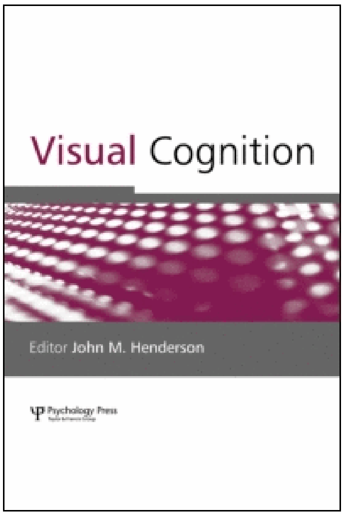

Visual Cognition
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713683696

A look at how we look at others: Orientation inversion and photographic negation disrupt the perception of human bodies

Richard Cook[a]; Bradley Duchaine[b]
[a] Division of Psychology and Language Sciences, University College London, London, UK [b] Department of Psychological and Brain Sciences, Dartmouth College, Hanover, NH, USA

Online publication date: 12 April 2011

To cite this Article Cook, Richard and Duchaine, Bradley(2011) 'A look at how we look at others: Orientation inversion and photographic negation disrupt the perception of human bodies', Visual Cognition, 19: 4, 445 — 468

To link to this Article: DOI: 10.1080/13506285.2010.541892

URL: http://dx.doi.org/10.1080/13506285.2010.541892

VISUAL COGNITION, 2011, 19 (4), 445–468

Psychology Press
Taylor & Francis Group

A look at how we look at others: Orientation inversion and photographic negation disrupt the perception of human bodies

Richard Cook[1] and Bradley Duchaine[2]

[1]Division of Psychology and Language Sciences, University College London, London, UK
[2]Department of Psychological and Brain Sciences, Dartmouth College, Hanover, NH, USA

Although disproportionate inversion effects have often been considered manifestations of the special processes recruited by upright faces, several papers using sequential matching tasks have reported that body postures also produce sizeable inversion effects. However, comparison of inversion effects observed with transient body postures and effects elicited by judgements of facial structure is complicated by qualitative differences between the stimuli and the tasks. Here we report a series of experiments that use attractiveness judgements to provide a better comparison of the effect of inversion as well as contrast negation on face and body perception. Significant effects of inversion and negation were observed for both face and body stimuli. While the magnitude of the inversion effects was broadly comparable, the negation effect was considerably larger for faces. These effects converge with evidence from cognitive neuroscience to suggest that both faces and bodies recruit similar orientation-specific processes distinct from processes used for generic objects.

Keywords: Bodies; Faces; Inversion; Negation; Physical attractiveness.

Human perceptual mechanisms allow us to extract effortlessly a remarkable variety of information about individuals simply from their appearance. Although numerous cues provide information about others, the majority of

---

Please address all correspondence to Richard Cook, Division of Psychology and Language Sciences, University College London, London WC1H 0AP, UK. E-mail: r.cook@ucl.ac.uk

The research reported in this article was supported by The Economic and Social Research Council (ESRC).

Supplementary data (Appendix) published online alongside this article at www.psypress.com/viscog

http://www.psypress.com/viscog DOI: 10.1080/13506285.2010.541892

research into social perception has focused on faces. Evidence from various techniques suggests that upright faces recruit perceptual mechanisms different from those used for objects (Kanwisher, McDermott, & Chun, 1997; Tsao, Freiwald, Tootell, & Livingstone, 2006; Yin, 1969).

The most widely known behavioural hallmark of this special processing is the "face inversion effect", whereby orientation inversion disproportionately disrupts the perception of faces compared with other classes of objects (Diamond & Carey, 1986; Yin, 1969). Most accounts of this effect suggest that upright faces are represented by an orientation-specific process tailored for upright faces, whereas inverted faces are represented with other, less effective procedures. Behavioural experiments suggest that the orientation-specific process holistically represents parts and their spatial relations as a nondecomposable whole (Tanaka & Farah, 1993; Young, Hellawell, & Hay, 1987). In contrast, inverted faces and objects are thought to be represented in a more parts-based manner (Biederman, 1987; Moscovitch, Winocur, & Behrmann, 1997). Because objects are represented in this way regardless of orientation, inversion has more limited effects on performance (McKone, Kanwisher, & Duchaine, 2007; Robbins & McKone, 2007; Yin, 1969).

Findings from cognitive neuropsychology provide insight into how upright and inverted faces are processed differently. When tested on inverted faces, several pure prosopagnosics have performed within the normal range (Busigny & Rossion, 2010; Duchaine, Yovel, Butterworth, & Nakayama, 2006), whereas Patient CK performs typically with upright faces but is severely impaired with inverted faces and objects (Moscovitch et al., 1997). These results suggest that the recognition of objects and inverted faces engage common mechanisms, and indicate that recognition of upright faces relies on a face-specific mechanism. Recent neurophysiological work in the macaque middle face patch has shed light on the neuronal basis of face inversion effects. Neurons in this patch are tuned to one or a few facial features (e.g., face aspect ratio, eye brow width, iris size, mouth size), with most having ramp-like firing rates dependent on the value of the represented feature(s). Although reduced, many of these neurons also show tuning to features in inverted faces. Revealingly, neurons tuned to particular features in upright faces tended to show sensitivity to a feature located in roughly the same position in an inverted face. For example, a neuron tuned to eyebrow width in upright faces might be tuned to mouth width in inverted faces. This pattern suggests that faces are fit to a template designed for upright faces regardless of the orientation of the perceived face (Freiwald, Tsao, & Livingstone, 2009).

Like orientation inversion, contrast negation also has a stronger effect on face processing than object processing (Galper, 1970; Nederhouser, Yue, Mangini, & Biederman, 2007; Robbins & McKone, 2007). It has been claimed that negation detracts from the inference of facial structure through the reversal of shading cues (Hill & Bruce, 1996; Johnston, Hill, & Carman, 1992) and may disrupt the configural processing of feature relations (Kemp, Pike, White, & Musselman, 1996; Lewis & Johnston, 1997). More recently, however, a consensus has emerged that the effects of negation are largely attributable to the reversal of the surface reflectance properties of faces (Bruce & Langton, 1994; Dakin & Watt, 2009; Russell, Sinha, Biederman, & Nederhouser, 2006). Surface reflectance cues appear particularly sensitive to negation. For example, material identification, a process almost exclusively dependent on surface reflectance cues, is drastically impaired by this manipulation (Fleming, Dror, & Adelson, 2003; Russell et al., 2006). When variations in facial surface reflectance are minimized, such that faces differ solely in underlying structure, negation has little effect on perceptual sensitivity. Conversely, when faces vary only in their pigmentation, colouration, and texture, negation drastically impairs discrimination performance (Russell et al., 2006).

The nature and origins of face processing have been a focus of substantial debate (Diamond & Carey, 1986; Kanwisher, 2000; Tarr & Gauthier, 2000), but broad agreement exists that the importance of facial information has led to the existence of these special procedures. Like faces, bodies also represent a rich source of information relevant for social computations. Moreover, bodies also have a canonical orientation, have highly consistent spatial configurations, and mediate biological motion. These similarities, in addition to results discussed later, have prompted several researchers to suggest that bodies and faces may be processed by the same or similar mechanisms (Reed, Stone, & McGoldrick, 2005; Slaughter, Stone, & Reed, 2004; Stekelenburg & de Gelder, 2004).

Support for this possibility has come from a series of experiments reporting sizeable inversion effects for body postures (Reed, Stone, Bozova, & Tanaka, 2003; Reed, Stone, Grubb, & McGoldrick, 2006; Yovel, Pelc, & Lubetzky, 2010). In sequential same–different tasks discrimination of whole body postures and faces show comparable decrements when stimuli are inverted. However, comparison of these body-posture inversion effects with face inversion effects is complicated by several issues. The tasks used are qualitatively different, with face judgements requiring the discrimination of subtle structural differences (e.g., facial identity), whereas body judgements require discrimination of transient states (e.g., postures). This distinction is important insofar as structural and transient aspects of face perception are thought to dissociate (Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2000). In addition, a recent paper showed that the body-posture inversion effect is absent when bodies are headless, and is greatly reduced when head position is fixed (Yovel et al., 2010). These results imply that it is the head rather than the body that is processed in a special fashion in the upright orientation. Moreover, unlike the observation of static neutral faces, viewing body postures may activate motor or proprioceptive representations associated with implied movements, as viewers implicitly simulate the movements implied (Reed et al., 2005). These differences make it difficult to compare the magnitudes of the face and body inversion effects reported, and raise the possibility that they are attributable to different factors.

