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Faces call for attention: evidence from patients with visual extinction

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Abstract

Three patients with left spatial neglect and visual extinction from right brain damage were studied to determine whether faces are privileged in summoning attention. In a first experiment, either a face, a name, or a meaningless shape were briefly presented in the right, left or both visual hemifields. On bilateral trials, all patients extinguished a left-side face much less often than a left-side name or a left-side shape. Conversely, they extinguished a left-side shape more often when it was accompanied by a right-side face rather than a right-side name. In a second experiment, either a face or a scrambled face could appear in the right, left or both hemifields. Again, on bilateral trials, a left-side face was less likely to be missed than a scrambled one. These results suggest an advantage of faces in capturing attention and overcoming extinction, which may be related to their special biological and social value, or to the very efficient and automatic operation of specific perceptual processes that extract facial organization in extrastriate visual areas. These findings also demonstrate that the distribution of spatial attention and extinction can be modulated by the relevance of visual stimuli. This implies that substantial analysis and categorization may take place in the visual system before information from the contralesional field is selected for, or excluded from, attentive vision. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Extinction; Visual attention; Neglect; Face perception

1. Introduction

Attentional mechanisms afford the selection of relevant objects in the visual world for conscious perception and goal-directed behavior. Neglect and visual extinction represent a deficit in orienting attention towards stimuli in the hemispace contralateral to a unilateral brain lesion. Damage typically involves the right parietal lobe and may leave the primary striate and secondary extrastriate visual areas intact [26,45]. Patients can normally detect a stimulus in their contralesional hemifield when presented alone, but they remain unaware of the same stimulus when it is simul-

taneously presented with a competing stimulus on the ipsilesional side.

Visual extinction provides a valuable opportunity to investigate processes that control the distribution of spatial attention, as well as those that operate at a pre-attentive level in the absence of conscious perception [13,45]. Several recent studies showed that in spite of neglect and extinction, preattentive mechanisms can still parse the visual scene into candidate objects [15,37,52], group objects based on Gestalts principles [19,55], or define their primary axis [14], and hence determine which region of space will be attended or neglected. Moreover, processing of extinguished stimuli may proceed up to the level where specific features [1] and semantic attributes [5,6,38,51] can be extracted, yet in the absence of awareness.

The present study investigated in two different experiments whether visual extinction would be differen-

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tially affected by faces as compared to other visual stimuli. Faces are a special class of objects with particular biological and social significance [10,22]. Their detection and categorization among other complex stimuli may involve a dedicated, partly innate cerebral “module” that automatically encodes the presence of characteristic facial features prior to any identification processes [9,22,39]. Furthermore, recent experimental evidence from normal subjects suggests that faces are more likely to be perceived than other stimuli under conditions of inattention or divided attention [36]. Because hemifield/hemispheric asymmetries in facial processing [17,22] might cause one to expect differential hemispheric activation and spatial attentional bias [32,33], the present experiments contrasted visual extinction using faces and written names in addition to shapes and scrambled nonfaces, which were presented either in the contralesional or ipsilesional field.

2. Patients

Three right-handed patients with a single focal lesion in the right hemisphere were studied (Fig. 1). SD was a 60-year-old housewife who suffered an infarction of the right middle cerebral artery 3 and a half years previously. She had left hemiplegia with moderate deep and superficial sensory loss. EN was a 58-year-old en-

gineer who suffered an infarction of the right middle cerebral artery 3 years previously. He had a mild left arm paresis with decreased touch and pain sensation but preserved position sensation. SS was a 75-year-old retired accountant who suffered an infarction of the right middle and anterior cerebral arteries 4 months previously. He had a dense left hemiplegia with intact touch but decreased pain and position sensation. All three patients had intact visual fields on both sides and showed consistent left visual extinction on double simultaneous stimulation at the time of investigation. All had mild signs of spatial neglect on standard clinical tests such as line bisection (mean rightward deviation 13, 30, and 7 mm on 170 mm-long lines for SD, EN, and SS, respectively) and cancellation task (17, 21, and 39 omissions out of 60 target letters, respectively). All were aware of their deficit and cooperative.

