

Attentional biases for faces and body parts

Tony Ro and Ashley Friggel
Rice University, Houston, TX, USA

Nilli Lavie
University College London, UK

In four experiments, we examined whether faces and body parts are processed faster and engage attention more than other objects. Participants searched for a green among blue frames and were asked to make speeded categorical decisions on an object presented within the target frame (e.g., was it food?). On half of the trials a colour singleton (a red frame) was also present and reaction times to targets were measured as a function of the object category within the singleton. The results show that categorical judgements of faces (Experiments 1–3) and body parts (Experiment 4) in the target frame were significantly faster as compared to other object categories. Furthermore, the cost associated with presenting a face or body part in the singleton frame was greater than the cost when another type of object was in the singleton. These results suggest an attentional bias towards stimuli of sociobiological significance such as faces and body parts.

Faces and body parts are stimuli of great biological and social significance. Indeed, there is much neuroscientific evidence to suggest dedicated neural systems for the processing of faces and body parts in humans. In addition to an abundance of evidence demonstrating dedicated neuronal architecture for the processing of faces (De Renzi et al., 1994; Farah, 1996; but see Gauthier, Skudlarski, Gore, & Anderson, 2000; Haxby et al., 2001, 2001 e.g., Kanwisher, McDermott, & Chun, 1997; Yovel & Kanwisher, 2004), some recent functional magnetic resonance imaging (fMRI) studies have further suggested that, like faces, there is dedicated neural architecture that selectively responds to body parts (Downing, Jiang, Shuman, & Kanwisher,

Please address all correspondence to Tony Ro, Department of Psychology—MS 25, Rice University, 6100 Main St., Houston, TX, 77005, USA. E-mail: tro@rice.edu

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2001; Peelen & Downing, 2005). The exact reasons for the existence of these cortical visual processing modules for faces and body parts are unknown, although one might speculate that having dedicated neuronal architecture for processing biological stimuli would lead to some processing advantages.

Here we test whether faces and body parts may have a special visual processing advantage over other objects as well as a special ability to engage attention. A few behavioural studies demonstrated that faces may have an attentional advantage over other objects. Using the flicker paradigm (Rensink, 2002; Rensink, O'Regan, & Clark, 1997), Ro, Russell, and Lavie (2001) found that faces have a change detection advantage over other objects in multiple object arrays. However, this advantage for faces was completely eliminated when just one object was presented, suggesting a special role for faces in competition for visual attention. More recently, Lavie, Ro, and Russell (2003) found that distractor faces cannot be ignored even under conditions of high perceptual load that eliminate processing for other types of distractor objects. Similarly to faces and consistent with the neuroimaging results suggesting that body parts may also be special, two recent behavioural studies have shown that body parts are organized and represented differentially than other objects (Reed, McGoldrick, Shackelford, & Fidopiastis, 2004) and are detected more often than other objects in Mack and Rock's (1998) inattentive blindness paradigm (Downing, Bray, Rogers, & Childs, 2004).

In the current study, we further examine whether faces and body parts are processed differentially and engage attention more than other objects. Previous studies have shown that visual search performance (e.g., for an odd shape) is typically disrupted by the presence of a singleton distractor even when the singleton feature is completely irrelevant to the current task (e.g., a nontarget item with an odd colour, for review see Theeuwes, 1996). The previous attentional capture in visual search studies, however, typically used neutral shapes, lines, or letter stimuli. In this study, we adapted a visual search paradigm to compare search performance as well as effects of singleton costs between faces (Experiments 1–3) or body parts (Experiment 4) and other object categories (e.g., plants). Since the categories of faces and body parts may not just differ from other object categories in terms of their ability to be efficiently processed and engage attention, but also in the particular visual features they contain, we presented all of the objects within outline frames, and defined the target and singleton distractor on the basis of the frame colour (the target frame was green and the singleton frame was red, whereas the rest of the frames were blue). This manipulation allowed us to examine how faces and body parts are processed once attention has been captured or directed to the location of the stimulus of interest. In this respect, any effects of the stimulus category on the singleton cost will be

informative about how once attention is captured by a colour singleton, certain stimulus categories such as faces engage attention and influence attentional dwell time.

EXPERIMENT 1

Experiment 1 examined whether faces might be processed faster than other objects and whether they may interfere more with target processing when presented as a distractor. Figure 1 presents an example of a trial in Experiment 1. Subjects were asked to search for a green frame (among blue)

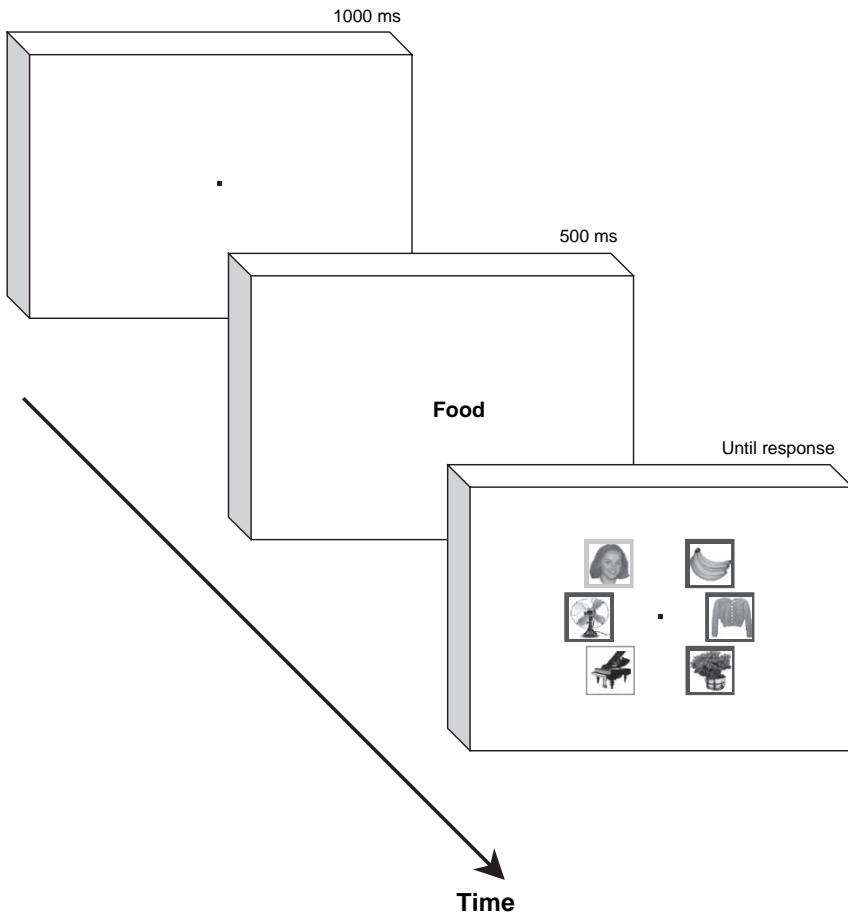


Figure 1. An example of the sequence of stimulus events on a typical trial of Experiment 1.

and indicate whether the object in that frame belonged to the category indicated by a preceding word cue (e.g., "Food"). A frame with a singleton colour (red) was also present on half of the trials. We compared effects on search response times (RTs) and accuracy between the different object categories presented in the singleton distractor (e.g., would faces produce larger singleton costs than other objects?) as well as between the different categories presented in the target frame (e.g., would faces produce a greater facilitation when in the target frame?).

Method

Participants. Eighteen subjects (five males) ranging between 18 and 33 years of age (mean = 20.9) participated in this experiment: Eight paid participants were run at the University College London; ten participants were run at Rice University, Houston, and received course credit for their participation. All participants reported normal or corrected to normal vision.

