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Original Article

Humans are not fooled by size illusions in attractiveness judgements

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ABSTRACT

Could signallers use size contrast illusions to dishonestly exaggerate their attractiveness to potential mates? Using composite photographs of women from three body mass index (BMI) categories designed to simulate small groups, we show that target women of medium size are judged as thinner when surrounded by larger women than when surrounded by thinner women. However, attractiveness judgements of the same target women were unaffected by this illusory change in BMI, despite small true differences in the BMIs of the target women themselves producing strong effects on attractiveness. Thus, in the context of mate choice decisions, the honesty of female body size as a signal of mate quality appears to have been maintained by the evolution of assessment strategies that are immune to size contrast illusions. Our results suggest that receiver psychology is more flexible than previously assumed, and that illusions are unlikely to drive the evolution of exploitative neighbour choice in human sexual displays.

1. Introduction

Evolutionarily stable sexual signals must provide honest information about a signaller's underlying qualities to some receivers, at least some of the time (Johnstone, 1998; Searcy & Nowicki, 2005; Rowell, Ellner, & Reeve, 2006). The honesty of a signal can be ensured either if it has high costs that prevent low quality cheaters from exploiting the fitness benefits associated with communicating high quality, or if it is physically constrained to be impossible to fake (Zahavi, 1975; Grafen, 1990; Maynard Smith & Harper, 2003). Physical size is a common attribute of sexual signals, presumably either because only high quality individuals can pay the increased costs associated with developing and maintaining larger signals, or because size is particularly hard to fake. Indeed, body size has been held up as an example of a signal where deception is impossible (Rowell et al., 2006). Although individuals can exaggerate their body size using ploys such as raising their hair or adopting flattering colour patterns, the deceptive advantage derived from such exaggerators will be evolutionarily short-lived because they will rapidly spread to fixation (Maynard Smith & Harper, 2003). However, the situation will not be so straightforward when exaggeration arises from illusions generated by comparison with other individuals, because signallers can potentially choose their immediate neighbours strategically (Bateson & Healy, 2005; Callander, Jennions, & Backwell, 2011). Indeed, Gasparini, Serena, and Pilastro (2013) argue that male guppies (*Poecilia reticulate*) choose females already surrounded by drab, less attractive males rather than females surrounded by bright, more attractive males because being relatively more attractive than the competition is likely to increase their mating success.

The visual illusion of size contrast is exemplified by the well-known Ebbinghaus illusion (also known as Titchener circles) in which the apparent size of a central target circle is altered by the size of surrounding inducer circles (Ebbinghaus, 1902). This illusion also occurs when the targets and inducers are of dissimilar shapes (Coren & Miller, 1974; Rose & Bressan, 2002) and when they are complex stimuli such as images of human faces (Stapel & Koomen, 1997), suggesting that size contrast could also be relevant to the perception of any size-based sexual signal. This phenomenon therefore raises problems for the honesty of size-based signals, because a signaller could use it to enhance their attractiveness at minimal cost simply by positioning themselves in a flattering group (Bateson & Healy, 2005). So why has physical size been maintained as a common signal of mate quality by sexual selection if it can so easily be exaggerated?

Here we ask whether size contrast illusions occur in the perception of a natural sexual signal for which the primary determinant of attractiveness is known to be size, namely the human female body. In human females of reproductive age, physical size, as measured by body mass index (BMI), is the primary predictor of physical attractiveness judgements (Tovée, Maisey, Emery, & Cornelissen, 1999; Rilling,

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Figure 1. A typical image array as seen by a subject in a single trial of the experiment. This image has the form $LM_LL\_HM_RH$ because the low BMI inducers are in the left-hand group.