3. Methods

All stimuli in experiments 1 and 2 were white-outlined drawings presented on a black background on computer screen. Patients sat at ~50 cm from the screen. In experiment 1, the stimuli were either a face, a name, or a meaningless shape (Fig. 2) that briefly appeared in a box frame at ~6° from fixation in either the right, left or both visual hemifields. The box

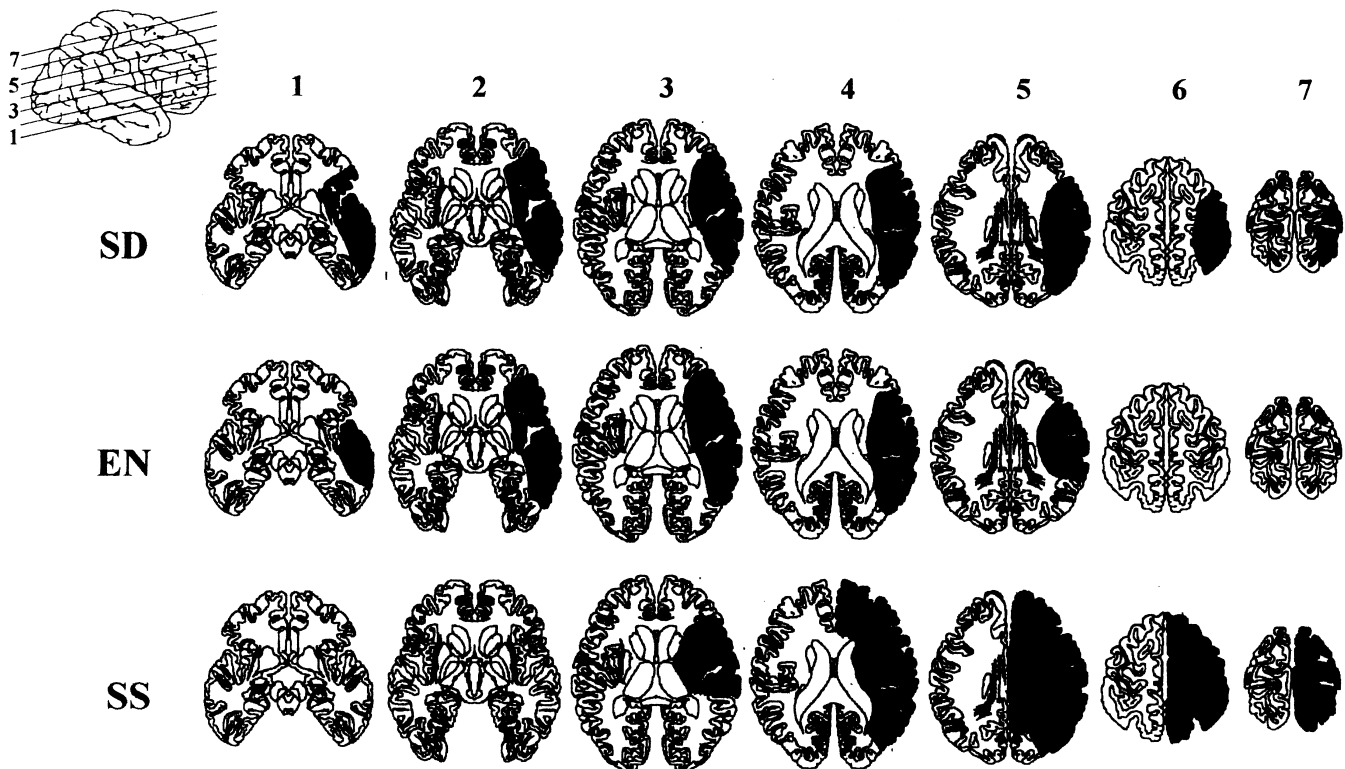


Fig. 1. Reconstruction of the brain lesion in each patient.

frames subtended $\sim 3^\circ$ and remained on the screen throughout the experiment. In addition to the three possible types of unilateral trials on each side, there were five possible bilateral trials: a left-side face with a right-side shape; a left-side shape with a right-side face; a left-side name with a right-side shape; a left-side shape with a right-side name; or two (left-side and right-side) shapes. An attempt was made to keep some elements of the stimuli contours and features as closely matched as possible (see Fig. 2). All bilateral trials and the unilateral shape trials were equiprobable. Each trial began with a fixation point displayed for 1000 ms, followed by stimuli presentation, and then a 1 second interval until the next trial. Patients were asked to report and locate the stimuli (e.g., “a face on the left and a shape on the right”) without constrained order. Responses were entered by the examiner into the computer keyboard. Stimuli duration was set informally during a practice phase in each patient and session so as to obtain a consistent rate of extinction on bilateral presentation while unilateral left stimuli were still reliably identified. Patients SD and EN were tested on two sessions (180 trials in each; 250 and 150 ms exposure duration for SD, 100 and 50 ms exposure duration for EN in session 1 and 2, respectively). SS was tested on three sessions (180, 144, and 90 trials at 150, 200 and 100 ms exposure duration for session 1, 2, and 3, respectively).