Apparatus and stimuli. The experiment was conducted on a personal computer connected to a video graphics array (VGA) monitor, set at a 640×480 pixel resolution using Borland C (Scotts Valley, CA) along with the Genus Microprogramming (Houston, TX) Graphics Kernel and PCX Toolkit. The timing of the visual displays was controlled by the vertical synchronization of the stimulus monitor at 16.67 ms intervals (60 Hz). Millisecond timing, used to obtain response latencies, was achieved by setting the 8253 chip of the computer to millisecond ticks. Responses were made on a two-button response pad connected to the gameport adapter of the computer.

A small black square (8×8 pixels) presented in the display centre was used as a fixation point. The category names were presented in black, Arial Bold 24 point font. All displays had a medium grey background. Each object in the visual search display was presented in grey-scale on a square white background that measured 3.6° of visual angle (74×74 pixels) from a viewing distance of 57 cm. Six different categories (household appliances, clothing, faces, food, musical instruments, and plants), with six exemplars in each category were used (see Appendix). These categories and stimuli were identical to those employed in a previous study (Ro et al., 2001), which provided us with some control data on some of the featural differences between the exemplars within each category. An outline frame that was 4.1° (83×83 pixels) in total width and 0.45° in line width (9×9 pixels from edge to edge) surrounded each object and was red, green, or blue.

Design and procedure. Each trial began with a fixation point displayed for 1000 ms. A word cue selected randomly and with equal probability on each trial from six category names (appliance, clothing, face, food, instrument, or plant), was then presented at the centre of the screen for 500 ms. Following the presentation of the word cue, a circular array of six objects surrounded by colour frames was presented (Figure 1). On every trial, a green target frame surrounded one of the objects. Participants were asked to search for the green target frame among blue frames and indicate, by pressing the buttons on the response pad, whether or not the visual object in the green frame was an exemplar of the category word that was presented for that trial. The target object belonged to the category of the word cue on half of the trials, and belonged to a different category on the other half of the trials. If no response was made within 2000 ms, the trial timed out and moved on to the next trial. On half of the trials, the singleton present trials, one of the nontarget frames was red. Participants were instructed to ignore this singleton as best as possible. The singleton object was selected randomly and with equal probability from the five nontarget object categories. The location of the target and singleton when it was presented was randomized across trials, but appeared in each possible position an equal number of times.

Following a practice block, which continued until the subject performed the task accurately and in a stable manner, three blocks of 160 trials each were run. There were 80 trials (40 trials for each of the yes/no category membership responses) for each of the six target categories. Since half of the trials contained a singleton, there was a total of 40 singleton trials for each target category, with 20 trials for each yes/no response.

Results

RTs. Incorrect responses (4.3%), responses faster than 100 ms or slower than 2000 ms (0.6%), and responses that were slower by more than 2 *SD* from each subject's mean (4.7%) were removed from the RT analysis (and included in the error analysis). Figure 2 shows the mean target RTs plotted as a function of the category of the visual object presented in the target frame and target (yes/no) response (top panel), as well as mean correct target RTs plotted as a function of the category of the object presented in the singleton frame and target (yes/no) response (bottom panel). Table 1 provides the mean RTs for each category collapsed across response for the singleton present and absent conditions. A three-way ANOVA of target RTs with the within-subject factors of target response (yes, no), target-object category (appliance, clothing, face, food, instrument, plant) and singleton presence (present, absent) revealed a main effect for target response, $F(1, 17) = 10.89, p < .005$: 'yes' responses (mean = 675 ms) were faster than

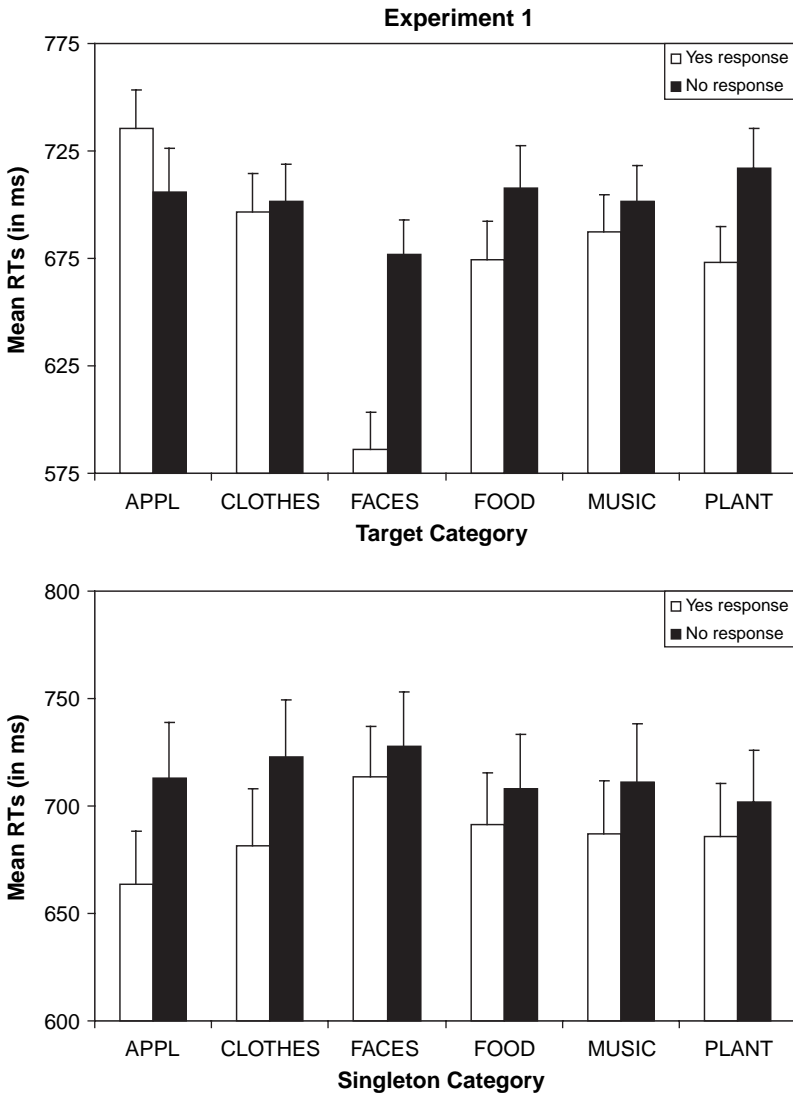


Figure 2. Top half: The mean RTs across subjects for the different target categories used in Experiment 1. Bottom half: The mean RTs, coded by singleton category, on singleton present trials. White bars indicate the RTs on 'yes' response trials; black bars indicate RTs on 'no' response trials.

'no' responses (mean = 702 ms). There was also a main effect of target object category, $F(5, 85) = 33.21$, $p < .001$. F -contrasts revealed that responses were faster when the target object was a face (mean = 631 ms) as compared to the other objects combined (mean = 700 ms), $F(1, 17) = 142.01$, $p < .001$. RTs to

TABLE 1
The mean RTs (top) and percentage of errors (bottom) in Experiment 1

		<i>Appliance</i>	<i>Clothing</i>	<i>Faces</i>	<i>Food</i>	<i>Music</i>	<i>Plant</i>
Target category RTs							
Singleton	Present	726.9	715.5	642.1	708.4	710.8	705.3
	Absent	714.3	682.4	620.7	673.4	678.0	684.8
Errors							
Target	Yes response	11.8	7.6	6.7	8.6	9.3	9.4
	No response	10.4	7.2	6.4	12.2	8.9	9.3
	Mean	11.1	7.4	6.5	10.4	9.1	9.4
Singleton	Yes response	10.3	10.6	11.1	12.2	10.8	6.4
	No response	9.4	12.2	13.3	9.7	8.9	8.6
	Mean	9.8	11.4	12.2	11.0	9.8	7.5

For the error data, target categories are averaged over singleton present and absent trials (middle rows) and singleton categories in singleton present trials averaged over target category (lower rows).

targets of the five nonface object categories were either significantly slower (appliance and clothing) or no different (food, instrument, and plant) than the combined means of the other categories.