The present study sought to determine whether orientation inversion has comparable effects on the perception of faces and bodies using tasks with similar demands and stimuli. This was achieved using judgements of the physical attractiveness of frontal views of faces and bodies. Although widely used, judgements of identity are not ideal for comparing the perception of faces and bodies, as we have more practice identifying individuals from faces than bodies. We can certainly identify individuals from their bodies, but it is much less intuitive than for faces. Insofar as inversion effects have been taken by some authors to reflect perceptual expertise (Diamond & Carey, 1986; Gauthier & Tarr, 1997; Gauthier et al., 2000), it is desirable to use judgements that are intuitive, and equally applicable to faces and bodies.

Considerable efforts have been made to identify those cues that cause particular faces and bodies to be perceived as attractive. Facial attractiveness is thought to depend on traits such as averageness (Langlois & Roggman, 1990), symmetry (Perrett et al., 1999), sexual dimorphism (Perrett et al., 1998), and skin-colour distribution (Fink, Grammer, & Matts, 2006). Comparable work on bodies has also revealed a number of determinants of attractiveness including waist-to-hip ratio (Singh, 1993), waist-to-chest ratio (Swami & Tovee, 2005), volume-to-height ratio (Fan, Dai, Liu, & Wu, 2005), body-fat (Smith, Cornelissen, & Tovee, 2007), breast size and symmetry (Manning, Scutt, Whitehouse, & Leinster, 1997), and foot size (Voracek, Fisher, Rupp, Lucas, & Fessler, 2007). However, the perceptual mechanisms mediating judgements of attractiveness have received much less research attention. Leading models of face perception posit that the perception of attractiveness is mediated by the same structural representation that supports other structural attributions including identity and age discriminations (Bruce & Young, 1986; Haxby et al., 2000). Just as orientation inversion and photographic negation disrupt identity recognition, these manipulations also produce atypical judgements of facial attractiveness (Bäuml, 1994; Santos & Young, 2008). Similarly, composite face effects have been reported for both identity (Young et al., 1987) and judgements of attractiveness (Abbas & Duchaine, 2008). The limited findings relevant to models of body processing provide little guidance as to whether body perception also recruits a common representation that mediates a range of attributions. Nevertheless, this remains a plausible account and the experiments described here will contribute to answering this question.

In addition to the manipulation of orientation, the present study also sought to determine whether photographic negation impairs the perception of bodies in the same way as faces. No studies have investigated the perceptual effects of negation of body stimuli. If body perception is mediated by mechanisms similar to those recruited by faces, then one might expect negation to produce comparable perceptual impairment. On the other hand, if body perception is mediated by more generic processes such as those recruited by other classes of object, one might expect little or no perceptual decrement. However, because negation changes faces and bodies differently, comparison of the perceptual effects of these manipulations should be interpreted cautiously.

EXPERIMENT 1A

Whereas previous studies have used preference probabilities (Bäuml, 1994) and binary attractive–unattractive classifications (Santos & Young, 2008) to measure the ability to perceive attractiveness, Experiments 1A and 1B used the degree of within-group agreement. While individual differences are present in ratings of physical attractiveness, there remains a robust consensus. Thus, if a given manipulation impairs the ability to perceive attractiveness, the degree of within-group agreement should be markedly reduced. Experiment 1A sought to validate the use of within-group agreement to infer ability to perceive attractiveness, by replicating the previously reported effects of orientation inversion (Bäuml, 1994; Santos & Young, 2008) and negation (Santos & Young, 2008) on perceptions of facial attractiveness. Four groups ranked sets of male and female facial stimuli in order of attractiveness, whilst presented upright, inverted, negated, or subject to both manipulations

Method

The participants were 72 undergraduates (14 males) from University College London who completed the experiment to fulfil a course requirement (mean age = 19.8 years, $SD = 4.1$ years). Participants were randomly assigned to one of the four presentation conditions. Comparable numbers of male subjects were allocated to each group. The study was approved by the University College London ethics committee and performed in accordance with the ethical standards set out in the 1964 Declaration of Helsinki.

Two sets of 12 male and 12 female Caucasian faces were generated using Singular Inversions FaceGen Modeller version 3.0. The faces were all of approximately the same age, of clear complexion, and had no excess body fat. All stimuli appeared to gaze directly at the observer. The faces varied in both their shape and their surface reflectance properties (e.g., skin pigmentation, eyebrow colour). Stimuli were cropped horizontally just below the hair line and presented in greyscale, subtending approximately 7° of visual angle. From each original stimulus, a further three were derived by inverting the orientation, applying photographic negation, or by applying both manipulations (Figure 1). Further examples of all stimuli used in the present study are included in the supplementary materials accompanying this article.

The experimental tasks initially presented all 12 stimuli simultaneously for a period of 45 s, during which time participants were instructed to study the images. Once the imposed delay had elapsed, participants were required to click on the stimulus they found most attractive. This stimulus then disappeared, and participants had to select the most attractive of the remaining images. This elimination process continued until all 12 stimuli had been rank ordered.

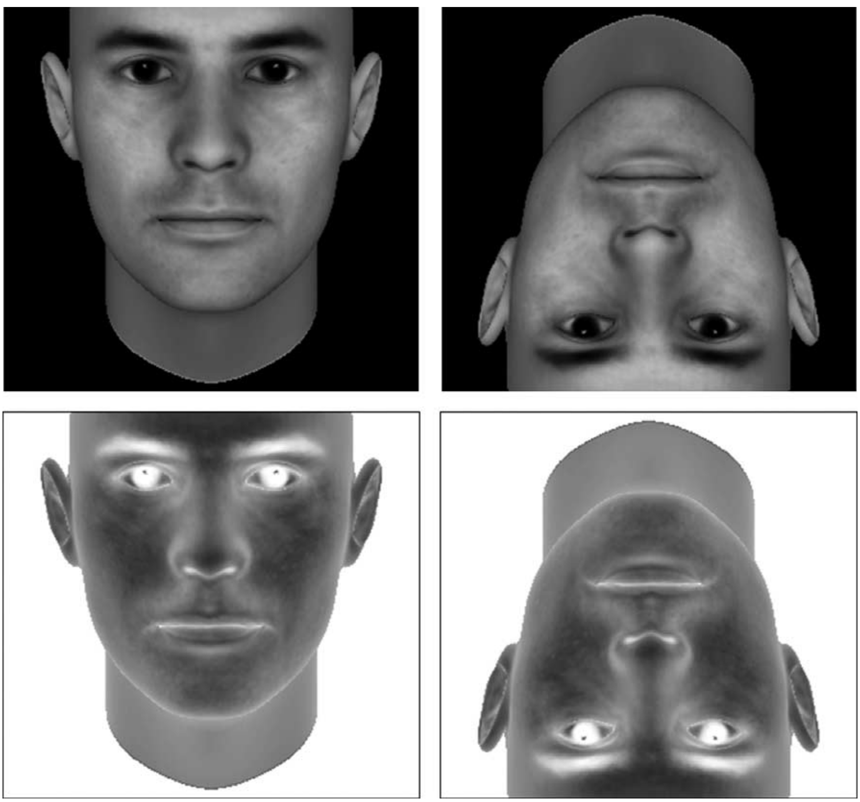

Figure 1. Examples of the male face stimuli used in Experiment 1A. Top-left canonical, top-right orientation inverted, bottom-left negated, bottom-right negated and inverted.

Results and discussion

Given the use of the group agreement design, we were keen to exclude participants who had not completed the task to the best of their ability. Consequently, participants who completed the experimental tasks in less than 35 s were excluded from analyses—informal piloting by the authors suggested that an average deliberation of at least 3 s was required to make 11 considered judgements (35/11 = 3.18 s per judgement). Use of this cutoff excluded 14 participants (four from the canonical group; two from the inverted group; five from the negated group; three from the negated and inverted group). This step prevents artefactual reductions in group agreement due to careless subjects.