In experiment 2, the stimuli were either a schematic face or a scrambled version of the same face (Fig. 2) presented at $\sim 6^\circ$ from fixation either in the right, left or both visual hemifields (without box frames). In addition to two possible types of unilateral trials on each side (schematic face or scrambled nonface), there were three possible bilateral trials: left-side face and right-side scrambled; left-side scrambled and right-side face; or two (left-side and right-side) scrambled faces. All bi-

lateral displays were equiprobable and there were as many unilateral than bilateral trials. The rest of the experiment was as the first one. All patient were tested on a single session (140 trials, 250 ms in SD; 200 trials, 100 ms in EN; 150 trials, 200 ms in SS).

4. Results

Results of experiment 1 are shown in Table 1 for each patient in each condition. The side of stimuli (right, left, or bilateral) had a consistent effect on the rate of misses across all three types of stimuli combined together (one-way ANOVA, $F_{2,30} = 37.6$, $P < 0.0001$). While unilateral stimuli were missed only slightly more often in the left than right hemifield, especially in patient SS (1–18% vs 0%, respectively; $P = 0.17$, Scheffe’s test), there was a marked extinction of left-side stimuli in bilateral trials (38–44%) as compared to unilateral left trials ($P < 0.001$, Scheffe’s test).

Table 1
Results of experiments 1 and 2 for each patient and each condition

Nb missed/Nb trials	Patients		
	SD	EN	SS
<i>Experiment 1</i>			
Unilateral trials			
<i>RVF misses</i>			
shape	0/40	0/40	0/46
name	0/20	0/20	0/23
face	0/20	0/20	0/23
<i>LVF misses</i>			
shape	1/40	0/40	7/46
name	0/20	2/20	7/23
face	0/20	0/20	3/23
Bilateral trials (LVF misses)			
2 shapes	19/40	23/40	24/46
L-shape + R-name	5/40	14/40	10/46
L-name + R-shape	22/40	20/40	21/46
L-shape + R-face	24/40	22/40	21/46
L-face + R-shape	8/40	8/40	13/46
<i>Experiment 2</i>			
Unilateral trials			
<i>RVF misses</i>			
R-scrambled nonface	0/14	0/20	1/15
R-face	0/14	0/20	0/15
<i>LVF misses</i>			
L-scrambled nonface	0/14	1/20	3/15
L-face	0/14	0/20	1/15
Bilateral trials			
<i>LVF misses (contralesional extinction)</i>			
2 scrambled nonfaces	26/28	30/40	21/30
L-scrambled + R-face	28/28	24/40	21/30
L-face + R-scrambled	16/28	14/40	10/30
<i>RVF misses (paradoxical extinction)</i>			
2 scrambled nonfaces	0/28	0/28	0/28
L-scrambled + R-face	0/28	3/40	2/30
L-face + R-scrambled	4/28	6/40	9/30

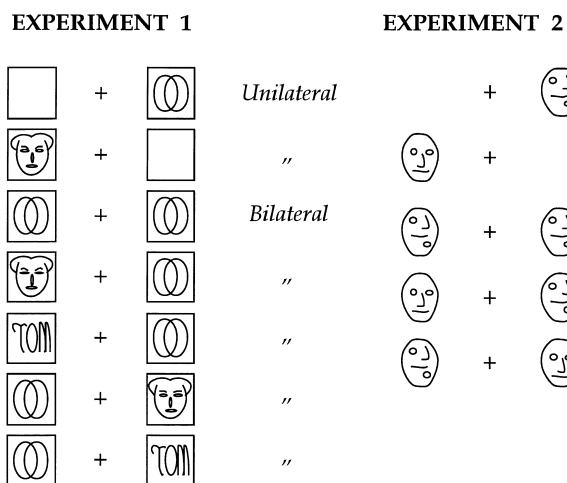


Fig. 2. Examples of stimuli and trials used in experiments 1 and 2.