A significant interaction between target response and target object, $F(1, 17) = 17.10$, $p < .001$, showed that the effect of response was different between the target objects. As can be seen in Figure 2, although 'no' responses were slower than 'yes' responses for most objects, the reverse pattern was found for appliances. In addition, the difference between 'yes' and 'no' responses was greater for faces than for the other objects. In other words, although the face advantage remained significant both in the 'yes' responses (these were fastest when the target object was a face, mean = 586 ms, compared to other objects, mean = 693 ms), $F(1, 17) = 153.92$, $p < .001$, and in the 'no' responses (subjects were faster to reject faces as not belonging to the category indicated by the word cue, mean = 677 ms, as compared to other objects, mean = 707 ms), $F(1, 17) = 17.82$, $p < .001$, the face advantage was greater in the 'yes' than in the 'no' responses. There were no other significant interactions, all $F_s < 1.1$. These findings indicate a classification advantage for faces, and support the claim that face recognition may be special (Farah, 1996).

In line with previous attentional capture findings (e.g., Theeuwes, 1994), there was also a main effect of singleton presence. RTs were slower when a colour singleton was present (mean = 701 ms) than when it was absent (mean = 676 ms), $F(1, 17) = 30.43$, $p < .001$. To further examine the singleton effect we entered target RTs in the singleton present trials into a two-way ANOVA with the within-subject factors of target response (yes, no)

and singleton category (appliance, clothing, face, food, instrument, plant; see Figure 2, bottom panel). This ANOVA showed a main effect of target response, $F(1, 17) = 8.94$, $p < .01$, again reflecting faster 'yes' responses (mean = 687 ms) than 'no' responses (mean = 714 ms). There was also a main effect of singleton category, $F(5, 85) = 2.56$, $p < .05$. F -contrasts revealed that target responses were slower when the singleton was a face (mean = 721 ms) as compared to other objects combined (mean = 697 ms), $F(1, 17) = 9.72$, $p < .01$. When the five nonface singleton categories were compared to the other combined singleton categories, only appliances were marginally faster (unlike faces, which were slower when in the singleton) than the other objects, $F(1, 17) = 3.81$, $p = .07$, all other F s < 1 , all p s $> .30$. The interaction between response and singleton category was not significant, $F(1, 17) = 1.49$, $p = .20$.

It might be that the stronger singleton effect for faces may have simply been due to the fact that there were faster responses when the targets were faces, and when the faces were the singleton category, the target objects could not also be a face. To address this issue, we conducted an additional analysis comparing RTs in the presence of a face singleton to RTs in the presence of a nonface singleton, excluding trials on which faces (the fastest category) and appliances (the slowest category) were targets.¹ Face singletons still produced the slowest responses in this analysis (mean = 721 ms for faces vs. mean = 706 ms for other objects), although this effect reached only marginal significance, one-tailed $t(17) = 1.53$, $p = .07$. Note that since faces as targets were processed *faster* than all of the other categories, the exact magnitude of this attentional engagement effect as measured by amount of *slowing* from faces may have been underestimated by their faster processing. For a purer measure of the category effects on singleton cost, we therefore conducted another analysis in which the differential target processing times for each category was factored into the singleton costs. This was achieved by taking the singleton RTs from the last analysis that does not include the fastest and slowest categories, and subtracting from the singleton RTs the target processing RTs for each category in each subject. This analysis confirmed that faces when in the singleton produced a highly significant delay on target processing as compared to the other objects, one-tailed $t(17) = 7.89$, $p < .001$. The singleton cost for faces (100 ms) was five times larger than the singleton cost for the other objects combined (20 ms). Thus, attention was clearly engaged much more by faces than other objects.

¹ We excluded the slowest category in addition to the fastest category in order to get mean RTs that are not biased towards either end of the RT range (i.e., excluding just the fastest category naturally results in slower overall RTs, and this masks the effects of singleton costs).

Errors. The error analysis included incorrect button presses, responses faster than 100 ms or 2 *SD* from the mean, and responses slower than 2000 ms or 2 *SD* from the mean. All of these types of errors were included in one error analysis as we expected that a face in the singleton frame would induce more incorrect button press responses and exceedingly slower RTs than the other categories. An ANOVA of the error rates with the factors of target response, target category, and singleton presence revealed a significant main effect of target category, $F(5, 85) = 5.73, p < .001$. As can be seen in Table 1, the error rates for determining whether or not a face belonged to the cued category were less than for determining exemplars from other categories, $F(1, 17) = 14.49, p < .001$, replicating the classification advantage found in the RTs. A similar classification advantage in accuracy was also found when an item of clothing was presented in the target frame as compared with the mean errors for all of the other categories of target object, $F(1, 17) = 7.71, p < .02$. No such advantage was found for any of the other object categories, with similar accuracy rates for the music and plant categories in comparison to the other object categories, both $F_s < 1$, or significantly more errors for the appliance and food categories in comparison to the others, $F(1, 17) = 6.27, p < .05$, and $F(1, 17) = 5.53, p < .05$, respectively. The main effect of target response and all of the interactions did not approach significance, all $p_s > .10$.

The error ANOVA also showed a significant main effect of singleton presence, $F(1, 17) = 17.43, p < .01$. There were more errors when a singleton was present than when it was absent. However, a two-way ANOVA of the errors in the singleton present trials with the within-subject factors of singleton category (six levels) and target response (two levels) only found a marginally significant main effect of singleton category, $F(5, 85) = 2.25, p = .056$. Thus, differences in singleton category were not sufficiently robust to produce significant effects in the errors. The main effect of target response and the target response by singleton category interaction did not approach significance either, both $p_s > .10$.

Discussion

Experiment 1 provides support for the hypothesis that faces are processed faster and that they engage and/or hold attention more than other objects. In addition to a classification advantage for faces versus other objects, a result that may be attributed to a perceptual advantage in face recognition (Farah, Wilson, Drain, & Tanaka, 1998), faces also produced the largest cost to performance when presented within an irrelevant singleton object. Interestingly, the category of clothes produced similar effects on error rates as those of faces, although the effects of the clothes and faces on RTs were

unrelated. This similarity in the error data between faces and clothes may have been due to our use of clothes pictures that appeared as dressed up body parts (e.g., see Figure 1), which have recently been suggested to have dedicated neuronal architecture for their processing and possibly a special status in the perceptual and attentional systems. We further and more directly pursue the role of body parts in engaging and biasing attention in Experiment 4.

One somewhat peculiar finding in this experiment was that the appliance category produced results that were more or less opposite to those that were obtained for faces. Namely, responses to appliance targets were significantly slower than the other categories combined, and responses to targets when appliances were presented in a singleton frame were significantly faster than other singleton categories combined. It therefore might be argued that the attentional biasing effects that we measured with faces may have been due to the inclusion of a category that was less attention engaging than others² or less typical of a category than the other categories used. To rule out this possibility, we conducted a further analysis that excluded the appliance category. This analysis still showed that faces were significantly faster to respond to when in the target frame, $F(1, 17) = 140.40$, $p < .001$, and produced significantly slower target responses when presented in the singleton frame, $F(1, 17) = 7.65$, $p < .02$. To further rule out any possible contributions from some of the other categories on the face effects, as well as to determine whether similarity in visual features across exemplars might be producing these faster processing and attentional biasing effects of faces, Experiment 2 replaced four out of the six categories that contained visually dissimilar exemplars, including the appliance category.

