of a stimulus can bias one's perception of other stimuli.¹¹ This phenomenon is known as adaptation. Prolonged exposure to an extreme “adaptation” stimulus leads to an aftereffect such that subsequently seen “test” stimuli appear distorted. Early work on visual adaptation included basic perceptual attributes, such as orientation, direction of motion or colour.¹² For example, exposure to downward motion makes a subsequently viewed stationary scene appear to drift upward.^{13,14}

The psychophysical paradigm of adaptation has been instrumental in revealing the underlying neural mechanisms of perception. It is known that prolonged exposure affects the response properties of the active neurons, causing an imbalance of activity,

and hence a perceptual bias.¹⁵ By changing the stimulus attributes and observing variations in aftereffect magnitude, we can infer the underlying properties of populations of neurons in a non-invasive manner. More recently, aftereffects in more complex stimuli such as faces have been established,^{16–18} allowing inferences about higher-level neural structures. Individuals exposed to contracted faces (with features compressed into the middle) subsequently see unaltered faces as expanded, and *vice versa*. This is the face distortion aftereffect. As these experiments have brought rapid progress in the understanding of face perception processes, it seems likely that adaptation may confer similar benefits for body perception.

Adaptation and BSSM

As with face distortion aftereffects, prolonged exposure to images of bodies that have been compressed (or stretched) horizontally to simulate smaller (larger) body sizes causes bodies that were previously perceived as average to appear larger (smaller).¹⁹ Similar effects have been shown for large or small computer-generated bodies, and for actual photographs.^{20,21} This laboratory demonstration of BSSM is reminiscent of the effects where some individuals who inspect themselves in a mirror after exposure to thin models in the media might misperceive their own size as unduly large. Similarly, those observing adaptation images of larger bodies perceived test images to be smaller than they were in reality, just as perennial exposure to an overweight population may cause individuals to consider themselves to be smaller than they actually are.

Whether those with severe forms of BSSM, sufferers of AN in particular, are actually experiencing the effects of visual adaptation has yet to be definitively established. However, this proposition receives support from a body size adaptation study

in ED (AN and BN) patients.²² Although participants showed the expected aftereffects following exposure to images of fat bodies (i.e. a perceptual “thinning”), no overestimation effects were shown following exposure to thin bodies. The authors suggested a ceiling effect – proposing that the clinical participants were so “pre-adapted” to thin bodies that the effect could not be further increased in a laboratory setting.²²

Exposure to other bodies affects perception of the self

For visual adaptation to be considered a potential contributory mechanism to clinical presentations of BSSM, it is necessary for the aftereffect to transfer between identities, such that exposure to the bodies of other individuals causes the misperception of one’s own size – a phenomenon known as cross adaptation.²³ Brooks et al. (2016)²⁴ used easily identifiable photographs of the full body and face, captured under identical conditions, to compare results from simple adaptation (i.e. same identity) and cross adaptation (different identity) conditions. If the same set of neurons were responsible for the perception of body size regardless of identity, the aftereffects should be identical for simple and cross adaptation. However, if the size of self and other were processed by entirely distinct populations, no cross adaptation would be expected at all. Although aftereffects were largest when the same body was used for exposure and testing, substantial aftereffects were also demonstrated for cross adaptation conditions.²⁴ The intermediate result of partial transfer indicates that the neural mechanisms are somewhat distinct, but also show some overlap in terms of the stimuli they respond to. This finding – that exposure to “thin” others leads to the misperception of one’s own body – also demonstrates

the viability of visual adaptation as a model of BSSM.

Independent aftereffects of muscle and fat

While body image distortion often refers to body fat concerns, more recent research has investigated concerns regarding muscularity, particularly among males.^{7,8} At the pathological end of this spectrum of muscularity concerns is muscle dysmorphia (MD) – a subtype of body dysmorphic disorder that shares many characteristics of EDs.^{7,25} MD is informally referred to as ‘reverse anorexia’ or ‘bigorexia’, due to the parallel preoccupation with inadequate muscularity, despite the fact that many sufferers are indeed more muscular than average. As for the thin ideal in AN, it has been suggested that the media’s promotion of the muscular ideal contributes to MD.²⁶ In addition, many sufferers spend long hours at the gym, and surround themselves in their traditional and online social worlds with like-minded individuals,⁷ increasing their visual exposure to muscular physiques. This raises the possibility that adaptation may also underlie the misperception of muscularity in MD. Sturman et al. (2017)²⁷ tested this possibility, assessing whether bodies that are high or low in muscle mass can yield a visual aftereffect in the laboratory, and if so, whether this aftereffect is independent of aftereffects of high or low fat. Using image morphing techniques,²⁸ observers could perform independent manipulations of the fat and muscle mass of bodies to make them appear “normal”. This was done both before and after inspecting images from one of four adaptation conditions (increased fat/decreased fat/increased muscle/decreased muscle). Exposure caused a shift in the point of subjective normality towards the adapting images along the relevant (fat or muscle) axis, suggesting that

the neural mechanisms involved in body fat and muscle perception are independent. In addition, this lends credence to the claim that visual adaptation may also be an underlying perceptual mechanism in MD. That is, males of average or above average muscularity may perceive themselves as less muscular than they are due to overexposure to images of highly muscular males.