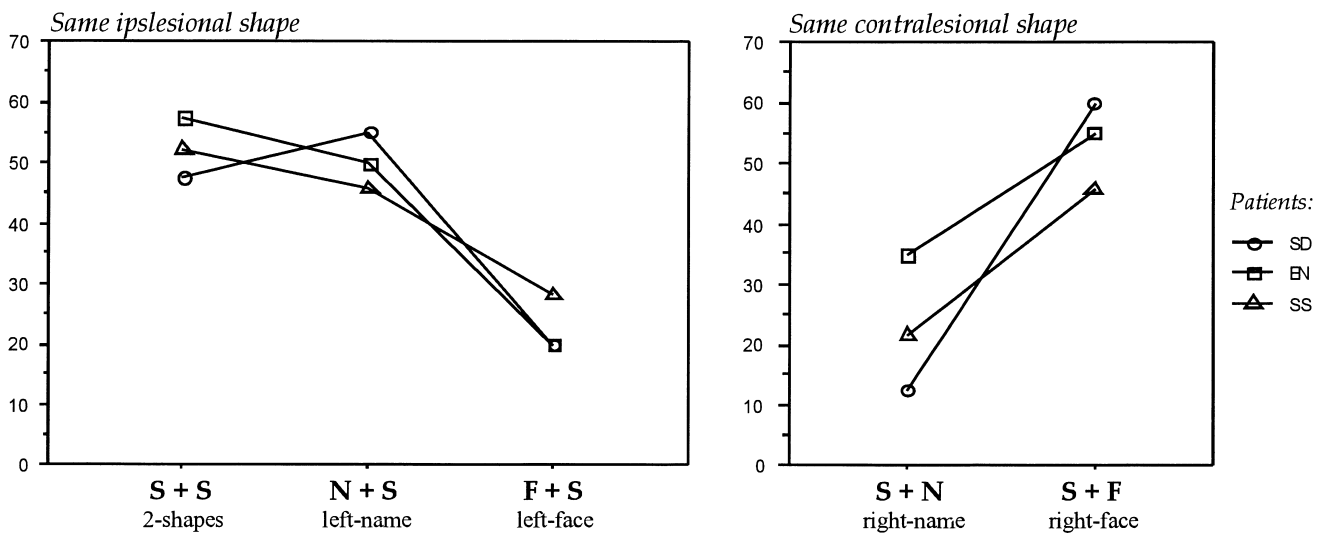


Fig. 3. Extinction rate on bilateral trials in experiment 1. Letter abbreviations refer to the stimuli presented in each hemifield to the left and right of the fixation point (+), respectively; F, face, N, name, S, shape.

On unilateral left trials, the type of stimuli (shape, name, or face) did not reliably affect the proportion of misses. On bilateral trials, however, the rate of extinction was strongly influenced by the stimuli condition (one-way ANOVA, $F_{4,10} = 17.0$, $P = 0.0002$). The three patients demonstrated the same pattern. Planned post-hoc comparisons showed that among all trials with a right-side shape (Fig. 3, left), extinction was consistently less for a left-side face (20–28%) than a left-side name (46–55%; $P = 0.009$, Scheffe's test) or a second left-side shape (48–58%; $P = 0.005$), while the two latter did not differ one from each other ($P = 0.9$). On the other hand, among all trials with a left-side shape (Fig. 3, right), extinction consistently increased when there was a face on the right side (46–60%) as compared to when there was a right-side name (13–35%; $P = 0.004$) but not as compared to when there was a second right-side shape (48–58%; $P = 0.9$), and the two latter conditions significantly differ one from each other ($P = 0.005$). Inspection of individual data confirms that the stimulus type had a significant influence on extinction in each patient ($\chi^2(4) \geq 13.1$, $P \leq 0.011$ in all cases), with a consistent advantage of faces over other stimuli in the contralesional field ($\chi^2(1) \geq 3$, $P \leq 0.08$ in all cases). The patients made only a few errors in which they mistook one stimulus for another ($\leq 4\%$ of trials) and none showed a bias in reporting one type (e.g. a face) more than other types.