EXPERIMENT 2

In the previous experiment the face exemplars were more visually similar to each other than the exemplars within each of the other categories (e.g., a telephone vs. a blender are highly dissimilar exemplars of the appliance category in comparison to two different faces in the face category). Although it is hard to explain the face associated singleton cost in terms of their greater within-category homogeneity, this difference along with the opposite effects of the appliance category could explain the face classification advantage when in the target. Experiment 2 sought to examine whether the faster processing times and potential attentional biases towards faces can be replicated when faces are compared with other highly homogenous categories of objects.

² We thank an anonymous reviewer for alerting us to this possibility.

Method

Participants. Eighteen subjects from Rice University (seven females) ranging between 18 and 25 years of age (mean = 19.7) participated in this experiment in exchange for course credit. All reported having normal or corrected to normal vision.

Apparatus, stimuli, procedures, and design. The apparatus, procedures, and design were all identical to the previous experiment. The only changes in the stimuli were the categories that were used. In this experiment, automobiles, birds, chairs, dogs, faces, and plants were the six categories that were used in this experiment, with each category containing six exemplars that were randomly selected on each trial.

Results

RTs. Incorrect responses (3.6%), responses faster than 100 ms or slower than 2000 ms (0.4%), and responses that were slower by more than 2 *SD* from each subject's mean (4.7%) were removed from the RT analysis (and included in the error analysis). Figure 3 shows the mean correct target RTs plotted as a function of the category of the visual object presented in the target frame and target (yes/no) response (top panel), as well as mean correct target RTs plotted as a function of the category of the object presented in the singleton frame and target (yes/no) response (bottom panel). Table 2 provides the mean RTs for each category collapsed across response for the singleton present and absent conditions. A three-way within-subject ANOVA with the factors of target response (yes, no), target category (automobile, birds, chairs, dogs, faces, and plants), and singleton presence (present, absent) was conducted on the mean correct RTs. This ANOVA, revealed a significant main effect of target response, with faster RTs for 'yes' (mean = 569 ms) compared to 'no' (mean = 608 ms) responses, $F(1, 17) = 21.33, p < .001$, as in Experiment 1. The main effect of target object category was significant, $F(5, 85) = 10.66, p < .001$. *F*-contrasts again revealed faster responses when the target object was a face (mean = 563 ms) as compared to the other objects combined (mean = 593 ms), $F(1, 17) = 46.98, p < .001$. All other categories were either significantly slower than the other combined object categories or showed no significant difference.

Again there was an interaction of object category by response, $F(5, 85) = 6.16, p < .001$. However, in this experiment 'no' responses were slower than 'yes' responses for all target objects, and the interaction reflected a greater difference between the object categories in the 'yes' responses than in the 'no' responses. The face advantage was greater and statistically significant in the 'yes' responses (fastest when the target object was a face, mean =

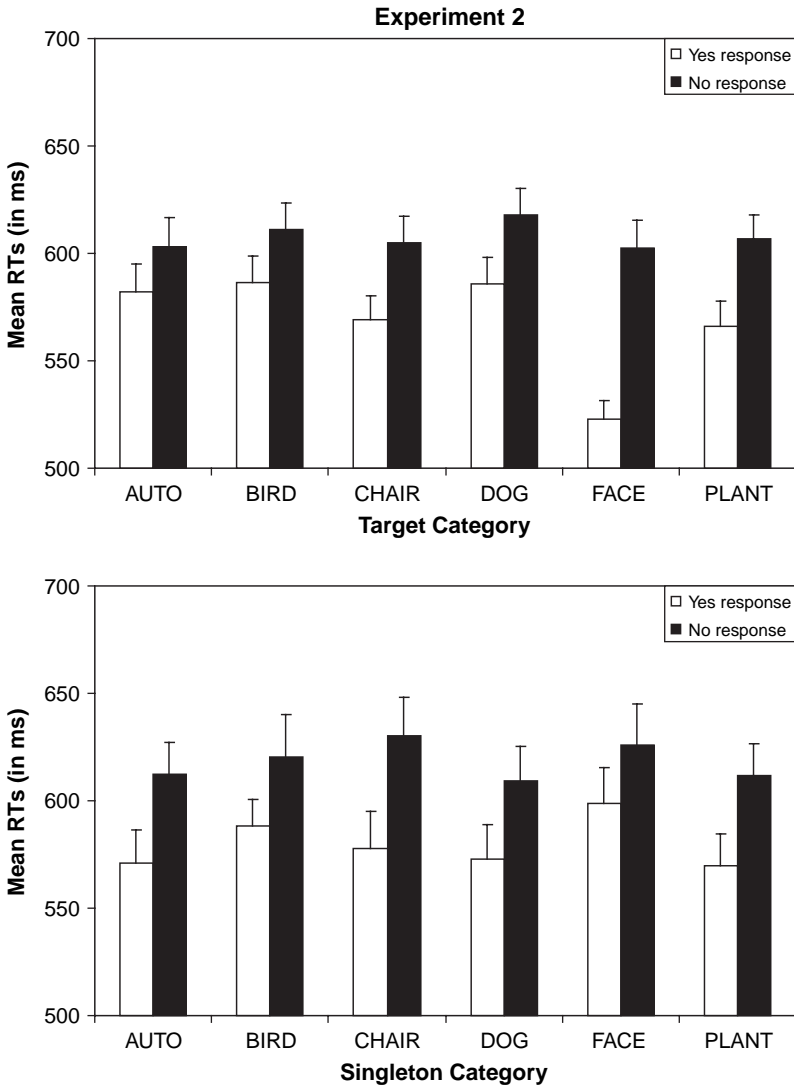


Figure 3. Top half: The mean RTs across subjects for the different target categories used in Experiment 2. Bottom half: The mean RTs, coded by singleton category, on singleton present trials. White bars indicate the RTs on 'yes' response trials; black bars indicate RTs on 'no' response trials.

523 ms, compared to other objects, mean = 578 ms), $F(1, 17) = 47.31$, $p < .001$, but not in the no responses in this experiment (603 ms for faces vs. 609 ms for other objects), $F < 1$. There were no other interactions, all F s < 1 .

TABLE 2
The mean RTs (top) and percentage of errors (bottom) in Experiment 2

		<i>Auto</i>	<i>Bird</i>	<i>Chair</i>	<i>Dog</i>	<i>Face</i>	<i>Plant</i>
Target category RTs							
Singleton	Present	606.3	610.0	598.9	612.9	570.1	596.6
	Absent	579.2	587.2	575.2	590.6	555.0	576.5
Errors							
Target	Yes response	8.2	9.3	7.1	7.1	6.8	8.2
	No response	8.9	11.4	10.97	8.5	9.2	9.2
	Mean	8.6	10.4	9.0	7.8	8	8.7
Singleton	Yes response	9.4	8.3	10.6	8.1	9.7	7.5
	No response	11.1	8.1	10.6	9.2	11.7	9.4
	Mean	10.2	8.3	10.6	8.6	10.7	8.4

For the error data, target categories are averaged over singleton present and absent trials (middle rows) and singleton categories in singleton present trials averaged over target category (lower rows).