To determine the degree of within group agreement across the four conditions, a Spearman's correlation coefficient was computed between each participant's rankings and the mean rankings provided by the remaining subjects in that condition. The distributions of raw correlations were then converted into Fisher *z*-scores, where $Zr = 0.5*\ln[(1+r)/(1-r)$. This transformation is required in order to use parametric statistics on correlations because of the upper and lower bounds of 1.0 and -1.0 inherent in the distribution of raw scores. Mean completion times and descriptive statistics can be seen in Table 1.

The data were analysed using ANOVA with stimulus sex as a within-subjects factor and presentation condition as a between-subjects factor. As can be seen in Figure 3, a highly significant main effect of group was observed, $F(3, 54) = 18.691$, $p < .001$, $\eta^2 = .509$. Simple effects analysis revealed that agreement within the canonical group for male faces exceeded that in the inverted group, $t(54) = 3.950$, $p < .001$; the negated group, $t(54) = 4.245$, $p < .001$; and the inverted and negated group, $t(54) = 4.489$, $p < .001$. An identical pattern was observed for the female faces with agreement within the canonical group exceeding the inverted group, $t(54) = 3.559$, $p < .001$, the negated group, $t(54) = 4.222$, $p < .001$, and the group subject to both manipulations, $t(54) = 3.973$, $p < .001$. No main effect of stimulus sex was observed ($p > .640$), nor was there an interaction between stimulus sex and group ($p > .980$). Cohen's *d* values were calculated for the inversion (male faces = 1.29; female face = 1.35) and negation (male faces = 1.86; female faces = 1.76) effects. All the observed values denote large effect sizes (Cohen, 1988).

The results from Experiment 1A confirm previous reports that inversion (Bäuml, 1994; Santos & Young, 2008) and negation (Santos & Young, 2008) disrupt the ability to perceive facial attractiveness, validating the use of within-group agreement as a means to assess judgements of attractiveness. Moreover, the completion times for each condition (Table 1) reveal that greater within-group agreement was associated with shorter completion

TABLE 1
Mean completion times and descriptive statistics for the distribution of raw correlation coefficients and the transformed distribution of Fisher z-scores for Experiment 1A (standard deviations are presented in parentheses)

Task	Group	Completion time (s)		Degree of agreement: Correlations		Fisher z-scores	
Male faces	Canonical ($n = 16$)	40.2	(5.1)	.391	(0.201)	.437	(0.258)
	Inverted ($n = 15$)	48.3	(8.2)	.061	(0.309)	.060	(0.327)
	Negated ($n = 13$)	47.7	(11.7)	−.025	(0.231)	−.028	(0.243)
	Both ($n = 14$)	54.7	(12.6)	.013	(0.317)	.008	(0.339)
Female faces	Canonical ($n = 16$)	41.4	(6.3)	.377	(0.198)	.417	(0.238)
	Inverted ($n = 15$)	49.4	(9.1)	.022	(0.161)	.022	(0.166)
	Negated ($n = 13$)	50.9	(11.3)	−.024	(0.222)	−.024	(0.230)
	Both ($n = 14$)	56.9	(10.9)	−.021	(0.349)	−.040	(0.421)

times, demonstrating that speed–accuracy tradeoffs cannot account for the differences in agreement. The comparable results observed for both male and female stimuli ensure that the effects are not artefacts of sexual preference.

EXPERIMENT 1B

In Experiment 1A, negation and orientation inversion disrupted the perception of facial attractiveness. Experiment 1B sought to determine whether these manipulations also impair the perception of bodily attractiveness.

Method

The same participants that completed Experiment 1A also took part in Experiment 1B. The stimuli consisted of 12 male and 12 female Caucasian bodies, generated using e-Frontier Poser V7.0 (see Figure 2), each subtending approximately 11° of visual angle. The bodies were presented in greyscale with head and face visible, but held constant within each stimulus set. While the size, shape, and relative location of component body parts were varied, figure height, posture, and approximate BMI were held constant. Unlike the face stimuli used in Experiment 1A, there was little or no variation in the surface reflectance properties of the bodies. For example, skin pigmentation and pubic hair was identical across stimuli. The experimental procedure was identical to Experiment 1A.

Results and discussion

As in Experiment 1A, participants who completed the experimental tasks in less than 35 s were excluded from analyses (three from the canonical group; four from

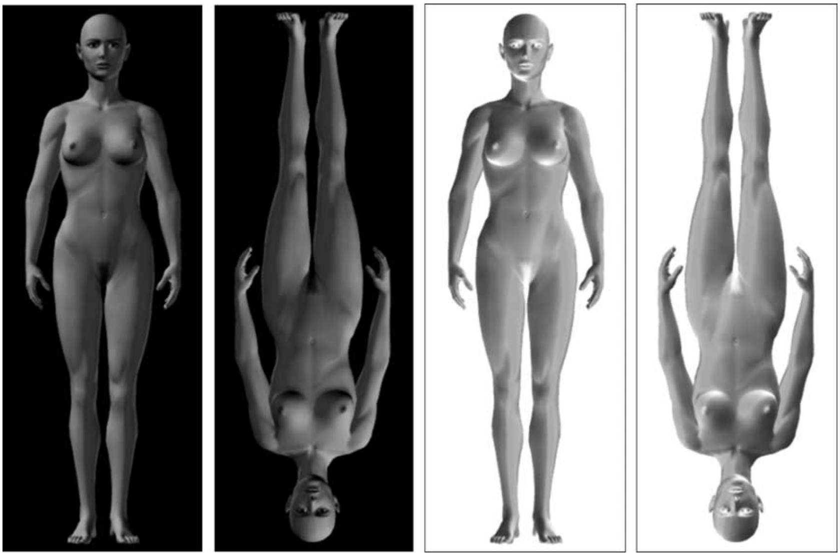

Figure 2. Examples of female body stimulus from Experiment 1B. From left to right; canonical, orientation inverted, negated, negated and inverted.

the inverted group; two from the negated group; and six from the negated and inverted group). The raw correlations were again transformed to Fisher *z*-scores. Mean completion times and descriptive statistics can be seen in Table 2.

The data were analysed using ANOVA with stimulus sex as a within-subjects factor and presentation condition as a between-subjects factor. A highly significant main effect of presentation condition was observed, $F(3, 53) = 21.846$, $p < .001$, $\eta^2 = .553$. Simple effects analysis revealed that agreement for male bodies was higher in the canonical condition than the inverted, $t(53) = 3.520$, $p < .001$, and the combined, $t(53) = 3.933$, $p < .001$, groups; but comparable with the negated condition ($p > .580$). A similar pattern was observed for the female bodies, with stronger agreement within the canonical group than either the inverted, $t(53) = 4.165$, $p < .001$, or combined, $t(53) = 3.853$, $p < .001$, groups; but comparable with the negated group ($p > .890$). The inversion effects observed for male (Cohen's $d = 1.48$) and female bodies (Cohen's $d = 2.43$) both represent large effects (Cohen, 1988), comparable with the effect sizes seen in Experiment 1A. A marginally significant main effect of stimulus sex was observed, $F(1, 53) = 3.926$, $p = .053$, $\eta^2 = .069$, indicating that there was slightly stronger agreement for the female set than for the male set. Finally, no stimulus sex $\times$ presentation condition interaction was revealed ($p > .570$), indicating that the presentation conditions had comparable effects on within group agreement for both the male and female stimuli.