Results of experiment 2 are also shown in Table 1 for each patient in each condition. Again, the side of stimuli (right, left, or bilateral) clearly affected the miss rate for both schematic faces and scrambled nonfaces combined together (one-way ANOVA, $F_{2,18} = 40.8$, $P < 0.0001$). Patients missed only a few more unilateral stimuli in the left than in the right hemifield (1–13%

vs 0%, respectively; $P = 0.67$, Scheffe's test) and showed a severe extinction of left-side stimuli in bilateral trials (58–83%) in comparison with unilateral left trials ($P < 0.001$). The stimulus type (face or nonface) did not clearly influence performance on unilateral left trials but again strongly influenced extinction on bilateral trials (one-way ANOVA, $F_{2,6} = 9.8$, $P = 0.013$) in all three patients (Fig. 4). Post-hoc comparisons revealed that a left-side face was less likely to be extinguished (33–57%) than a nonface either accompanied by a right-side face (60–100%; $P = 0.031$, Scheffe's test) or accompanied by another right-side nonface (70–93%; $p = 0.019$), whereas the two latter did not differ ($P = 0.91$). Inspection of individual data also confirms a significant influence of the stimulus type on extinction in each patient ($\chi^2(2) \geq 11$, $P \leq 0.004$ in all cases) with consistent advantage of faces over nonfaces

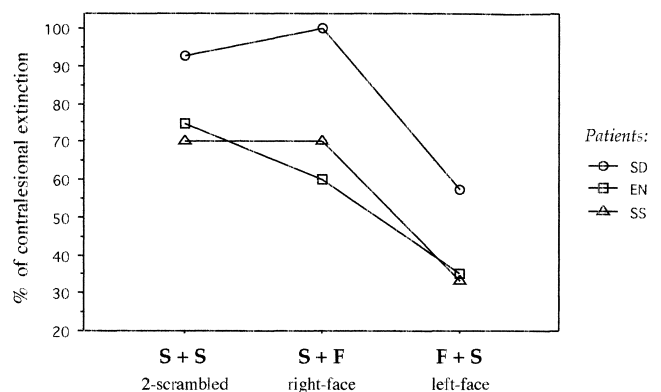


Fig. 4. Extinction rate on bilateral trials in experiment 2. Letter abbreviations refer to the stimuli presented in each hemifield to the left and right of the fixation point (+), respectively; F, face, S, scrambled nonface.

in the contralesional field ($\chi^2(1) \geq 4.7$, $P \leq 0.04$ in all cases).

Moreover, in experiment 2, the patients paradoxically missed a number of stimuli in their ipsilesional field on bilateral trials with a left-side face (14–30%); this occurred significantly more often than on other bilateral trials with a left-side nonface (0–7.5%) or two nonfaces (0%; see Table 1; $\chi^2(2) \geq 6.5$, $P \leq 0.039$ in all cases for the proportion of ipsilesional misses across bilateral trials). The patients made only a few errors in which they mistook one stimulus for another ($\leq 3\%$ of trials) and this occurred equally for faces or nonfaces.

5. Discussion

In both experiments, the rate of extinction in the contralesional field was consistently influenced by the nature of stimuli. For a same competing event simultaneously presented on the ipsilesional side, a left-side face was less likely to be extinguished than other visual stimuli such as a meaningless shape, a written name, or a scrambled face. The three patients showed a very similar pattern of performance, suggesting a unique effect of faces on extinction as compared to other stimuli used in these experiments. This is unlikely to result from some confounding physical characteristics of the stimuli themselves [44], as it was similarly found in the two experiments using different stimuli. It is also unlikely to result from face stimuli being merely easier to process or requiring less attentional capacity as compared to other stimuli, since this would predict a similar decrease of extinction for contralesional events when there is a face on the ipsilesional side. Contrary to this, in experiment 1, extinction worsened (for the same contralesional shapes) with right-side faces compared with right-side names. There was no significant difference between bilateral trials with a right-side face and those with a second right-side shape (in experiment 1) or a second right-side scrambled nonface (in experiment 2), but this does not permit unequivocal conclusions because repetition of similar stimuli may increase extinction when their identification is required [1], obscuring the comparison with other conditions that consisted of two dissimilar stimuli. These results suggest a number of important conclusions.