Importantly, the ANOVA also showed a significant main effect of singleton presence. As in Experiment 1, RTs were slower when an irrelevant singleton was present (mean = 599 ms) as compared to when a singleton was absent (mean = 577 ms), $F(1, 17) = 31.14$, $p < .001$. To further examine this singleton effect, a two-way ANOVA was conducted on the RTs with the factors of target response and singleton category (see Figure 3 bottom panel). This ANOVA revealed a significant main effect of target response, $F(1, 17) = 20.96$, $p < .001$, again reflecting faster 'yes' (mean = 580 ms) than 'no' (mean = 618 ms) responses. The main effect of singleton object category was significant, $F(5, 85) = 2.75$, $p = .02$, with faces producing the slowest responses when in the singleton frame (mean = 612 ms for the faces vs. mean = 596 ms for the other objects), $F(1, 17) = 5.16$, $p = .036$. The comparisons between the five nonface singleton categories vs. the other combined categories showed no statistical differences, all F s < 1.65 , ns , or in the case of the dogs and plants categories, effects that approached significance in the opposite direction (i.e., faster when dogs or plants were in the singleton), both p s = .08. The interaction was not significant, $F(5, 85) = 1.01$, ns . As this experiment showed very similar results to the first experiment despite using object categories that were more homogenous than in Experiment 1, this replication clearly shows that attentional biases for faces do not depend on the factor of within-category homogeneity.

As in Experiment 1, the stronger singleton effect for faces may have simply been due to the fact that there were faster responses when the targets were faces, and when the faces were the singleton category, the target objects could not also be a face. An additional analysis was therefore performed that

excluded trials on which faces (the fastest category) and dogs (the slowest category) were excluded (see footnote 1). Without the face target and dog target trials, the slowing by the face singletons (mean = 612 ms) when compared to the other combined categories (mean = 603 ms) was no longer significant, one-tailed $t(17) = 1.25$, $p = .11$. As described for Experiment 1, however, the singleton costs for faces may have been counteracted by the faster processing times for faces in the singleton. We therefore conducted a further analysis in which the differential target processing times for each category was factored into the singleton costs by subtracting from the singleton RTs the target processing RTs for each category in each subject. This analysis further confirmed that faces when in the singleton produced a highly significant delay on target processing as compared to the other objects, $t(17) = 3.50$, $p < .005$. The singleton cost for faces (56 ms) was nearly three times larger than the singleton cost for the other objects combined (21 ms). Thus, attention was engaged more by faces than these other objects.

Errors. Error analysis included incorrect button presses, RTs faster than 100 ms or 2 *SD* from the mean, as well as RTs slower than 2000 ms or 2 *SD* from the mean. The mean error rates are presented in Table 2. An ANOVA of the errors with the factors of target response, target category, and singleton presence revealed a significant main effect of singleton presence, with more errors for singleton present trials (10.7%) than for singleton absent trials (8.7%), $F(1, 17) = 7.05$, $p < .02$. The Singleton presence \times Target category interaction was marginally significant, $F(1, 17) = 2.256$, $p = .056$. None of the other main effects or interactions approached significance, all $ps > .10$. To further examine this effect of singleton presence, an ANOVA with the factors of singleton category and target response was computed on the error rates for singleton present trials. However, the main effects of target response and singleton category, and their interaction, did not approach significance, all $ps > .15$.

Discussion

The results from Experiment 2 demonstrate again that faces are classified faster than other objects and may have produce more interference when presented as a singleton distractor. As this experiment showed very similar results to the first experiment despite using object categories that were more homogenous than in Experiment 1, this replication clearly shows that the efficient processing and attentional biases for faces do not depend on the factor of within-category homogeneity. To determine whether some feature or property of faces as compared to the other object categories is

responsible for the observed effects, Experiment 3 examined performance in this task using inverted objects and faces.

EXPERIMENT 3

The effects of faces on attention, as assessed through the previous experiments, suggests that there may be some visual property of the faces that causes them to engage attention. In Experiment 3 we attempted to clarify the nature of this effect further. Specifically, we attempted to determine whether the visual property of faces that results in their classification advantage and in the greater singleton cost is related to mere detection of the face as a face or whether it is related to higher level visual processing involving recognition of the face identity. For example, one might attribute the greater singleton cost with the faces to a greater attentional engagement on the faces simply because processing of face identity might be more interesting than processing the token identity for each of the other categories (e.g., each bird or plant identity), and hence faces were able to maintain attention for longer. We therefore asked in Experiment 3 whether inverted faces might induce similar effects as the upright faces used in the previous experiments. Face inversion is known to disrupt face recognition (Farah, Wilson, Drain, & Tanaka, 1995; Yin, 1969; Yovel & Kanwisher, 2004), but should not affect face detection. Thus, if the effects of the faces on attention in Experiments 1 and 2 arise from high level processing of the faces involving recognition of face identity, the effect should no longer be found with inverted faces. If, however, the effects arise on the basis of detection of the faces as such, then the effects of faces on attention may remain even when these are inverted. This study was therefore identical to Experiment 1 except that all of the stimuli were inverted by rotating each image by 180 degrees.

Method

Participants. Sixteen subjects from Rice University (eight males) ranging between 18 and 22 years of age (mean = 19.6) participated in this experiment in exchange for course credit. All reported having normal or corrected to normal vision.

Apparatus, stimuli, procedures, and design. The apparatus, procedures, and design were all identical to Experiment 1. The only change in the stimuli was a 180 degree inversion.

Results

RTs. Incorrect responses (5.8%), responses faster than 100 ms or slower than 2000 ms (0.7%), and responses that were slower by more than 2 *SD* from each subject's mean (3.8%) were removed from the RT analysis (and included in the error analysis). Figure 4 shows the mean correct target RTs plotted as a function of the category of the visual object presented in the target frame and target (yes/no) response (top panel), as well as mean correct target RTs plotted as a function of the category of the object presented in the singleton frame and target (yes/no) response (bottom panel). Table 3 provides the mean RTs for each category collapsed across response for the singleton present and absent conditions. A three-way within-subject ANOVA with the factors of target response (yes, no), target category (appliance, automobile, body parts, food, instrument, plant), and singleton presence (present, absent) was conducted on the mean correct RTs. This ANOVA revealed a significant main effect of target response, with marginally faster RTs for 'yes' (mean = 682 ms) compared to 'no' (mean = 694 ms) responses, $F(1, 15) = 4.16, p = .059$. The main effect of target object category was significant, $F(5, 75) = 29.50, p < .001$. *F*-contrasts revealed faster responses when the target object was an inverted face (mean = 634 ms) as compared to other objects (mean = 699 ms), $F(1, 15) = 139.28, p < .001$. The comparisons for each of the nonface categories with the combined other categories showed no significant differences or, for the case of the appliance, musical instrument, and plant categories, significantly slower responses, all $F_s > 5.18, p < .05$. Except for an interaction of object category by response, $F(5, 75) = 12.03, p < .001$, which indicated that slowing by 'no' (vs. 'yes') responses was only found for some object categories but not others, there were no other interactions, all $F_s < 1$.

Importantly, the ANOVA also showed a significant main effect of singleton presence; RTs were slower when an irrelevant singleton was present (mean = 693 ms) as compared to when a singleton was absent (mean = 683), $F(1, 15) = 10.37, p < .01$. To further examine this singleton effect, a two-way ANOVA was conducted on the RTs with the factors of target response and singleton category (see Figure 4 bottom panel). This ANOVA revealed a significant main effect singleton object category, $F(5, 75) = 3.6, p < .01$, as inverted faces were the slowest singleton category (713 ms for the faces vs. mean = 689 ms for the other objects combined), $F(1, 15) = 6.92, p = .20$. Apart from appliances and food, which were the fastest singleton categories, $F(1, 15) = 8.40, p = .01$, and $F(1, 15) = 3.78, p = .07$, respectively, none of the other objects showed a singleton cost in comparison of their means to the rest of the other objects combined, all $F_s < 1.82, ns$. The interaction was not significant, $F < 1$.

