Available online at www.sciencedirect.com

SCIENCE DIRECT

COGNITION

Cognition 93 (2004) B27–B38

www.elsevier.com/locate/COGNIT

Brief article

Bodies capture attention when nothing is expected

Paul E. Downing*, David Bray, Jack Rogers, Claire Childs

School of Psychology, University of Wales, Bangor, UK

Received 5 September 2003; accepted 22 October 2003

Abstract

Functional neuroimaging research has shown that certain classes of visual stimulus selectively activate focal regions of visual cortex. Specifically, cortical areas that generally and selectively respond to faces (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; Puce, A., Allison, T., Asgari, M., Gore, J. C., & McCarthy, G. (1996). Differential sensitivity of human visual cortex to faces, letterstrings, and textures: a functional magnetic resonance imaging study. *Journal of Neuroscience*, *16*(16), 5205–5215.) and to the human body (Downing, P. E., Jiang, Y., Shuman, M., & Kanwisher, N. (2001). A cortical area selective for visual processing of the human body. *Science*, *293*(5539), 2470–2473.) have recently been described using fMRI. A parallel body of research has focused on the ability of faces to "capture" the focus of attention, compared to other kinds of objects (Lavie, N., Ro, T., & Russell, C. (2003). The role of perceptual load in processing distractor faces. *Psychological Science*, *14*(5), 510–515; Ro, T., Russell, C., & Lavie, N. (2001). Changing faces: a detection advantage in the flicker paradigm. *Psychological Science*, *12*(1), 94–99; Vuilleumier, P. (2000). Faces call for attention: evidence from patients with visual extinction. *Neuropsychologia*, *38*(5), 693–700.). The present study uses Mack and Rock's "inattentional blindness" paradigm to investigate whether unexpected, task-irrelevant human body stimuli capture awareness when attention is occupied by a primary task (Mack, A., & Rock, I. (1998). *Inattentional blindness*. London: MIT Press). Silhouettes and stick figures of human bodies, and silhouettes of hands, were compared to control stimuli including object silhouettes, object stick figures, and scrambled silhouettes of bodies, body parts, and objects. Participants were significantly better able to detect a human figure relative to the control stimuli. These results suggest that the human body, like the face, may be prioritized for attentional selection. More generally, they are consistent with the proposal that the visual system assigns attentional priority to types of stimuli that are also represented in strongly selective cortical regions.

---

* Corresponding author. School of Psychology, Centre for Cognitive Neuroscience, University of Wales, Bangor, LL57 2AS, UK. Tel.: +44-1248-382-159; fax: +44-1248-382-599.

E-mail address: p.downing@bangor.ac.uk (P.E. Downing).

0022-2860/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.cognition.2003.10.010

Keywords: Attention; Body; Inattentional blindness

1. Introduction

The functional architecture of object processing in human visual cortex has become a focus of much recent research (Cohen & Tong, 2001). The "ventral stream" in particular has been associated with object identification (Ungerleider & Mishkin, 1982). Recent proposals have suggested that ventral stream representations are organized: (a) by cognitive process (Gauthier, 2000); (b) by extension of early retinotopic regions (Malach, Levy, & Hasson, 2002); (c) in a distributed fashion, in which the pattern of activity represents the stimulus (Haxby et al., 2001); and (d) along category boundaries, with cortical "modules" specialized for particular categories such as faces (Caramazza & Shelton, 1998; Fodor, 1983; Kanwisher, 2000).

A strongly modular organization, in which most or all object categories are represented in distinct neural areas, can likely be ruled out a priori as infeasible. But evidence from neuropsychology, neurophysiology, and functional neuroimaging does support claims of independent neural systems for a few object types. Much of the recent research has focused on the case of human faces (Carmel & Bentin, 2002; Desimone, Albright, Gross, & Bruce, 1984; Farah, Wilson, Drain, & Tanaka, 1998; Kanwisher, 2000; Kanwisher, McDermott, & Chun, 1997; Moscovitch, Winocur, & Behrmann, 1997; Perrett, Rolls, & Caan, 1982; Puce, Allison, Asgari, Gore, & McCarthy, 1996) although a modular interpretation of this evidence is not universally accepted (Haxby et al., 2001).