First, these findings show that the distribution of spatial attention in patients with extinction can be influenced by the nature and relevance of stimuli, in keeping with other recent studies [1,53]. However, they cannot be readily explained by Kinsbourne's model [32,33] of opponent attentional gradients controlled by each hemisphere. In this view, given the well-known right hemisphere superiority for face processing and left hemisphere superiority for word processing [17,22],

the use of facial or verbal material might differentially boost the right or left hemisphere, respectively, and therefore cause different bias of attention towards the left or right hemispace. This model would predict a decrease of extinction with faces in the left hemifield due to right hemisphere activation. However, it also predicts some degree of right hemispheric activation by right-side faces, hence decreased rather than increased contralesional extinction. Further, it predicts the greatest left hemisphere activation, hence the most severe rate of extinction with words in the right hemifield, contrary to what we observed. On the other hand, it is possible that some interaction between hemifields and hemispheric specialized processes for verbal and facial stimuli (i.e. better encoding of faces in the left field and names in the right field) might have contributed to the results.

A second major conclusion is that faces seem to have a special advantage over other stimuli (such as names or shapes) in visual processing and attention orienting mechanisms. There is considerable evidence that face recognition involves specialized perceptual processes and cortical areas in the brain that are not used for other visual objects [17,22]. Support for this includes neuropsychological studies of patients with prosopagnosia after focal brain damage [11,17,35], evoked potentials [4,47] and functional neuroimaging studies [25,29,42,48] in normal human subjects, as well as neurophysiological recordings of neurons with face-selective responses in monkeys [12,41]. Further, the ability to detect and orient to faces appear very early in human babies, suggesting that it may rely in part on prewired neural mechanisms [7,21] (but see [10]). Each of these lines of evidence has raised particular methodological issues, and several questions about the specificity of facial processing and its underlying operations remain unresolved [17,22,39]. Nevertheless, the present findings provide further support for the view that face perception is subserved by specific processes which can be automatically engaged in spite of contralesional inattention. Inferior temporo-occipital areas in the fusiform gyrus that are critical for facial encoding [29,42] were bilaterally preserved in all three patients, and these areas may have received sufficient inputs from ventral visual pathways to sustain face recognition in both the intact and unattended hemifields.

More important, the present results indicate that faces can overcome extinction more than other stimuli (i.e. names) likely to be processed along the same visual pathways. This might suggest that faces can capture attention and be more difficult to ignore than other objects. In support for an attention-grabbing effect, face stimuli seem to cause more contralesional extinction than others (e.g. names) when presented on the right side (in experiment 1) and even cause para-

doxical ipsilesional extinction on some trials when presented on the left side (in experiment 2). Similar ipsilesional misses have been previously observed in neglect patients in discrimination tasks [30,46] and taken to suggest a nonlateralized capacity limitation of attention. A possible account for a special immunity of faces against extinction might be that their special meaningfulness afford for the capture of attention, consistent with the idea that they constitute a visual pattern with high signal value and unique social significance [10,22]. Moreover, these findings are in keeping with recent studies of inattention blindness in normal subjects. Mack and Rock [36] showed that when people engage their attention with some task in a given part of the visual field, they often fail to perceive a suprathreshold stimulus unexpectedly presented at another location and may remain totally unaware of it — except for two exceptions whereby a stimulus reliably captures attention, namely: one's *own name* (as in the so-called cocktail party effect) and a *smiling face*. Other meaningful or familiar stimuli do not show a similar effect [36]. However, an important difference between inattention blindness studies and the present experiments is that in the former, faces automatically summon attention even when they are not expected by the subjects, whereas in the latter the patients were explicitly asked to look for and report faces. As top-down control settings may influence attentional capture [18,53] and partly contribute to the face advantage observed here, this aspect might be worth to consider in further studies.¹