Kaufman, Smith, Patel, & Worthman, 2009; Tovée, Edmonds & Vuong, 2012). For example, Tovée et al. (1999) found that BMI accounted for over 70% of the variance in a regression model of their participants' attractiveness judgements. A result found to be cross-culturally consistent (e.g. Swami & Tovée 2005; Tovée, Swami, Furnham, & Mangalparsad, 2006). In Western populations, women are optimally attractive with a BMI of 19–20, and attractiveness declines as BMI increases (Tovée et al., 1999). If size contrast occurs in the judgement of female BMI, then a woman could reduce her perceived BMI, and therefore increase her judged attractiveness, merely by positioning herself in close proximity to higher BMI, less attractive women. To date, studies investigating the relationship between BMI and attractiveness have employed judgements of isolated images of female bodies, precluding the possibility of size contrast effects. However, since there is a strong positive relationship between BMI and the dimensions of the human female body in a two dimensional photograph (e.g. correlations between BMI and Perimeter–Area Ratio (PAR); Tovée et al., 1999), the potential exists to explore size contrast effects in attractiveness judgements using the standard methodology of body attractiveness studies.

For the current experiments we designed stimuli consisting of composites of photographs of real women. Each composite picture featured two groups of three women standing side by side. The body sizes of the six women were chosen to replicate the contrasts present in stimuli used to illustrate the standard Ebbinghaus illusion. The six women came from three BMI classes designated low, medium and high. The central women in the two groups were non-identical women of medium BMI (the 'targets': M_L and M_R). These target women were flanked in one case by two women of lower BMI, and in the other by two women of higher BMI (the 'inducers': L and H), resulting in an image of the form $LM_LL\_HM_RH$ or $HM_LH\_LM_RL$ (see Fig. 1). Observers viewed a series of different stimuli of this form and were instructed to make a judgement of which of the two targets present in each image they perceived as either larger (size judgement condition) or more attractive (attractiveness judgement condition).

In Experiment 1 male and female observers each completed both judgement conditions. If a typical size contrast effect is observed, then we predicted that the target woman flanked by the higher BMI inducers should be judged as both thinner and more attractive than the target woman flanked by the lower BMI inducers. Experiment 2 was a between-subjects replicate of Experiment 1 in which we additionally tracked the eye movements of observers in order to understand how they viewed the composite images when making their judgements.

2. Materials and methods

2.1. Stimuli

The digital photographs of young women (mean age 20.7 years, s.d. 2.2 years) used for the current experiment were a subset of 18 from a larger set collected by Smith et al. (Smith, Cornelissen, & Tovée, 2007) where details of stimulus collection and skin tone quantification are described. The volunteers' heads were blurred in the resulting images to ensure anonymity and also remove any confounding effects of facial attractiveness on subsequent judgements of attractiveness. The photographs were chosen such that there were six images from each of three BMI classes: low (18.4–19.2), medium (22.0–22.7) and high (25.3–26.7). We have previously shown that Western observers reliably rate women from the low class as more attractive than women from the medium class, and women from the medium class as more attractive than women from the high class (Tovée, Reinhardt, Emery, & Cornelissen, 1998; Tovée et al., 1999). For the set of 18 bodies used in this study, the area covered by each body in the photograph was measured using Imagej (http://imagej.nih.gov/ij/). In this set, BMI is correlated with the area each body covers in the digital photograph (Pearson correlation; $r = 0.70$, $p < 0.001$) and height is not correlated with body area (Pearson correlation; $r = -0.14$, $p = 0.592$). This shows that the size of the body is proportional to its BMI, consistent with our use of BMI to guide our image selection in our version of the Ebbinghaus illusion.

For the purposes of this experiment, the images obtained above were arranged into groups of three. The central target image of each group was always an image of a woman with a medium BMI. The two flanking images in each group were identical inducers from either the low or high BMI class. To verify that our stimuli were consistent with standard presentations of the Ebbinghaus illusion, we checked that the area covered by the bodies was significantly different between the three BMI classes (one-way ANOVA, $F_{2,15} = 8.2$, $p < 0.005$). In each trial the observer was simultaneously presented with two such groups of three images. In one group the inducers were always of lower BMI and in the other the inducers were always of higher BMI (see Fig. 1 for an example). The entire array of six images was presented on a 21" LCD display (1600 × 1200 native resolution; 32-bit colour depth), and subtended ~8º horizontally and ~4º vertically at a viewing distance of 2 m.

In each trial the two target images were one of the 15 possible pairs of the six medium BMI images (a target image was never paired with