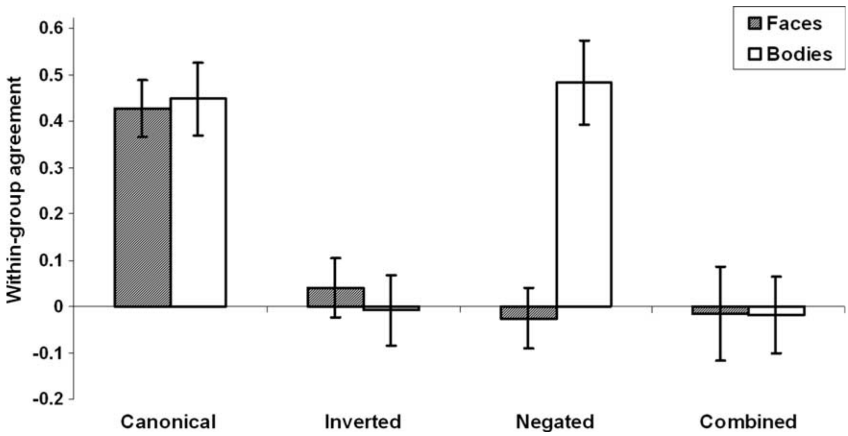

Figure 3. Mean agreement observed in Experiment 1 for the four presentation conditions, collapsed across male and female stimuli. Within group agreement is measured using Fisher *z* transformations of the raw correlations. Error bars represent the standard error of the mean.

In addition to comparable within-group agreement across the canonical and negated groups, the pattern of rankings was also very similar with high correlations observed for both the male ($r = .82$) and female ($r = .89$) stimuli. Thus, the canonical and negated groups appear to have based their judgements on the same cues. Like the first experiment, greater within-group agreement was associated with shorter completion times (Table 2), indicating that speed–accuracy tradeoffs cannot account for the differences in agreement.

TABLE 2
Mean completion times and descriptive statistics for the distribution of raw correlation coefficients and the transformed distribution of Fisher *z*-scores for Experiment 1B (standard deviations are presented in parentheses)

				Degree of agreement			
Task	*Group*	*Completion time (s)*		*Correlations*		*Fisher z-scores*	
Male bodies	Canonical ($n = 17$)	45.1	(6.4)	.313	(0.180)	.336	(0.204)
	Inverted ($n = 13$)	49.6	(9.1)	−.012	(0.251)	−.010	(0.263)
	Negated ($n = 15$)	47.2	(8.2)	.346	(0.232)	.388	(0.292)
	Both ($n = 12$)	53.6	(13.1)	−.057	(0.281)	−.060	(0.314)
Female bodies	Canonical ($n = 17$)	44.7	(5.9)	.442	(0.318)	.560	(0.452)
	Inverted ($n = 13$)	54.5	(9.3)	−.011	(0.267)	−.008	(0.277)
	Negated ($n = 15$)	52.8	(10.8)	.471	(0.296)	.577	(0.411)
	Both ($n = 12$)	55.2	(11.2)	.026	(0.242)	.022	(0.256)

EXPERIMENT 2A

Experiments 1A and 1B demonstrate that inversion disrupts attractiveness judgements of both faces and bodies, but the results suggest that the mechanisms mediating body and face perception differ insofar as body perception may be insensitive to negation. However, it is possible that the absence of a negation effect for the body stimuli in Experiment 1B is attributable to the lack of surface reflectance variation with the stimulus set employed. Several authors have argued that photographic negation impairs perception by preventing observers from representing surface reflectance variation (Bruce & Langton, 1994; Dakin & Watt, 2009; Russell et al., 2006) so the first two experiments may not represent a fair comparison of the effects of negation on faces and bodies, because the set of bodies contained only minimal surface reflectance variation. Consequently, two further experiments were conducted using photographic face and body stimuli, richer in pigmentation variation than the synthetic stimuli used in Experiments 1A and 1B.

We also wanted to address directly the degree of consistency within attractiveness judgements of canonical, inverted, and negated stimuli. It is not clear whether the lack of within group agreement observed for inverted and negated faces in Experiment 1A and inverted bodies in Experiment 1B is due to poor perceptual representation, which may thereafter produce unreliable judgements, or to individual differences in the use of inverted/negated cues. To distinguish between these accounts, we employed a within-subjects paradigm, whereby participants were required to rate stimuli for attractiveness when subject to the canonical, inverted, negated or combined manipulations. Each stimulus was rated twice, once per block, and correlation coefficients calculated to assess the degree of consistency between the ratings in each of the four conditions. If the lack of within-group agreement observed for inverted bodies is due to a poor perceptual representation, inversion should be associated with poorer within-rater reliability. Experiment 2A first assessed the reliability of face judgements, in order to validate the within-rater reliability design. This also allows comparison of effect sizes produced by face and body stimuli.

It was necessary to adopt a ratings approach in order to accommodate the larger number of images necessary to prevent participants recalling the ratings awarded previously. In addition, employing a ratings approach meant that larger stimuli could be presented, as we were unconstrained by the simultaneous presentation of the stimulus set. It was reasoned that this may make surface reflectance variation more salient.

Method

The participants were 18 undergraduates (five males) recruited from the University College London subject pool who completed the experiment for a small honorarium (mean age = 23.8 years, $SD = 3.6$ years). The stimuli used comprised 26 colour photographs of female Caucasian faces courtesy of Michael J. Tarr, Brown University (http://www.tarrlab.org/). The individuals depicted were all of approximately the same age (20–35). Stimuli were cropped around the forehead, and presented against a grey background (Figure 4). All stimuli appeared to gaze to the observer's left. A further 78 stimuli were derived by inverting the image orientation, by reversing the polarity of the image, or by

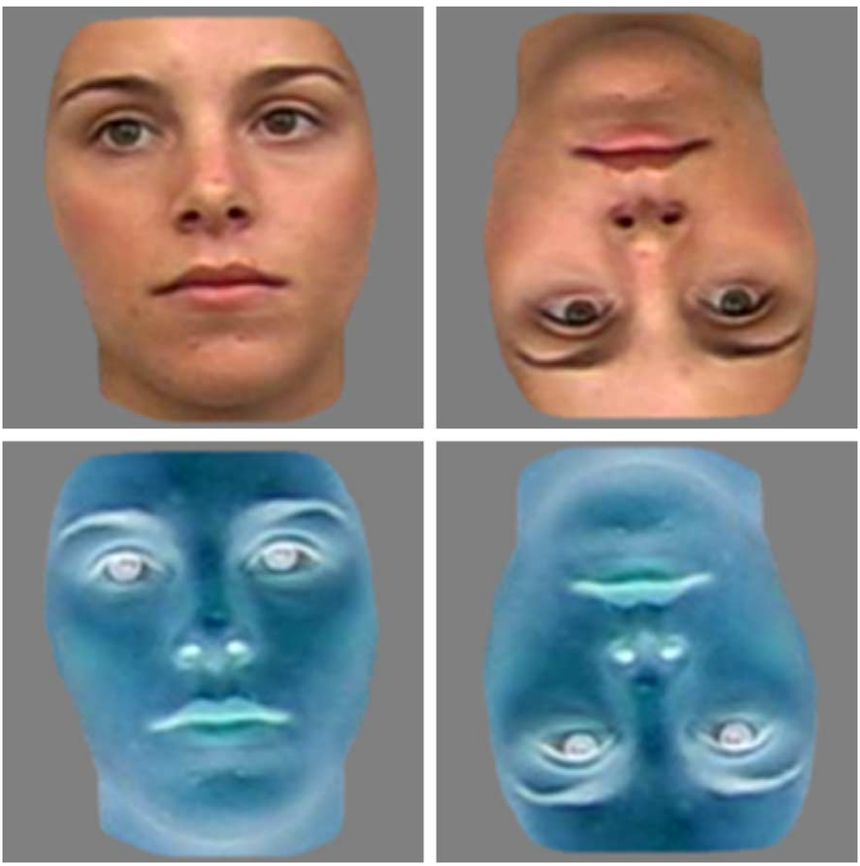

Figure 4. Examples of the face stimuli used in Experiment 2A. Top-left canonical, top-right orientation inverted, bottom-left negated, bottom-right negated and inverted. [To view this figure in colour, please visit the online version of the paper.]

employing both manipulations. Stimuli subtended approximately 9° of visual angle.