One implication of the possible existence of a face-specific cortical module is that processing of faces may proceed automatically regardless of how attention is allocated. A strong version of this hypothesis can be ruled out by the finding that attention modulates face-related neural activity (Downing, Liu, & Kanwisher, 2001; Holmes, Vuilleumier, & Eimer, 2003; O'Craven, Downing, & Kanwisher, 1999; Wojciulik, Kanwisher, & Driver, 1998). However, several recent studies have found evidence for a general attentional bias favouring faces. For example, Ro, Russell, and Lavie (2001) found that participants were better able to detect a change in a circular array of images when it was an upright (but not inverted) face that changed, compared to other kinds of objects. Neuropsychological evidence supports their conclusion that faces have a special role in the competition for attention – Vuilleumier (2000) found that extinction following a right hemisphere lesion is reduced when a face appears in the contralesional hemifield.

Another strong source of evidence for attention capture by faces comes from the experiments on "inattentional blindness" (IB) conducted by Mack, Rock, and colleagues (Mack, Pappas, Silverman, & Gay, 2002; Mack & Rock, 1998; Mack, Tang, Tuma, Kahn, & Rock, 1992; Rock, Linnett, Grant, & Mack, 1992). In the typical IB procedure, participants are required to make a line length judgement on the two arms of a cross. After performing this task for a few trials, an irrelevant stimulus (the "critical stimulus") is presented inside one of the four quadrants of the cross without the participants' knowledge or expectation. A series of studies showed that a substantial number of participants failed to detect simple, high-contrast geometric shapes (Mack & Rock, 1998). After being alerted to the possibility that something besides the cross would appear, however, participants successfully detected the critical stimulus – demonstrating that the "blindness" seen on the critical trial was due to attention and not a result of perceptual limitations.

Mack and Rock (1998) tested this procedure using schematic cartoon faces. In their study, 85% of participants detected a "happy" face, compared to 40% for a "sad" face, 63% for a scrambled face and 15% for a simple circle. This robust effect suggests that the processing of faces, particularly the highly-familiar "happy face" icon, takes precedence over other stimulus types. In combination with similar findings showing capture by the participants' own names, and a few other emotionally significant stimuli, this result is consistent with a late-selection attentional system, in which items are processed to the level of meaning before selection for awareness occurs.

One possible account of the attentional bias seen for faces in a number of paradigms is that there is a relationship between cortical specialization and advantages in attentional capture. On this hypothesis, stimulus categories favoured by a focal, selective cortical area will tend to be selected at a higher priority compared to other object classes. (We do not, however, suggest the complementary hypothesis, that all stimulus classes that capture attention will necessarily be represented in specialized cortical regions.)

The visual representation of the human body provides an opportunity to test this hypothesis. Various lines of evidence implicate distinct cortical areas in the processing of information related to the human body. Cells in the superior temporal sulcus respond to action images of complex body movements, such as walking, dancing and throwing (Jellema, Baker, Wicker, & Perrett, 2000; Wachsmuth, Oram, & Perrett, 1994). Likewise, a number of fMRI studies have found activations that respond more to biological motion (e.g. walking) compared to other kinds of motion (Grossman & Blake, 2002; Wheaton, Pipingas, Silberstein, & Puce, 2001). A recent case study describes a patient with a left occipital lobe lesion who has deficits in semantic knowledge about objects from familiar categories, with the exception of body parts (Shelton, Fouch, & Caramazza, 1998). Finally, a recent fMRI study (Downing, Jiang, Shuman, & Kanwisher, 2001) examined a cortical region in humans that responds selectively to images of the human body. An area located in the lateral occipitotemporal cortex (named the extrastriate body area, or "EBA") preferentially responds to human body images represented by photographs, line drawings, stick figures or silhouettes, relative to control stimuli.

By analogy to faces, this evidence raises the possibility that images of the human body will be relatively resistant to IB. Mack and colleagues made an initial test of this hypothesis, finding that when the critical stimulus was a schematic stick figure of a person, it was perceived by 80% of observers, compared to 45% for a schematic Christmas tree and 33% for a schematic house (Mack & Rock, 1998). (A control experiment with inverted stimuli showed no difference between conditions.) However, this study was somewhat limited in that it tested only one stimulus exemplar in each condition. In the present study we tested a broad range of body and non-body stimuli represented as both silhouettes and line drawings, in order to test the generality of attention capture by bodies across different exemplars and image formats (see Fig. 1). Furthermore, in one control condition we included images of human hands – a stimulus that is both biological and highly familiar, as is the human body – to test the specificity of capture to bodies per se (cf. Kanwisher et al., 1997).