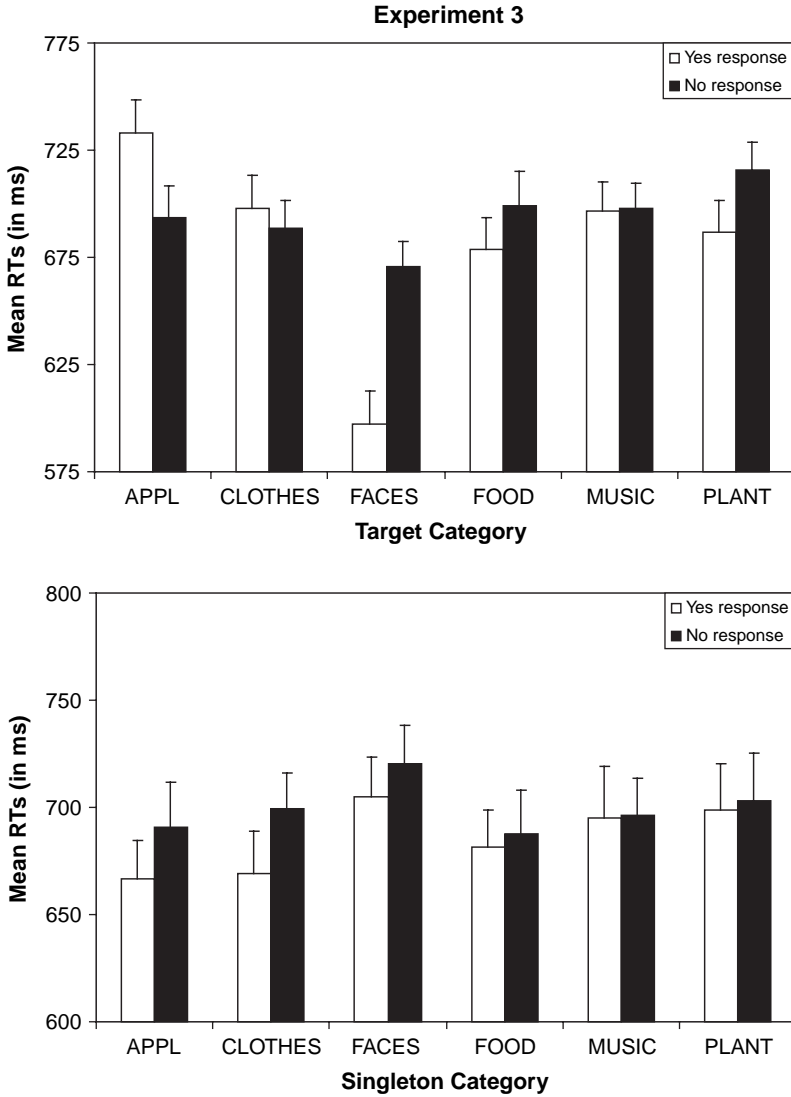


Figure 4. Top half: The mean RTs across subjects for the different target categories used in Experiment 3. Bottom half: The mean RTs, coded by singleton category, on singleton present trials. White bars indicate the RTs on ‘yes’ response trials; black bars indicate RTs ‘on’ no response trials.

As in the first two experiments, the stronger singleton effect for inverted faces may have been due to the faster responses when the targets were faces, and when the faces were the singleton category, the target objects could not also be a face. To circumvent this concern, we conducted an additional

TABLE 3
The mean RTs (top) and percentage of errors (bottom) in Experiment 3

		<i>Appliance</i>	<i>Clothes</i>	<i>Faces</i>	<i>Food</i>	<i>Music</i>	<i>Plant</i>
Target category RTs							
Singleton	Present	717.3	693.9	640.6	699.3	707.8	699.2
	Absent	709.3	692.7	627.3	678.1	686.7	703.0
Errors							
Target	Yes response	13.6	10.9	6.1	11.7	12.0	11.1
	No response	9.7	8.6	8.4	12.2	12.0	10.5
	Mean	11.6	9.8	7.2	12.0	12.0	10.8
Singleton	Yes response	10.6	12.2	14.4	10.0	13.1	13.1
	No response	10.0	13.1	14.7	9.1	10.6	11.6
	Mean	11.3	12.6	14.6	9.5	11.8	12.4

For the error data, target categories are averaged over singleton present and absent trials (middle rows) and singleton categories in singleton present trials averaged over target category (lower rows).

analysis comparing RTs in the presence of a face singleton to RTs in the presence of a nonface singleton excluding trials on which faces (the fastest category) and appliances (the slowest category) were targets (see footnote 1). Face singletons still produced the slowest responses in this analysis (mean = 717 ms for faces vs. mean = 698 ms for the other objects), one-tailed $t(15) = 1.68$, $p = .055$. However, this marginally significant singleton cost for inverted faces may have been counteracted by the faster processing times for faces in the singleton. A further analysis was therefore conducted in which the differential target processing times for each category was factored into the singleton costs by subtracting from the singleton RTs the target processing RTs for each category in each subject. This analysis further confirmed that inverted faces when in the singleton produced a highly significant delay on target processing as compared to the other objects, one-tailed $t(15) = 5.37$, $p < .001$. The singleton cost for faces (90 ms) was more than 20 times larger than the singleton cost for the other objects combined (4 ms). Thus, attention was engaged more by faces than these other objects.

Errors. Error analysis included incorrect button presses, RTs faster than 100 ms or 2 *SD* from the mean, as well as RTs slower than 2000 ms or 2 *SD* from the mean. The mean error rates are presented in Table 3. An ANOVA of the errors with the factors of target response, target category, and singleton presence revealed a significant main effect for target category, $F(5, 75) = 4.68$, $p < .001$. This reflected the same pattern of results as the RT data, with the smallest number of errors for the faces followed by clothing. The singleton presence main effect was also significant, $F(1, 15) = 17.92$, $p < .001$, showing more errors when a singleton was present (11.9%) than absent

(9.3%). Neither the main effect of target response nor any of the interactions approached significance, all $ps > .10$.

To further examine this effect of singleton presence, an ANOVA with the factors of singleton category and target response was computed. This ANOVA showed a marginally significant main effect of singleton category, $F(1, 15) = 2.00$, $p < .09$, with face singletons producing the largest percentage of errors as compared to the other categories combined, $F(1, 15) = 9.15$, $p < .01$. The main effect of target response and the Response \times Singleton category interaction did not approach significance, both $ps > .5$.

Discussion

The results from Experiment 3 suggest that the effects of faces on classification speed and on attention in our experiments arise from a lower level visual processing that allows for detection of the faces as faces, rather than from a higher level process involving recognition of the face identity. Recognition of face identity is known to be disrupted by face inversion but the effects of faces in our tasks were clearly found even with inverted faces. This may not be surprising given that our category classification task required subjects to merely discriminate faces from other categories of objects rather than the recognition of face identity. The findings of this experiment concur with previous findings that both the N170 face-related event-related potential (ERP) component (Bentin et al., 1996) and activation of the fusiform face area by faces as measured with fMRI (Kanwisher, Tong, & Nakayama, 1998) are present, albeit to a lesser extent (Yovel & Kanwisher, 2004), even with inverted faces. Interestingly our findings indicate that in order to cause a greater distraction and dwelling of attention, it is sufficient to detect that a face is present, even when it is inverted.