The experiment began with a pre-exposure phase where participants were presented with all 104 images in a random order, for 2 s each. Participants were instructed to ascertain the range of attractiveness present within the set. This was followed by two blocks during which participants rated each stimulus on a 9-point scale. Images were presented centrally for 2 s, until replaced by a "5", also presented centrally. Participants entered their ratings by adjusting the 5 upwards or downwards as appropriate using the up and down arrows on the keyboard provided. Participants were instructed to use the entire range so that the least attractive stimuli *in the set* should be awarded "1", while the most attractive *in the set* should be awarded "9". Participants were asked to assess the attractiveness of the individual depicted and not the aesthetics of the image manipulation. The procedure took approximately 30–35 minutes. Participants were invited to take a short break between the first and second blocks if they wished.

Results and discussion

Mean ratings and descriptive statistics can be seen in Table 3. To determine the within-rater reliability for each manipulation, a Pearson's correlation coefficient was calculated between the first and second ratings for the faces when presented in the canonical, inverted, negated, or combined manipulations. High correlations thus indicate that participants rated faces in that condition consistently. The distributions of raw correlations were converted into Fisher *z*-scores for significance testing.

The within-rater reliability scores were analysed using one-way ANOVA with presentation condition as a within-subjects factor. As can be seen in Figure 6, a highly significant main effect of group was observed, $F(3,\ 51) = 47.093$, $p < .001$, $\eta^2 = .735$. Planned contrasts revealed that within-rater consistency was significantly higher when stimuli were presented canonically than when subject to the inverted, $t(17) = 3.929$, $p < .001$, negated, $t(17) = 10.114$, $p < .001$, or combined, $t(17) = 11.628$, $p < .001$, manipulations. Moreover, within-rater consistency was significantly higher in the inverted, $t(17) = 5.679$, $p < .001$, and negated, $t(17) = 2.757$, $p < .025$, conditions, compared to the combined condition.

The data were also analysed to determine whether within-group agreement varied as a function of presentation condition, an analysis comparable to that employed in Experiment 1. The ratings provided by each participant in each of the four conditions were correlated with the mean ratings given to the faces by the remaining *n*-1 participants. High scores thus indicate that the ratings of a given participant were consistent with the ratings given by the rest of the sample. Raw correlations were again transformed into Fisher

TABLE 3
Mean response latencies and descriptive statistics for the distribution of raw correlation coefficients and the transformed distribution of Fisher *z*-scores for Experiment 2A (standard deviations are presented in parentheses)

	Canonical		*Inverted*		*Negated*		*Combined*	
Response latency (s)	1.605	(0.418)	1.630	(0.389)	1.602	(0.396)	1.606	(0.438)
Mean rating	4.653	(0.630)	5.541	(0.697)	3.899	(0.888)	4.292	(0.845)
Within-rater reliability (*r*)	.798	(0.087)	.654	(0.217)	.469	(0.255)	.283	(0.290)
Within-rater reliability (*Zr*)	1.148	(0.283)	.870	(0.381)	.559	(0.348)	.332	(0.370)
Within-group agreement (*r*)	.708	(0.116)	.585	(0.237)	.480	(0.153)	.300	(0.210)
Within-group agreement (*Zr*)	.920	(0.242)	.729	(0.334)	.544	(0.217)	.328	(0.247)

z-scores for the purposes of significance testing. A one-way ANOVA with presentation condition as a within-subjects factor revealed a significant main effect of presentation condition on within group agreement, $F(3, 51) = 20.707$, $p < .001$, $\eta^2 = .549$. Planned contrasts indicated that within-group agreement was higher when faces were presented canonically than when subject to the inverted, $t(17) = 2.396$, $p < .03$, negated, $t(17) = 4.999$, $p < .001$, or combined, $t(17) = 8.024$, $p < .001$, manipulations. Agreement was also higher for the inverted, $t(17) = 4.892$, $p < .001$, and negated, $t(17) = 2.673$, $p < .001$, presentations than for the combined manipulation.

Finally, participants' response latencies and their mean ratings for each manipulation were analysed using one-way ANOVAs with presentation condition as a within-subjects factor. No main effect of presentation condition on response latencies was revealed ($p > .90$), indicating that the effects of condition on within-rater reliability were not due to a speed–accuracy tradeoff. However, a main effect of presentation condition on mean ratings was observed, $F(3, 51) = 22.156$, $p > .001$, $\eta^2 = .566$. Post hoc contrasts revealed that mean ratings were higher in the inverted condition than for the canonical condition, $t(17) = 4.723$, $p < .01$, while mean ratings for the negated faces were lower than for the canonical faces, $t(17) = 4.065$, $p < .01$.

That within-rater reliability was significantly reduced for inverted and negated faces suggests that the perceptual representation of the faces was less robust. Importantly, the poor within-rater reliability observed for inverted and negated faces cannot be explained in term of individual differences between participants. Moreover, that the effects of inversion and negation were found to be additive suggests that these two manipulations disrupt the representation of different cues (Kemp, McManus, & Pigott, 1990).

The unexpected finding that inverted faces were rated as more attractive, and negated faces as less attractive is potentially of theoretical interest because participants were explicitly told to rate the attractiveness of the individuals depicted and not the aesthetics of the image manipulations. A potential explanation is that deviations from the prototypical configuration typically signal unattractiveness. If orientation inversion disrupts the ability of observers to represent such deviation, faces may appear more attractive. Conversely, subjects seem unable to recover true shape/pigmentation of a face from the negated image. Specifically, it appears as though there is a systematic bias towards an unattractive reconstruction of the underlying face. However, while intriguing, these suggestions are speculative.

EXPERIMENT 2B

In Experiment 2A, negation and orientation inversion elicited unreliable ratings of facial attractiveness, suggesting that these image manipulations impair the perceptual representation of faces. Experiment 2B sought to determine whether these manipulations have a similar effect on judgements of bodily attractiveness using an identical paradigm to that employed in Experiment 2A.

Method

The participants were 18 healthy adults (nine males) recruited from the University College London subject pool who completed the experiment in return for a small honorarium (mean age = 24.8 years, $SD = 4.2$ years). The stimuli comprised 26 colour photographs of female Caucasian bodies courtesy of Akira Gomi, FINEART.SK (http://fineart.sk/). The individuals depicted were all of approximately the same age (20–35). Stimuli were cropped at the neck, and presented against a grey background (Figure 5). All of the individuals depicted stood in a neutral pose, facing forwards with their hands by their side. A further 78 stimuli were derived by inverting the image orientation, by reversing the polarity of the image, or by employing both manipulations. Stimuli subtended approximately 18° of visual angle. The experimental procedure was identical to that employed in Experiment 2A.

Results and discussion

Mean ratings and descriptive statistics can be seen in Table 4. To determine the within-rater reliability for each stimulus manipulation, a Pearson's correlation coefficient was calculated between the first and second ratings for the faces when presented in the canonical, inverted, negated, or combined manipulations. The distributions of raw correlations were again converted into Fisher z-scores for significance testing. The within-rater reliability scores were analysed using one-way ANOVA with presentation condition as a within-subjects factor. As can be seen in Figure 6, a highly

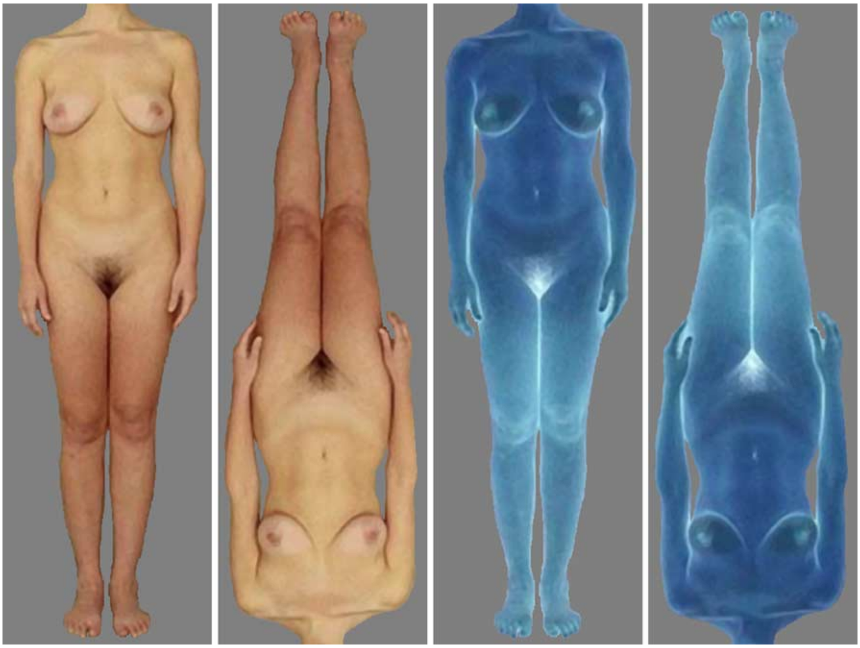

Figure 5. Examples of the body stimuli used in Experiment 2B. From left to right; canonical, orientation inverted, negated, negated and inverted. [To view this figure in colour, please visit the online version of the paper.]