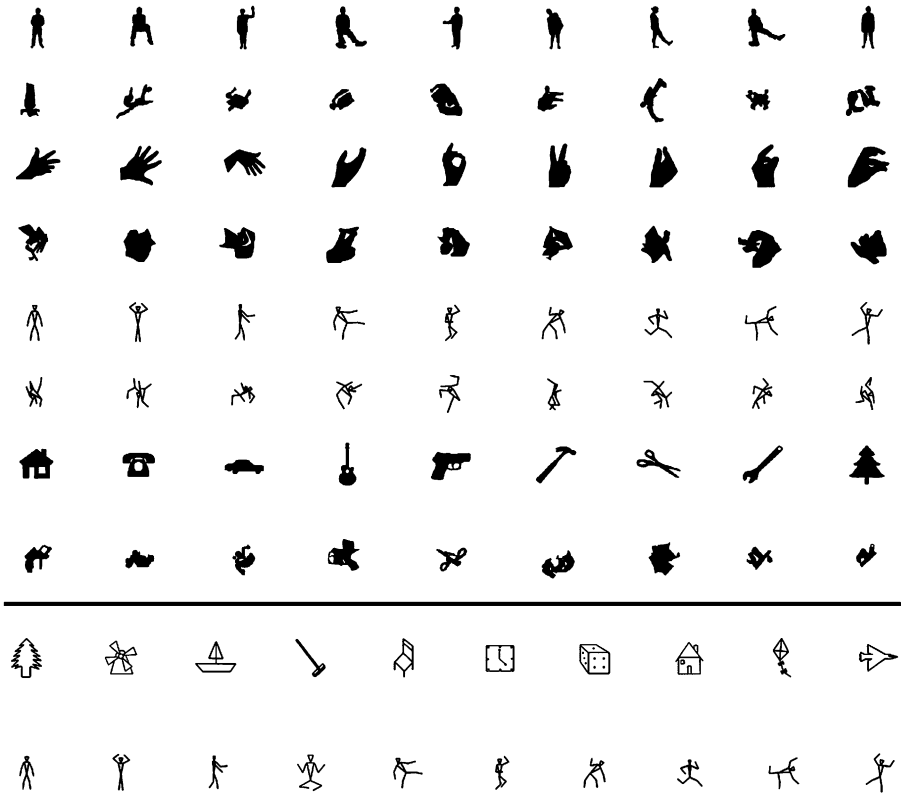

Fig. 1. All critical stimuli tested. Stimuli from Experiment 1 are above the black divider, and those from Experiments 2 and 3 are below. Each row represents a different stimulus type; from top down, they are: body silhouettes, scrambled body silhouettes, hand silhouettes, scrambled hand silhouettes, body stick figures, scrambled body stick figures, object silhouettes, scrambled object silhouettes, object stick figures, and body stick figures.

2. Experiment 1

In this study, we used the IB procedure to compare the attentional precedence of stick figures of bodies and silhouettes of bodies, hands, and objects. These were each compared to scrambled stimuli formed by rearranging the features of the intact stimuli. We hypothesized that IB would be weaker for body-related images compared to controls.

2.1. Method

2.1.1. Participants

One hundred and forty-four experimentally-naive undergraduates participated for printer credits and/or candy.

2.1.2. Stimuli

All critical stimuli are illustrated in Fig. 1. Nine silhouettes of human bodies, hands, and objects were created by tracing photographs and then filling in and reducing the resulting contour. Scrambled versions of each of these images were constructed by rearranging them in a way that destroyed the original outline, but retained a central contiguous figure. Stick figures of human bodies were created with reference to photographs, and scrambled versions of these were constructed by rearranging the elements. Images were approximately 1 cm square. Sizes and distances are given in centimetres as viewing distance, which varied from approximately 40 to 70 cm, was not fixed with a chin rest.

2.1.3. Design

As participants could only be exposed to one critical trial without expecting any other stimulus, the experiment was a between-participants design. Eight trials were tested for each participant. Critical stimuli appeared along with the task-relevant cross on trials 4, 7, and 8. Trial 4 served as the primary experimental trial; here, participants should have no anticipation of the critical stimulus appearing. On trial 7, participants were asked to perform the cross task as well as monitor for the appearance of another item. This trial therefore served as a divided attention test to ensure that participants could attend to both the line length task and the critical stimulus. On trial 8, participants ignored the cross and sought the critical stimulus; this trial served as a control to ensure that critical stimuli could be identified when they were the sole focus of attention.