EXPERIMENT 4

This experiment examined whether body parts may show a classification advantage and are more attention capturing than other types of objects in the absence of competition with faces. Our findings regarding clothing, which can be conceived of as being dressed up body parts in Experiment 1, together with recent findings that the brain may contain an area that specializes in processing of body parts (Downing et al., 2001) and that body parts suffer from less inattention blindness than other objects (Downing et al., 2004), were encouraging for this hypothesis. This experiment was identical to Experiment 1 except that we replaced the category of clothes with undressed body parts, and the category of faces with cars.

Method

Participants. Sixteen subjects from Rice University (three males) ranging between 18 and 25 years of age (mean = 19.6) participated in this experiment in exchange for course credit. All reported having normal or corrected to normal vision.

Apparatus, stimuli, procedures, and design. The apparatus, procedures, and design were all identical to Experiment 1. The only changes in the stimuli were replacing the clothing items with body parts (e.g., a picture of a hand) and the faces with cars. In addition, as three of the food items used in Experiment 1 resembled body parts (e.g., the eggplant resembled a torso due to their shape similarity), these food items were replaced with different fruits and vegetables.

Results

RTs. Incorrect responses (6.1%), responses faster than 100 ms or slower than 2000 ms (0.7%), and responses that were slower by more than 2 *SD* from each subject's mean (3.8%) were removed from the RT analysis (and included in the error analysis). Figure 5 shows the mean correct target RTs plotted as a function of the category of the visual object presented in the target frame and target (yes/no) response (top panel), as well as mean correct target RTs plotted as a function of the category of the object presented in the singleton frame and target (yes/no) response (bottom panel). Table 4 provides the mean RTs for each category collapsed across response for the singleton present and absent conditions. A three-way within-subject ANOVA with the factors of target response (yes, no), target category (appliance, automobile, body parts, food, instrument, plant), and singleton presence (present, absent) was conducted on the mean correct RTs. This ANOVA revealed a significant main effect of target response, with faster RTs again for 'yes' (mean = 674 ms) compared to 'no' (mean = 698 ms) responses, $F(1, 15) = 6.58, p < .05$. The main effect of target object category was significant, $F(5, 75) = 8.00, p < .001$. *F*-contrasts revealed faster responses when the target object was a body part (mean = 661 ms) as compared to other objects (mean = 691 ms), $F(1, 15) = 31.94, p < .001$. The comparisons for each of the nonbody categories with the combined other categories showed no significant differences or, for the case of the appliance and food categories, a trend for significantly slower responses. Except for an interaction of object category by response, $F(5, 75) = 4.72, p < .001$, which indicated that slowing by 'no' (vs. 'yes') responses was only found for some object categories but not others, there were no other interactions, all *F*s < 1.

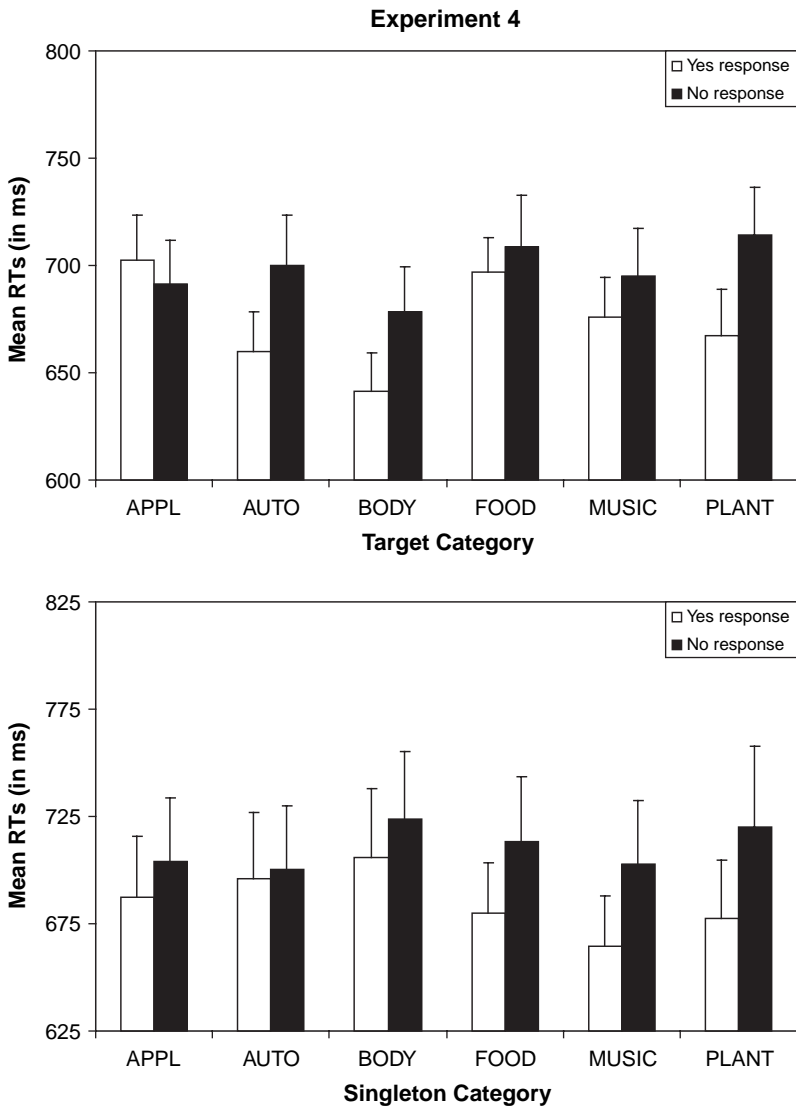


Figure 5. Top half: The mean RTs across subjects for the different target categories used in Experiment 4. Bottom half: The mean RTs, coded by singleton category, on singleton present trials. White bars indicated the RTs on 'yes' response trials; black bars indicate RTs on 'no' response trials.

Importantly, the ANOVA also showed a significant main effect of singleton presence; RTs were slower when an irrelevant singleton was present (mean = 697 ms) as compared to when a singleton was absent (mean = 675), $F(1, 15) = 26.10$, $p < .001$. To further examine this singleton

TABLE 4
The mean RTs (top) and percentage of errors (bottom) in Experiment 4

		<i>Appliance</i>	<i>Auto</i>	<i>Body part</i>	<i>Food</i>	<i>Music</i>	<i>Plant</i>
Target category RTs							
Singleton	Present	706.9	686.2	671.4	716.9	694.0	705.9
	Absent	686.9	673.8	648.9	688.5	677.1	675.4
Errors							
Target	Yes response	10.6	7.8	9.4	13.1	12.2	6.9
	No response	10.2	9.4	9.4	15.9	11.7	11.1
	Mean	10.4	8.6	9.4	14.5	12.0	9.0
Singleton	Yes response	10.9	13.1	14.1	10.3	10.0	14.1
	No response	12.5	17.2	10.3	12.5	13.8	7.5
	Mean	11.7	15.2	12.2	11.4	11.9	10.8

For the error data, target categories are averaged over singleton present and absent trials (middle rows) and singleton categories in singleton present trials averaged over target category (lower rows).

effect, a two-way ANOVA was conducted on the RTs with the factors of target response and singleton category (see Figure 5 bottom panel). This ANOVA revealed a significant main effect of target response, $F(1, 15) = 8.83, p < .01$, again reflecting faster 'yes' (mean = 685 ms) than 'no' (mean = 711 ms) responses. Although the main effect of singleton object category was not significant, $F(5, 75) = 1.71, p = .14$, body parts were the slowest singleton category (mean = 715 ms for the body parts vs. mean = 695 ms for the other objects combined), $F(1, 15) = 5.85, p = .03$. Apart from musical instruments, which was the fastest singleton category, $F(1, 15) = 5.70, p = .03$, none of the other objects showed a singleton cost in comparison of their means to the rest of the other objects combined, all $F_s < 1$. The interaction was not significant either, $F(5, 75) = 1.8, p = .13$.