significant main effect of group was observed, $F(3, 51) = 15.045$, $p < .001$, $\eta^2 = .469$. Planned contrasts revealed that within-rater consistency was significantly higher when bodies were presented canonically than when subject to the inverted, $t(17) = 3.207$, $p < .01$, negated, $t(17) = 2.250$, $p < .05$, or combined, $t(17) = 6.608$, $p < .001$, manipulations. Moreover, within-rater consistency was significantly higher in the inverted,

TABLE 4
Mean response latencies and descriptive statistics for the distribution of raw correlation coefficients and the transformed distribution of Fisher *z*-scores for Experiment 2B (standard deviations are presented in parentheses)

	Canonical		*Inverted*		*Negated*		*Combined*	
Response latency (s)	1.734	(0.628)	1.707	(0.682)	1.681	(0.650)	1.656	(0.690)
Mean rating	5.026	(0.804)	5.037	(0.834)	4.855	(0.998)	4.946	(0.927)
Within-rater reliability (*r*)	.706	(0.104)	.597	(0.164)	.583	(0.228)	.402	(0.233)
Within-rater reliability (*Zr*)	.907	(0.211)	.727	(0.264)	.728	(0.341)	.461	(0.304)
Within-group agreement (*r*)	.409	(0.258)	.376	(0.228)	.339	(0.275)	.305	(0.233)
Within-group agreement (*Zr*)	.470	(0.318)	.416	(0.261)	.379	(0.319)	.333	(0.265)

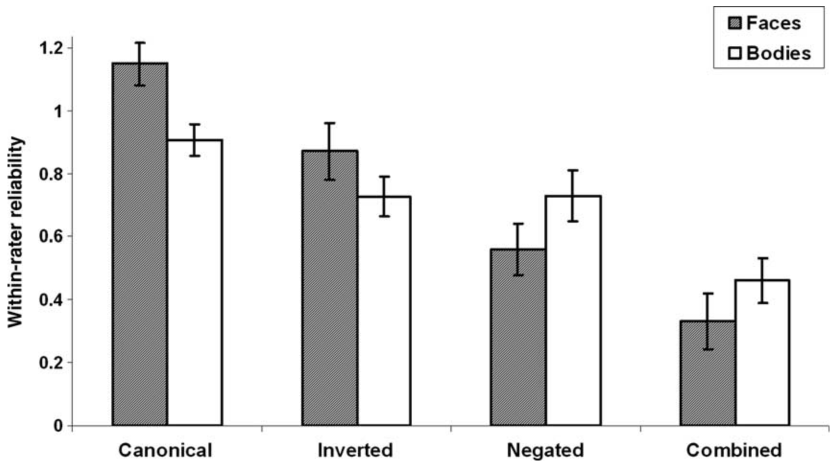

Figure 6. Mean within-rater consistency observed in Experiment 2A across each of the presentation conditions. Within-rater consistency is measured using Fisher *z* transformations of the raw correlations. Error bars represent the standard error of the mean.

$t(17) = 3.750$, $p < .01$, and negated, $t(17) = 4.376$, $p < .001$, conditions, compared to the combined condition.

The data were also analysed to determine whether the degree of within-group agreement varied as a function of presentation condition, using an identical procedure to Experiment 2A. Inspection of the means revealed a trend identical to that observed Experiment 2A (canonical > inverted > negated > combined). However, a one-way ANOVA with presentation condition as a within-subjects factor revealed no significant main effect of presentation condition ($p > .14$). It is worth noting that within-group agreement for the canonical bodies ($M = 0.41$, $SD = 0.26$) is substantially lower than the consensus seen for the canonical faces ($M = 0.71$, $SD = 0.12$). An independent samples *t*-test confirmed that this difference is significant, $t(34) = 4.767$, $p < .001$. This disparity may account for the absence of effects of inversion and negation on within-group agreement.

Two further analyses were also conducted: A one–way ANOVA on the mean ratings given to the bodies revealed no effect of presentation condition ($p > .60$). Similarly, a one-way ANOVA on participants' response latencies also revealed no effect of presentation condition ($p > .60$), indicating that the effects of condition on within-rater reliability were not due to a speed–accuracy tradeoff.

That within-rater reliability was significantly reduced in the inverted condition replicates the effects from Experiment 1B, and confirms that this manipulation impairs the perceptual representation of bodies. The magnitude of the body-inversion effect (Cohen's $d = 0.76$) is comparable with the face-inversion effect observed in Experiment 2A (Cohen's $d = 0.84$), with both considered large effects using the criteria set out by Cohen (1988). The body inversion effect observed in Experiment 2B suggests that the absence of agreement seen for inverted bodies in Experiment 1B was due to poor perceptual representation of the body stimuli rather than criteria that varied between participants.

The significant effect of contrast negation observed suggests that negation may also disrupt the perception of bodies. Importantly, this body-negation effect does not accord with the results from Experiment 1B, and an account of these conflicting results is considered in the General Discussion. However, while the body-negation effect observed may be characterized as a medium-sized effect (Cohen's $d = 0.65$), the negation effect seen with faces is considerably larger (Cohen's $d = 1.86$). Finally, that the effects of inversion and negation on within-rater reliability were additive, may suggest that these manipulations disrupt different cues (Kemp et al., 1990), and represents a further parallel between the face and body effects.

GENERAL DISCUSSION

There is widespread agreement that faces recruit specialized perceptual processes that are different from those engaged by most types of object perception. The present study used judgements of physical attractiveness to investigate whether human bodies also recruit specialized processes. In Experiment 1A, both orientation inversion and negation drastically reduced within-group agreement when participants ranked male and female faces for attractiveness. However, in Experiment 1B, only stimulus inversion disrupted the perception of bodily attractiveness; negation had no effect, either on the degree of within-group agreement or the pattern of rankings. To determine whether the lack of a body negation effect was due to insufficient pigmentation variation, two further experiments were conducted using photographic stimuli. Experiment 2A found that both inversion and negation elicited less reliable ratings of facial attractiveness, replicating the effects from Experiment 1A. However, unlike Experiment 1B, the results from Experiment 2B revealed detrimental effects of both inversion and negation on the reliability of body ratings, suggesting that both manipulations impair perception.

Inversion effects

That stimulus inversion disrupts the perception of faces is well-established (Diamond & Carey, 1986; Yin, 1969). However, the body-inversion effect observed here provides firm behavioural evidence that the inversion effect for upright bodies is comparable to that of upright faces. Because the stimuli and tasks used to assess face and body perception were closely matched, the comparable effect sizes indicate that both face *and* body perception are highly sensitive to orientation. Moreover, our findings also show that orientation affects assessments of bodily attractiveness—an intuitive and highly familiar perceptual judgement with important interpersonal consequences.

Recent studies indicate that previous inversion effects for body *posture* matching are due to head perception, and that such effects disappear when postures are presented in the absence of a head (Brandman & Yovel, 2010; Yovel et al., 2010). However, the current results demonstrate that orientation affects body perception even when head information is not varied (Experiment 1B), or when the head is absent (Experiment 2B). Despite this apparent disparity, we do not believe the present findings are inconsistent with the insensitivity of headless body *postures* to orientation. Instead, we propose that the different findings reflect differences in the stimuli: Specifically, we suggest that the use of transient postures, particularly unfamiliar ones, may convey additional significance to the head, as observers seek to identify a "primary axis" against which to encode the position of the limbs. However, because the stimuli used here all depicted a single familiar posture, the head was not afforded this additional significance.