Two groups of 72 participants were tested. For the first group, the critical item on trial 4 was either a body silhouette, object silhouette, scrambled body silhouette, or scrambled object silhouette. Eighteen participants were tested for each stimulus type on trial 4; two participants saw each of the nine stimuli available for each type. The critical item on trial 7 was selected from one of the remaining three conditions, and the critical item on trial 8 was selected from the remaining two conditions, resulting in six possible combinations of stimulus types for these trials. The choice of condition for these trials was counterbalanced so that three participants were tested on each of these six combinations.

The second group of participants was tested exactly as above, except that the set of critical stimuli was drawn from hand silhouettes, human stick figures, and scrambled versions of these stimuli.

2.1.4. Procedure

Participants were tested individually on an Apple Macintosh desktop computer with Matlab (Mathworks, Inc., Natick, MA) and the “Psychophysics Toolbox” software (Brainard, 1997). Each trial was initiated when the participant pressed the space bar, which was followed by an initial fixation point (1507 ms), the cross, with or without the critical stimulus (200 ms), and finally a pattern mask (507 ms; see Fig. 2). The critical stimulus, when present, appeared in one of the quadrants of the cross, centred on a 45° diagonal from the middle of the cross, centred at approximately 1.5 cm from the fixation point. The quadrant in which the critical stimulus appeared was determined randomly, with the constraint that no quadrant was used twice for a given participant. The lengths of the two arms of the cross were each randomly selected to be between 2.7 and 4.7 cm in length.

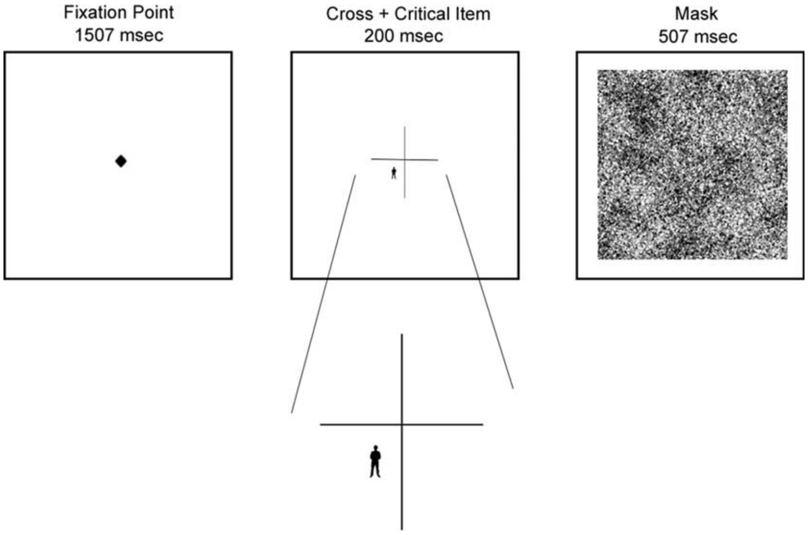

Fig. 2. Schematic of the presentation sequence of a typical critical trial. Images are not to scale. The trial sequence proceeds from left to right.

Participants were instructed to judge whether the vertical or horizontal arm of the cross was longer. They responded after each trial by pressing the "up" arrow key if the vertical line was longer, or by pressing the "right" arrow key if the horizontal line was the longer. On trials 4, 7 and 8, a critical stimulus appeared simultaneously with the cross as illustrated in Fig. 2. No warning of this was given before trial 4. Before trial 7, participants were asked to respond to both the line length task and the critical stimulus, and before trial 8, participants were instructed to look for the critical stimulus only.

Immediately after each critical trial, participants were asked if they saw anything besides the cross and the mask on the last trial. After answering this question, a choice array was presented on paper, and they were asked to identify the item they felt was most likely to have appeared with the cross, whether or not they had seen anything. The choice arrays consisted of two randomly selected items from each of the four categories, with the constraint that one image always matched the critical item.

2.2. Results

Each participant was scored on the line judgement task, and on detection and identification of the critical stimulus. Overall accuracy on the line judgement task was 68%. Accuracy did not differ significantly among the eight conditions on critical trials 4 and 7 (both Ps > 0.10). Performance on the line task was worse on critical trials (4 and 7) relative to adjacent non-critical trials (2, 3, 5, and 6), 61% vs. 76%, suggesting that attention was diverted from the line task on critical trials.