As in Experiments 1–3, an additional analysis was performed excluding trials with body parts (the fastest category) and food (the slowest category) targets from all other singleton conditions (see footnote 1). In this analysis, body part singletons still produced the slowest responses in comparison to the other categories combined (712 ms vs. 689 ms), but this difference just missed significance, one-tailed $t(15) = 1.59, p = .06$. As the singleton costs for body parts may have been underestimated by the faster processing times for body parts, we conducted a further analysis in which the differential target processing times for each category was factored into the singleton costs by subtracting from the singleton RTs the target processing RTs for each category in each subject. This analysis further confirmed that body parts when in the singleton produced a highly significant delay on target processing as compared to the other objects, one-tailed $t(15) = 3.40, p < .005$. The singleton cost for body parts (63 ms) was more than twice as large

as the singleton cost for the other objects combined (17 ms). Taken together, these RT results demonstrate that body parts are classified faster than other objects and are more engaging when presented as a singleton distractor.

Errors. Error analysis included incorrect button presses, RTs faster than 100 ms or 2 *SD* from the mean, as well as RTs slower than 2000 ms or 2 *SD* from the mean. The mean error rates are presented in Table 4. An ANOVA of the errors with the factors of target response, target category, and singleton presence revealed a trend for a significant main effect of target response, with more errors for 'no' (11.3%) than 'yes' (10.0%) responses, $F(1, 15) = 3.75$, $p = .07$, consistent with the RT data. There was also a significant main effect for target category, $F(5, 75) = 5.71$, $p < .001$. However, this did not reflect the same pattern of results as the RT data; the smallest number of errors was found for the automobile and plant categories (body part error rates was the third smallest number). The singleton presence main effect was also significant, $F(1, 15) = 13.30$, $p < .005$, showing more errors when a singleton was present (12.2%) than absent (9.1%). None of the interactions approached significance, all $ps > .15$.

To further examine this effect of singleton presence, an ANOVA with the factors of singleton category and target response was computed. This ANOVA showed a marginally significant main effect of singleton category, $F(1, 15) = 2.15$, $p < .07$, and a significant Target response \times Singleton category interaction, $F(5, 75) = 3.35$, $p < .01$, but the main effect of target response did not approach significance, $p > .15$.

Discussion

This experiment showed that body parts, like faces, can be rapidly and efficiently processed and may bias and engage the attentional system more than other types of objects. These results, in conjunction with other recent findings demonstrating the differential processing of body parts as compared to other objects (Downing et al., 2004; Reed et al., 2004), suggest that body parts may be of special interest to the visual system. Although the results for some of the categories in this experiment differed from those obtained in Experiment 1 (e.g., food targets were marginally slower than the other categories), overall the pattern of results were similar (e.g., appliances were marginally slower than the other categories) and any minor differences may have been a consequence of the inclusion of different categories between the two experiments and the use of a different set of participants.

GENERAL DISCUSSION

In four experiments using a modified attentional capture visual search paradigm, we have provided evidence that faces and body parts are special categories within the visual system. When these two categories were presented as target objects, category classification responses were significantly faster as compared to all other objects. In line with recent reports demonstrating dedicated neural architecture for the processing of these biological stimuli (Downing et al., 2001; Kanwisher et al., 1997), these results suggest a fast and efficient mechanism for analysing faces and body parts. In addition to demonstrating a faster and more efficient processing of faces and body parts, these results also suggest that faces and body parts engage and hold attention more than other objects. The cost in visual search RTs associated with the presence of an irrelevant singleton (odd coloured frame) was greater when faces or body parts were presented in singletons, as compared to other categories.

It is important to note that our studies do not directly address whether faces automatically capture attention because the design and paradigm that we employed used irrelevant colour singletons for the capture attention. Therefore, unlike the study of bottom-up or stimulus-driven attention with irrelevant singletons (Theeuwes, 1994, 1996; Theeuwes & Burger, 1998), abrupt onsets (Yantis & Jonides, 1990), or exogenous cues (Posner & Cohen, 1984), our results are likely to be more informative regarding the types of stimuli that engage and hold attention once it is allocated to a given location. Hence, the faster responses to face and body part targets and the slower responses to other targets when faces and body parts are in distractors suggest that faces and body parts produce a larger magnitude of attentional dwell than other types of objects.

Although participants were instructed that the singleton frames and the objects within them were to be ignored, certain objects within these singletons significantly affected the response times and error rates to spatially displaced targets. This finding, along with several other findings using this paradigm (Theeuwes, 1994, 1996; Theeuwes & Burger, 1998), demonstrates that once a stimulus is captured by attention, in this case the colour singleton frame, the attended stimulus may be processed regardless of whether or not it is task relevant. However, our results demonstrating that faces and body parts within the singleton frames affected performance on the task more than other objects suggests, in conjunction with several other behavioural and neuropsychological results (Farah, 1996), that faces and body parts may be special and obligatorily processed. Thus, not all stimuli may be processed to the same extent even when attention is already allocated towards them.

One question that these results raise concerns the exact mechanisms that may be operating that distinguish these complex biological objects (i.e., faces and body parts) from other objects as being special. Although faces are subordinate exemplars of a category, the classification task used in Experiment 1 did not involve categorization at this level. In addition, Experiment 2 used subordinate exemplars from other categories and the body parts in Experiment 3 were not exemplars of a subordinate category, further ruling out an explanation based on subordinate categorization effects. Another possible mechanism that might be responsible for the attentional engaging properties of faces and body parts is a bias towards animate as compared to inanimate objects. However, Experiment 2 employed birds and dogs as two of the categories and yet the face bias was still observed. Therefore, categorization level and an animate/inanimate distinction are also insufficient explanations for our results.

An additional finding of interest is that similar attentional effects were measured for inverted as for upright faces. Thus, in addition to demonstrating that faces engage attention more than other objects, our results with inverted faces show that the detection of a face as being a face is sufficient to drive these attentional biasing effects. The lack of an inversion effect on face detection as measured in these experiments provides an important boundary condition on the well-known face inversion effect (Farah et al., 1995; Yin, 1969; Yovel & Kanwisher, 2004): The larger inversion cost associated with faces as compared to other objects only occurs when higher level recognition rather than lower level detection processes are involved.

It is also possible that the distinguishing characteristics that cause attentional biases to faces and body parts have more to do with experience, familiarity, and expertise at classifying these types of objects rather than any visual properties of the objects themselves (Gauthier et al., 2000; Gauthier & Tarr, 1997; Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999). Although our current findings do not directly address the perceptual mechanisms that distinguish faces and body parts from other objects, they clearly indicate that their advantageous visual processing is also associated with an advantage in attracting attention, even when presented in an irrelevant distractor object.

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APPENDIX
 TABLE A
 The exemplars used for each category in Experiment 1

Stimulus	Category					
	Appliance	Clothes	Faces	Food	Musical instrument	Plants
1	Blender	Boot	Anonymous	Apple	Accordion	Boston fern
2	Fan	Blouse	Anonymous	Banana	Guitar	Chrysanthemums
3	Iron	Dress shirt	Anonymous	Broccoli	Harp	Daisies
4	Oven	Jeans	Anonymous	Eggplant	Harmonica	Dieffenbachia
5	Telephone	Overcoat	Anonymous	Onion	Piano	Dracaena
6	Toaster	T-shirt	Anonymous	Potato	Violin	Juniper