The disproportionate inversion effects reported for bodies and faces suggest that upright bodies and faces recruit perceptual processes distinct from those engaged by other classes of object. The inversion effects observed with face stimuli have often been taken as evidence that upright faces are represented "holistically" such that both parts and spacing cues are integrated into a single nondecomposable whole (Tanaka & Farah, 1993; Young et al., 1987). This interpretation is supported by evidence that aligned task-relevant and task-irrelevant face halves are "perceptually fused" when viewed upright but not when orientation is inverted (Abbas & Duchaine, 2008; Young et al., 1987). Similarly, when presented upright, participants show better discrimination of whole faces that differ by a single feature, than they do of the individual features themselves, but show no holistic advantage for inverted stimuli (Tanaka & Farah, 1993). An alternative account of inversion effects is that inverted faces and bodies cannot be represented effectively by neural mechanisms attuned to the variation present in upright exemplars (Freiwald et al., 2009). While this latter, more general explanation is not inconsistent with the holistic account, it makes clear that the body inversion effect should not necessarily be taken as evidence of a holistic representation of bodies. More direct evidence such as composite or part–whole effects are necessary to infer the existence of holistic body perception.

The comparable inversion effects observed for faces and bodies are consistent with findings from an earlier event-related potential (ERP) study. The N170, a negative brain potential peaking approximately 170 ms following stimulus onset, has long been thought to be face-specific (Bentin, Allison, Puce, Perez, & McCarthy, 1996). However, some evidence suggests that the N170 is also elicited by human bodies (Stekelenburg & de Gelder, 2004). Moreover, these authors report that stimulus inversion delayed the onset of the N170 and enhanced its magnitude, for both faces and bodies. This similarity suggests that faces and bodies may be subject to comparable perceptual processing.

Contrast negation

The present study has again demonstrated that negation disrupts the perceptual processing of faces. This disruption may be primarily due to reversals in surface reflectance cues (i.e., variations in pigmentation, colouration, and texture) (Bruce & Langton, 1994) as it has been shown that negation disrupts perception of these cues more than the inference of facial structure (Russell et al., 2006). Faces are rich in texture and colouration differences. Indeed, it has been proposed that such variation comprises a perceptual "bar-code" that mediates easy detection and discrimination of faces (Dakin & Watt, 2009). Because photographic negation reverses the polarity of surface reflectance variation, it is particularly detrimental to face perception. Under typical viewing conditions, human perception also uses variation in shadow and shading to infer the three-dimensional structure of a face, and disruption to these "shape-from-shading" cues may also contribute to the detrimental effects of negation (Bruce, 1988; Santos & Young, 2008).

In Experiments 1A and 1B we observed a clear difference in the effect of negation on face and body attractiveness judgements: In Experiment 1A judgements were uncorrelated when faces were negated, while judgements of body attractiveness remained unaffected. However, in Experiment 2B, we found a significant negation effect for bodies when photographic stimuli were used. Whereas the synthetic body stimuli used in Experiment 1B had identical pigmentation and varied solely in terms of the ratios and proportions of the bodies, the stimuli employed in Experiment 2B were much richer in terms of their pigmentation variation. These experiments, taken together, thus indicate that photographic negation *does* disrupt body perception by impairing observers' ability to represent surface reflectance cues. That negation had no effect when bodies varied only in their form and contained no pigmentation variation strongly suggests that any detrimental effects are not attributable to disruption of shape-from-shading cues. Moreover, the fact that the effects of inversion and negation were additive suggests that these manipulations may disrupt distinct cues (Kemp et al., 1990). The effects of negation on body perception therefore mirror closely the negation effects observed with faces.

It is worth noting that the negation effect observed with bodies is smaller than that seen with faces, indicating that body perception may be less reliant on surface reflectance cues. Whereas faces are rich in surface reflectance variation, bodies may contain fewer cues associated with colouration, pigmentation, and texture changes. Consequently, surface reflectance may be of less use, in terms of detecting and representing human bodies. In addition, while we have considerable exposure to "naked" faces, we have much less visual experience of naked bodies. We may therefore not develop comparable expertise in representing surface reflectance and extracting shape-from-shading information from bodies. However, this suggestion remains tentative: Due to the differences in the true size of bodies and faces, it was necessary to present faces and bodies at different scales. Because faces appeared closer to the observers, their pigmentation variation may have been more salient. It remains a question for future research whether bodies elicit stronger negation effects when viewed at larger scales.

That faces and bodies recruit similar types of perceptual processes should not be surprising, insofar as they pose similar problems to the visual system. Faces and bodies are both critical stimuli for which precise representation is necessary. Both have been viewed almost exclusively in the upright orientation both within observers' lifetimes and over evolutionary history. Just as faces comprise discrete components in a consistent spatial arrangement, so do bodies. Moreover, many of the attributions that may be derived from a face are also available from bodies including gender, age, health, and mood.

While the present findings suggest that the perceptual processes recruited by faces and bodies may be more similar than originally believed, considerable evidence demonstrates that distinct neural substrates mediate face and body perception. Neuroimaging findings have identified separate regions that respond selectively to faces and bodies in the lateral occipital cortex (Downing, Jiang, Shuman, & Kanwisher, 2001; Gauthier et al., 2000) and in the fusiform gyrus (Kanwisher et al., 1997; Peelen & Downing, 2005). Consistent with these findings, the application of transcranial magnetic stimulation to category-selective areas can selectively impair the perception of bodies and faces (Pitcher, Charles, Devlin, Walsh, & Duchaine, 2009), and neuropsychological evidence shows that face and body perception are dissociable (Duchaine et al., 2006; Moro et al., 2008). Consequently, we would not wish to argue that faces and bodies recruit a single common mechanism; rather that the two parallel systems may have a number of characteristics in common which distinguish them from generic object routines.

In summary, the inversion and negation effects observed demonstrate that both faces and bodies recruit perceptual processes distinct from those mediating object perception. These comparable effects serve to underline the parallels between face and body perception, and accord with suggestions that faces and bodies pose comparable problems for our perceptual system. That negation disrupted body perception only when surface reflectance variation was present within the stimuli suggests that the body negation effect may disrupt similar processes to that seen with the face-negation effect.

Supplementary data (Appendix) published online alongside this article at www.psypress.com/viscog

REFERENCES

Abbas, Z. A., & Duchaine, B. (2008). The role of holistic processing in judgments of facial attractiveness. *Perception*, *37*(8), 1187–1196.

Bentin, S., Allison, T., Puce, A., Perez, E., & McCarthy, G. (1996). Electrophysiological studies of face perception in humans. *Journal of Cognitive Neuroscience*, *8*(6), 551–565.

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review*, *94*(2), 115–147.

Brandman, T., & Yovel, G. (2010). The body inversion effect is mediated by face-selective, not body-selective, mechanisms. *Journal of Neuroscience*, *30*(31), 10534–10540.

Bruce, V. (1988). *Recognising faces*. Hove, UK: Lawrence Erlbaum Associates Ltd.

Bruce, V., & Langton, S. (1994). The use of pigmentation and shading information in recognising the sex and identities of faces. *Perception*, *23*(7), 803–822.

Bruce, V., & Young, A. (1986). Understanding face recognition. *British Journal of Psychology*, *77*(3), 305–327.

Busigny, T., & Rossion, B. (2010). Acquired prosopagnosia abolishes the face inversion effect. *Cortex*, *46*(8), 965–981.

Bäuml, K. H. (1994). Upright versus upside-down faces: How interface attractiveness varies with orientation. *Perception and Psychophysics*, *56*(2), 163–172.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Dakin, S. C., & Watt, R. J. (2009). Biological "bar codes" in human faces. *Journal of Vision*, *9*(4), 1–10.

Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General*, *115*(2), 107–117.

Downing, P. E., Jiang, Y. H., Shuman, M., & Kanwisher, N. (2001). A cortical area selective for visual processing of the human body. *Science*, *293*(5539), 2470–2473.

Duchaine, B., Yovel, G., Butterworth, E., & Nakayama, K. (2006). Prosopagnosia as an impairment to face-specific mechanisms: Elimination of the alternative hypotheses in a developmental case. *Cognitive Neuropsychology*, *23*(5), 714–747.