We focus our analyses of detection and identification performance on trial 4, as detection performance was at or near ceiling on trials 7 and 8, and as this was the critical trial in which participants had no expectation of seeing any additional stimulus.

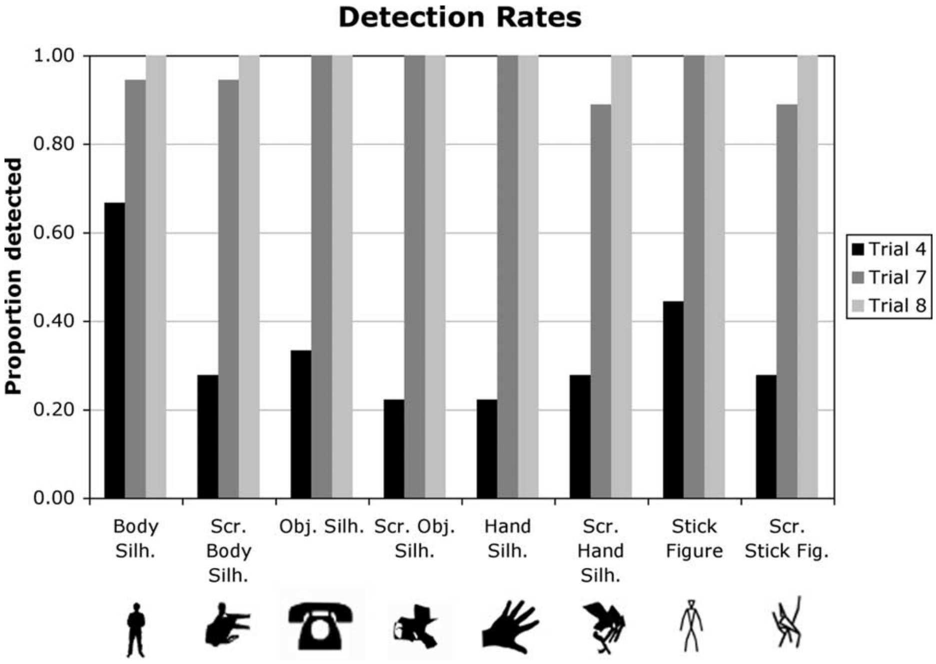

Fig. 3. Proportion of successful detections of critical stimuli in Experiment 1.

2.2.1. Detection rates

Chi-square analysis showed a significant difference among the four types of intact critical item (body silhouette, hand silhouette, object silhouette, and body stick figure) ($\chi^2(3) = 8.0, P < 0.05$) (see Fig. 3). There was no significant difference among scrambled versions of these stimuli ($\chi^2(3) = 0.2$, NS). Detection of body silhouettes was significantly greater than object silhouettes ($\chi^2(1) = 4.0$, $P < 0.05$) and greater than hand silhouettes ($\chi^2(1) = 7.2$, $P < 0.01$). Differences in detection rates were not significant for hand silhouettes compared to object silhouettes ($\chi^2(1) = 0.6$, NS) nor for body stick figures compared to scrambled body stick figures ($\chi^2(1) = 1.1$, NS).

2.2.2. Identification rates

Chi-square analysis showed a marginally significant difference among the four types of intact critical item (body silhouette, hand silhouette, object silhouette, and body stick figure) ($\chi^2(3) = 7.0$, $P < 0.10$) (see Fig. 4). There was no significant difference among scrambled versions of these stimuli ($\chi^2(3) = 0.0$, NS). Identification of body silhouettes was not significantly greater than object silhouettes ($\chi^2(1) = 2.8, P < 0.10$). There was no significant difference between hand silhouettes compared to object silhouettes ($\chi^2(1) = 0.6$, NS) nor for body stick figures compared to scrambled body stick figures ($\chi^2(1) = 0.6$, NS).