The influence of attention

Although many people’s visual diet is similar, not all will go on to develop body image disturbance or an ED. While factors such as family history, early childhood difficulties with feeding, a history of abuse, and low self-esteem have potency for the development of EDs,²⁹ an area of research gaining traction involves the investigation of attentional correlates of BSSM and EDs.³⁰ In particular, those with AN³¹ and MD show a reduced ability to shift attention between tasks.^{32,33} This may explain the propensity of AN patients to fixate on specific aspects (e.g., the stomach or thigh region) when viewing others’ bodies or their own reflections.³⁴

Increased attention to a particular stimulus or location (object or spatial attention) affects the magnitude of visual aftereffects by intensifying neural responses.³⁵ This brings increased levels of neural adaptation, as shown in the motion aftereffect,³⁶ and the face identity aftereffect.³⁷ Similarly, attention to a specific aspect of a stimulus (featural attention) has been found to increase the strength of the motion aftereffect.³⁸ Stephen et al. (2016)³⁹ examined the possibility that manipulations of featural attention may cause changes in the magnitude of body fat aftereffects. Here, the strength of the adaptation effect was not significantly different when observers were asked to rate the fatness or sex typicality of the adaptation images. However, this null result could be explained if the two stimulus

dimensions being attended to were processed by largely overlapping populations of neurons. This appears possible, given that body fat and sex are typically correlated.⁴⁰ In addition, aftereffect magnitude may be moderated by spatial or object attention – a possibility that is currently being investigated in our laboratory.

Implications for clinical treatment

The technique of visual adaptation has rapidly advanced our understanding of the perceptual representation of human bodies, providing insight into real-world examples of BSSM. These advances have the potential to inform the future development of interventions designed to reduce body image disturbance in AN, BN and MD, as well as producing a more accurate body percept for overweight and obese individuals. Behavioural interventions may benefit from what has been learnt from visual adaptation studies by asking patients who have AN or MD to spend discrete periods of time viewing ideal bodies versus more “everyday” bodies, to assess the effects on their own body image. The results of such therapeutic experiments may encourage patients to actively reduce their exposure to “ideal bodies” in their daily lives and also assist patients with AN to be more accepting of weight gain in treatment – a major obstacle to treatment success.⁴¹ Another implication of these findings pertains to the practice of group treatment for patients. Given that increased exposure to thin bodies appears to skew the viewer’s perception of normal body size, and that this at least partially affects perception of one’s own body, assembling underweight patients together may inadvertently exacerbate BSSM and further reduce motivation to gain weight. Including people with a range of body sizes in group therapy may

mitigate this putative adverse effect. Finally, if future experiments testing the effects of attention to certain body parts proves to moderate the strength of visual adaptation, then this may provide support for the use of attention training and mirror re-education intervention. Mirror exposure therapy for individuals with EDs is currently an active field of research but the optimal parameters for this treatment are unclear.³⁴

Concluding remarks and future directions

Visual adaptation studies of BSSM demonstrate promise in terms of advancing our understanding of the underlying cognitive processes and symptoms of EDs and other disorders involving body image disturbance. In addition to establishing a framework for studying the potential moderating effects of attention on BSSM, visual adaptation has been used to simulate body misperception phenomena, including i) the effects of viewing extreme bodies of others on the perception of one’s own size and shape, ii) size overestimation following the viewing of thin bodies, and size underestimation following the viewing of overweight or obese bodies, and iii) misperception of muscularity following exposure to highly muscular bodies. However, it is by no means beyond doubt that adaptation is the root cause of all examples of BSSM. Further research is required to establish many basic properties of the visual adaptation effect, and to check their correspondence with other features of real-world examples of BSSM, including those seen in clinical populations. Further, it should be acknowledged that the perceptual aspect of EDs is just one of many factors in these complex and multidimensional psychological conditions. Full understanding of the perception of size and shape will

still leave many unanswered questions in terms of the features of EDs, and their development. However, given that perception is the first link in the chain of mental events involved in social comparison, and that our understanding of body perception is still rudimentary, further scrutiny of this stage of processing may offer great potential for an enhanced understanding of EDs and the development of innovative therapies. For this reason, studies on the potential link between BSSM and visual adaptation are continuing in our laboratory and others around the world.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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