Fan, J. T., Dai, W., Liu, F., & Wu, J. (2005). Visual perception of male body attractiveness. *Proceedings of the Royal Society: Biological Sciences*, *272B*(1560), 219–226.

Fink, B., Grammer, K., & Matts, P. J. (2006). Visible skin color distribution plays a role in the perception of age, attractiveness, and health in female faces. *Evolution and Human Behavior*, *27*(6), 433–442.

Fleming, R. W., Dror, R. O., & Adelson, E. H. (2003). Real-world illumination and the perception of surface reflectance properties. *Journal of Vision*, *3*(5), 347–368.

Freiwald, W. A., Tsao, D. Y., & Livingstone, M. S. (2009). A face feature space in the macaque temporal lobe. *Nature Neuroscience*, *12*(9), 1187–1196.

Galper, R. E. (1970). Recognition of faces in photographic negative. *Psychonomic Science*, *19*(4), 207–208.

Gauthier, I., & Tarr, M. J. (1997). Becoming a "greeble" expert: Exploring mechanisms for face recognition. *Vision Research*, *37*(12), 1673–1682.

Gauthier, I., Tarr, M. J., Moylan, J., Skudlarski, P., Gore, J. C., & Anderson, A. W. (2000). The fusiform "face area" is part of a network that processes faces at the individual level. *Journal of Cognitive Neuroscience*, *12*(3), 495–504.

Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2000). The distributed human neural system for face perception. *Trends in Cognitive Sciences*, *4*(6), 223–233.

Hill, H., & Bruce, V. (1996). Effects of lighting on the perception of facial surfaces. *Journal of Experimental Psychology: Human Perception and Performance*, *22*(4), 986–1004.

Johnston, A., Hill, H., & Carman, N. (1992). Recognising faces: Effects of lighting direction, inversion, and brightness reversal. *Perception*, *21*(3), 365–375.

Kanwisher, N. (2000). Domain specificity in face perception. *Nature Neuroscience*, *3*(8), 759–763.

Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. *Journal of Neuroscience*, *17*(11), 4302–4311.

Kemp, R., McManus, C., & Pigott, T. (1990). Sensitivity to the displacement of facial features in negative and inverted images. *Perception*, *19*(4), 531–543.

Kemp, R., Pike, G., White, P., & Musselman, A. (1996). Perception and recognition of normal and negative faces: The role of shape from shading and pigmentation cues. *Perception*, *25*(1), 37–52.

Langlois, J. H., & Roggman, L. A. (1990). Attractive faces are only average. *Psychological Science*, *1*(2), 115–121.

Lewis, M. B., & Johnston, R. A. (1997). The Thatcher illusion as a test of configural disruption. *Perception*, *26*(2), 225–227.

Manning, J. T., Scutt, D., Whitehouse, G. H., & Leinster, S. J. (1997). Breast asymmetry and phenotypic quality in women. *Evolution and Human Behavior*, *18*(4), 223–236.

McKone, E., Kanwisher, N., & Duchaine, B. C. (2007). Can generic expertise explain special processing for faces? *Trends in Cognitive Sciences*, *11*(1), 8–15.

Moro, V., Urgesi, C., Pernigo, S., Lanteri, P., Pazzaglia, M., & Aglioti, S. M. (2008). The neural basis of body form and body action agnosia. *Neuron*, *60*(2), 235–246.

Moscovitch, M., Winocur, G., & Behrmann, M. (1997). What is special about face recognition? Nineteen experiments on a person with visual object agnosia and dyslexia but normal face recognition. *Journal of Cognitive Neuroscience*, *9*(5), 555–604.

Nederhouser, M., Yue, X., Mangini, M. C., & Biederman, I. (2007). The deleterious effect of contrast reversal on recognition is unique to faces, not objects. *Vision Research*, *47*(16), 2134–2142.

Peelen, M. V., & Downing, P. E. (2005). Selectivity for the human body in the fusiform gyrus. *Journal of Neurophysiology*, *93*(1), 603–608.

Perrett, D. I., Burt, D. M., Penton-Voak, I. S., Lee, K. J., Rowland, D. A., & Edwards, R. (1999). Symmetry and human facial attractiveness. *Evolution and Human Behavior*, *20*(5), 295–307.

Perrett, D. I., Lee, K. J., Penton-Voak, I., Rowland, D., Yoshikawa, S., Burt, D. M., et al. (1998). Effects of sexual dimorphism on facial attractiveness. *Nature*, *394*(6696), 884–887.

Pitcher, D., Charles, L., Devlin, J. T., Walsh, V., & Duchaine, B. (2009). Triple dissociation of faces, bodies, and objects in extrastriate cortex. *Current Biology*, *19*(4), 319–324.

Reed, C. L., Stone, V. E., Bozova, S., & Tanaka, J. (2003). The body-inversion effect. *Psychological Science*, *14*(4), 302–308.

Reed, C. L., Stone, V. E., Grubb, J. D., & McGoldrick, J. E. (2006). Turning configural processing upside down: Part and whole body postures. *Journal of Experimental Psychology: Human Perception and Performance*, *32*(1), 73–87.

Reed, C. L., Stone, V. E., & McGoldrick, J. E. (2005). Not just posturing: Configural processing of the human body. In G. Knoblich, I. Thornton, M. Grosjean, & M. Shiffrar (Eds.) *Human body perception from the inside out* (pp. 229–258). New York, NY: Oxford University Press.

Robbins, R., & McKone, E. (2007). No face-like processing for objects-of-expertise in three behavioural tasks. *Cognition*, *103*(1), 34–79.

Russell, R., Sinha, P., Biederman, I., & Nederhouser, M. (2006). Is pigmentation important for face recognition? Evidence from contrast negation. *Perception*, *35*(6), 749–759.

Santos, I. M., & Young, A. W. (2008). Effects of inversion and negation on social inferences from faces. *Perception*, *37*(7), 1061–1078.

Singh, D. (1993). Adaptive significance of female physical attractiveness—role of waist-to-hip ratio. *Journal of Personality and Social Psychology*, *65*(2), 293–307.

Slaughter, V., Stone, V. E., & Reed, C. (2004). Perception of faces and bodies—similar or different? *Current Directions in Psychological Science*, *13*(6), 219–223.

Smith, K. L., Cornelissen, P. L., & Tovee, M. J. (2007). Color 3D bodies and judgements of human female attractiveness. *Evolution and Human Behavior*, *28*(1), 48–54.

Stekelenburg, J. J., & de Gelder, B. (2004). The neural correlates of perceiving human bodies: An ERP study on the body-inversion effect. *Neuroreport*, *15*(5), 777–780.

Swami, V., & Tovee, M. J. (2005). Male physical attractiveness in Britain and Malaysia: A cross-cultural study. *Body Image*, *2*(4), 383–393.

Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *Quarterly Journal of Experimental Psychology*, *46*(2), 225–245.

Tarr, M. J., & Gauthier, I. (2000). FFA: A flexible fusiform area for subordinate-level visual processing automatized by expertise. *Nature Neuroscience*, *3*(8), 764–769.

Tsao, D. Y., Freiwald, W. A., Tootell, R. B., & Livingstone, M. S. (2006). A cortical region consisting entirely of face-selective cells. *Science*, *311*(5761), 670–674.

Voracek, M., Fisher, M. L., Rupp, B., Lucas, D., & Fessler, D. M. T. (2007). Sex differences in relative foot length and perceived attractiveness of female feet: Relationships among anthropometry, physique, and preference ratings. *Perceptual and Motor Skills*, *104*(3), 1123–1138.

Yin, R. K. (1969). Looking at upside-down faces. *Journal of Experimental Psychology*, *81*(1), 141–145.

Young, A. W., Hellawell, D., & Hay, D. C. (1987). Configurational information in face perception. *Perception*, *16*(6), 747–759.

Yovel, G., Pelc, T., & Lubetzky, I. (2010). It's all in your head: Why is the body inversion effect abolished for headless bodies? *Journal of Experimental Psychology: Human Perception and Performance*, *36*(3), 759–767.

Manuscript received April 2010
Manuscript accepted November 2010