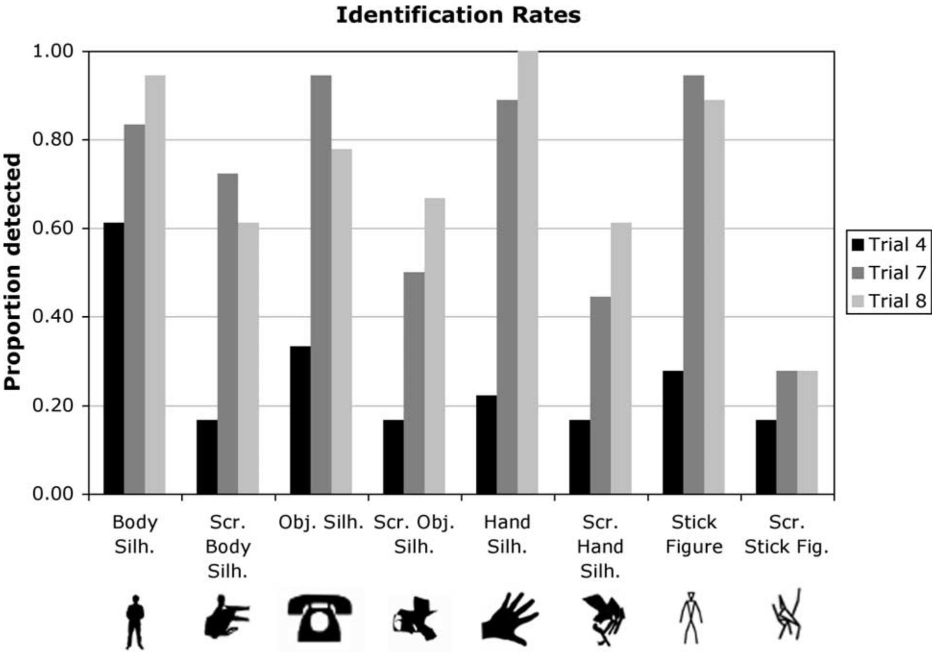

Fig. 4. Proportion of successful identifications of critical stimuli in Experiment 1.

2.3. Discussion

On trial 4, when participants had no expectation of any stimulus except the cross, detection of a body silhouette was significantly better than detection of other non-body stimuli. Correct selection of the critical stimulus was better for bodies than for objects, though this difference was only marginally significant. There were no detection differences among scrambled stimuli, suggesting that different detection rates for the intact stimuli were not due to low-level visual confounds such as complexity or surface area. Nor was there an advantage for silhouettes of hands, suggesting that the detection advantage seen for whole bodies does not extend to body parts.

We did not find a significant detection benefit for stick figures, compared to scrambled stick figures (the most appropriate control stimulus in the present study). This stands in contrast to Mack and Rock's (1998) finding of significantly reduced IB for a stick figure compared to a Christmas tree and a house. In Mack and Rock's stick figure study, unlike some of their earlier studies with geometric figures, the critical stimulus appeared at the fovea, while the cross was centred nearby, off of fixation. It may be that in the present study, the visual resolution available at the parafoveal location in which the critical stimuli appeared was not sufficient to resolve them fully. This, in turn, may have prevented the stick figures from influencing detection via top-down mechanisms.

3. Experiment 2

To test this possibility, we conducted a second experiment in which the critical stimulus appeared at the fovea, maximizing visual resolution. On each trial, the cross appeared centred at one of four randomly selected locations on a 45° diagonal from fixation. In this experiment we tested stick figures in various poses, compared to simple line drawings of common objects (see Fig. 2, lower half). Thus, in both conditions the critical stimulus was a depiction of a real object composed of line segments.

In an initial study using this paradigm ($N = 40$), we found that although the body stick figures were detected on trial 4 more often (6/20) than the object stick figures (3/20), the overall detection rate was quite low (23%). Participants reported finding the line judgement task difficult as the location of the cross was unpredictable. To provide further practice on the primary task, with the aim of raising overall detection rates, we presented four additional cross-only trials at the beginning of the study. That is, there were now 12 trials per subject, and critical stimuli were presented on trials 8, 11, and 12.

3.1. Method

3.1.1. Participants

Forty experimentally-naive volunteers participated and were compensated with candy.

3.1.2. Stimuli

Stimuli consisted of ten stick figures (those from Experiment 1, plus one addition) and ten line drawings of common objects (see Fig. 2). These drawings, like the body stick figures, were composed only of straight lines.

3.1.3. Design and procedure

Twenty participants were tested with a body stick figure as the critical stimulus on trial 8, and 20 with an object line drawing. Within each of these two groups, five participants were tested on each possible combination of stimulus types (body or object) for trials 11 and 12. Each stimulus item was used exactly twice across participants in each critical trial, with the constraint that no participant saw the same critical stimulus twice. On critical trials, the stimulus was centred at the same location as the preceding fixation point. The cross appeared centred on one of four 45° diagonals, approximately 1 cm from fixation. Cross location was selected randomly with the constraint that each quadrant was occupied three times. Participants were tested on a laptop computer in a quiet library study room. In other respects, the design and procedure were the same as Experiment 1.

3.2. Results

On the eighth trial, when the first presentation of the critical stimulus occurred, 11 of 20 participants (55%) detected the stick figure, and four of 20 (20%) successfully detected the object line drawing ($\chi^2(1) = 5.2$, $P < 0.05$). Identification rates were 15/20 for the stick figures and 8/20 for the objects ($\chi^2(1) = 5.0$, $P < 0.05$).

3.3. Discussion

When the critical stimuli appeared at fixation, participants were better able to detect body stick figures compared to object line drawings. Like silhouette images of the human body, stick figures also receive priority for attentional selection, relative to other kinds of objects. This is best seen when the critical items are presented at fovea, where the most detailed information about the stimulus is available to higher level visual mechanisms that in turn guide attention.

4. General discussion

Previous research has raised the hypothesis that those stimuli that have a distinct or specialized neural representation may also be given priority for attentional selection. Here we used the IB paradigm developed by Mack and Rock (1998) to test this hypothesis for the case of images of the human body. Because the critical data in this paradigm come from a single trial, in which the participant has no expectation of any task-irrelevant stimuli, he or she can have formed no biases about the stimulus. It is not compared to any other stimulus for that participant, so its influence on attention is "pure" in the sense that it is not measured following previous stimuli which may induce relative biases of their own.

We find that simple images of the whole human body are more likely to be detected by observers in the IB task compared to three types of controls. Detection of bodies was superior compared to scrambled versions of the critical stimuli, which preserve low-level properties such as contrast, number of pixels, etc., ruling out these factors as the basis of the effect. Detection was also superior to schematic images of non-body objects, suggesting that bodies capture attention over and above other meaningful stimuli. Finally, detection of bodies was superior to detection of hands, suggesting that bodies do not capture attention simply due to high familiarity, or to their biological nature. (It may be noteworthy that the response of the EBA to hands, as measured by fMRI, is somewhat lower than that to entire bodies, although higher than that to objects (Downing, et al., 2001).) None of the images we used contain a depiction of the face, so previous findings of attention capture by faces do not explain the present results. Finally, attention capture by stick figures appears to require the resolution of foveal vision, which may be due to the small size and fine detail of the critical stimuli in this condition.

It is not clear whether attentional priority for faces and bodies is a consequence of neural specializations for these categories. The opposite may in fact hold – perhaps domain-general mechanisms guide visual attention to faces and bodies, leading, over the course of development, to specialized focal representations of these stimuli (de Haan, Humphreys, & Johnson, 2002). But further experiments of the kind presented here, in conjunction with neurophysiological and neuropsychological evidence, will shed light on whether attentional priority and category-specific neural representations go hand-in-hand. Recent evidence for a bilateral parahippocampal region that is highly selective for images of scenes (Epstein, Graham, & Downing, 2003; Epstein & Kanwisher, 1998) may provide a third test of this hypothesis. This would likely require a modified paradigm, however, as the size and resolution of the critical stimuli tested here are insufficient to convincingly depict an entire scene.

Acknowledgements

This project was supported by BBSRC grant 5/S15293 to P. Downing. We thank Marius Peelen and Annie Chan for helpful comments on this work.

References

Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision*, *10*, 433–436.

Caramazza, A., & Shelton, J. R. (1998). Domain-specific knowledge systems in the brain the animate-inanimate distinction. *Journal of Cognitive Neuroscience*, *10*(1), 1–34.

Carmel, D., & Bentin, S. (2002). Domain specificity versus expertise: factors influencing distinct processing of faces. *Cognition*, *83*(1), 1–29.

Cohen, J. D., & Tong, F. (2001). Neuroscience. The face of controversy. *Science*, *293*(5539), 2405–2407.

de Haan, M., Humphreys, K., & Johnson, M. H. (2002). Developing a brain specialized for face perception: a converging methods approach. *Developmental Psychobiology*, *40*(3), 200–212.

Desimone, R., Albright, T. D., Gross, C. G., & Bruce, C. (1984). Stimulus-selective properties of inferior temporal neurons in the macaque. *Journal of Neuroscience*, *4*(8), 2051–2062.

Downing, P., Liu, J., & Kanwisher, N. (2001). Testing cognitive models of visual attention with fMRI and MEG. *Neuropsychologia*, *39*(12), 1329–1342.

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

Epstein, R., Graham, K. S., & Downing, P. E. (2003). Viewpoint-specific scene representations in human parahippocampal cortex. *Neuron*, *37*(5), 865–876.

Epstein, R., & Kanwisher, N. (1998). A cortical representation of the local visual environment. *Nature*, *392*(6676), 598–601.

Farah, M. J., Wilson, K. D., Drain, M., & Tanaka, J. N. (1998). What is "special" about face perception? *Psychological Review*, *105*(3), 482–498.

Fodor, J. (1983). The modularity of mind. Cambridge, MA: MIT Press.

Gauthier, I. I. (2000). What constrains the organization of the ventral temporal cortex? *Trends in Cognitive Sciences*, *4*(1), 1–2.

Grossman, E. D., & Blake, R. (2002). Brain areas active during visual perception of biological motion. *Neuron*, *35*(6), 1167–1175.

Haxby, J. V., Gobbini, M. I., Furey, M. L., Ishai, A., Schouten, J. L., & Pietrini, P. (2001). Distributed and overlapping representations of faces and objects in ventral temporal cortex. *Science*, *293*(5539), 2425–2430.

Holmes, A., Vuilleumier, P., & Eimer, M. (2003). The processing of emotional facial expression is gated by spatial attention: evidence from event-related brain potentials. *Brain Research: Cognitive Brain Research*, *16*(2), 174–184.

Jellema, T., Baker, C. I., Wicker, B., & Perrett, D. I. (2000). Neural representation for the perception of the intentionality of actions. *Brain and Cognition*, *44*(2), 280–302.

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.

Mack, A., Pappas, Z., Silverman, M., & Gay, R. (2002). What we see: inattention and the capture of attention by meaning. *Consciousness and Cognition*, *11*(4), 488–506.

Mack, A., & Rock, I. (1998). Inattentional blindness. London: MIT Press.

Mack, A., Tang, B., Tuma, R., Kahn, S., & Rock, I. (1992). Perceptual organization and attention. *Cognitive Psychology*, *24*(4), 475–501.

Malach, R., Levy, I., & Hasson, U. (2002). The topography of high-order human object areas. *Trends in Cognitive Sciences*, *6*(4), 176–184.

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.

O'Craven, K. M., Downing, P. E., & Kanwisher, N. (1999). fMRI evidence for objects as the units of attentional selection. *Nature*, *401*(6753), 584–587.

Perrett, D. I., Rolls, E. T., & Caan, W. (1982). Visual neurones responsive to faces in the monkey temporal cortex. *Experimental Brain Research*, *47*(3), 329–342.

Puce, A., Allison, T., Asgari, M., Gore, J. C., & McCarthy, G. (1996). Differential sensitivity of human visual cortex to faces, letterstrings, and textures: a functional magnetic resonance imaging study. *Journal of Neuroscience*, *16*(16), 5205–5215.

Ro, T., Russell, C., & Lavie, N. (2001). Changing faces: a detection advantage in the flicker paradigm. *Psychological Science*, *12*(1), 94–99.

Rock, I., Linnett, C. M., Grant, P., & Mack, A. (1992). Perception without attention: results of a new method. *Cognitive Psychology*, *24*(4), 502–534.

Shelton, J. R., Fouch, E., & Caramazza, A. (1998). The selective sparing of body part knowledge: a case study. *Neurocase*, *4*, 339–351.

Ungerleider, L. G., & Mishkin, M. (1982). Two cortical visual systems. In D. J. Ingle, M. A. Goodale, & R. J. W. Mansfield (Eds.), *The analysis of visual behaviour*. Cambridge, MA: MIT Press.

Vuilleumier, P. (2000). Faces call for attention: evidence from patients with visual extinction. *Neuropsychologia*, *38*(5), 693–700.

Wachsmuth, E., Oram, M. W., & Perrett, D. I. (1994). Recognition of objects and their component parts: responses of single units in the temporal cortex of the macaque. *Cerebral Cortex*, *4*(5), 509–522.

Wheaton, K. J., Pipingas, A., Silberstein, R. B., & Puce, A. (2001). Human neural responses elicited to observing the actions of others. *Visual Neuroscience*, *18*(3), 401–406.

Wojciulik, E., Kanwisher, N., & Driver, J. (1998). Covert visual attention modulates face-specific activity in the human fusiform gyrus: fMRI study. *Journal of Neurophysiology*, *79*(3), 1574–1578.