On the other hand, a number of studies in normal

¹ It is possible that the face advantage observed in both experiments might be stronger when the task requires explicit identification rather than simple detection of the stimuli. Two patients (SD, EN) were tested in additional sessions of experiment 1 in which they were required only to locate the stimuli (right, left, or both) without identifying their shape, so that there was now no explicit attentional control set for faces. The third patient (SS) was unfortunately not available for further testing. In spite of the new instruction set making face identity now irrelevant to the task, EN showed a similar extinction pattern as in the previous condition. He missed 25, 21, 27, 33, and 18 contralesional stimuli out of 40 bilateral trials with two shapes, right name, left name, right face, and left face, respectively; $\chi^2(4) = 14$, $P = 0.007$. Left-side faces significantly differed from left-side names ($P = 0.047$, Fisher's test) but not from bilateral shapes ($P = 0.18$), whereas trials with right-side faces differed from those with right-side names ($P = 0.008$) or bilateral shapes ($P = 0.05$). By contrast, SD showed a different pattern of results. Unlike in the two previous sessions, her extinction rate revealed no consistent effect of stimulus type (16, 13, 12, 15, 14 contralesional stimuli missed out of 40 bilateral trials with two shapes, right name, left name, right face, and left face, respectively; $\chi^2(4) = 1.1$, $P = 0.89$). These findings appear consistent with the suggestion that the advantage of faces stems from the product of visual recognition and categorization processes, and further imply that these processes can be influenced to some extent by top-down influences on ventral visual pathways (e.g. from frontal areas).

observers investigated whether faces have a privileged role in attracting attention and may pop-out from concurrent distractors in visual search tasks [8,23,24,34,40,44,56], but yielded varying and somewhat contradictory results. Most studies found that faces or facial expressions are detected by serial attentive search rather than parallel preattentive mechanisms [8,34,40,44,49], suggesting that face processing is not preattentive and does not afford pop-out. Only a few investigators found partial or equivocal evidence that upright faces [8] or facial emotional expressions [24,56] may have some processing advantage and be preattentively discriminated under certain circumstances, e.g. depending on task practice [8]. However, visual search studies typically employ crowded displays in which a target face is embedded among many (up to 48!) other faces, face-like distractors, or other equivalent stimuli [34]. This is clearly unlike Mack and Rock's [36] and the experiments reported here, where there was always only a single real face across the visual fields. Neurophysiological [12] and neuroimaging [31] evidence indicate that neurons with face and other pattern-specific responses in the inferior temporo-occipital cortex have large receptive fields that span wide portions of the visual space, and that their activation by an otherwise optimal stimulus is reduced when another stimulus is simultaneously presented at a different location within the same receptive field. Therefore, parallel processing across the visual field is likely to be limited for complex entities, and search particularly inefficient among multiple competitors that share many similar features and presumably overlap in the space of their neuronal receptive fields [12,16,57]. Such a limitation in search does not necessarily imply that some preattentive analysis or categorization cannot take place, however, especially in an uncrowded field. Thus, even though individual faces are detected serially, facial organization constitutes an emergent high-level feature that can mediate search more efficiently than nonfacial arrangement of the same low-level features [20,49] and impede access to the constituent features themselves [49,50], suggesting that facial organization automatically groups the low-level features into a unitized face representation before the level at which attentive visual processes and awareness operate.

Accordingly, an alternative account for a face advantage in extinction is that it may reflect the particular strength of facial organization and the highly automatized efficiency of its dedicated underlying perceptual mechanisms. Patients with unilateral neglect [54] or simultanagnosia [2,28] show less extinction for stimuli that have better closure and form "good" objects as opposed to scrambled or open shapes, and less omissions for letter strings that form words rather than nonwords [2,3], indicat-

ing that attention is biased to select “good” objects over other stimuli. The human face might constitute a special case of good object [20,43], establishing very effective representation within the ventral visual areas that process objects features [47], and therefore having a stronger weight in the competition for attentional selection and awareness. The particular strength and automaticity of the perceptual operations that extract facial organization is exemplified not only by studies showing low threshold for detection and discrimination of faces under poor viewing conditions [20,43], but also by our common experience in the real world when we involuntarily see faces in random patterns or inanimate objects such as rocks, clouds, or fire hydrants [22,49]. Such an account for the face advantage would be consistent with recent models of attention in which both object-based and space-based selection mechanisms can interact [27,55].

Further studies appear needed to examine the reason why faces call attention more than other visual stimuli. In the present experiments, face stimuli differed from other stimuli in a number of ways besides their identity as faces (e.g. more “real world objects” compared to written names or shapes, stronger symmetrical gestalt compared to scrambled nonfaces). It would be critical to learn whether faces per se are special in their unique meaningfulness, for example by comparing familiar vs unfamiliar faces, or faces vs other real significant objects; or whether faces are special in their unique perceptual saliency, for example by comparing upright faces vs inverted faces or other symmetrical gestalt stimuli.

Finally, the current results support the suggestion that, in patients with extinction, considerable processing may still take place in ventral extrastriate pathways for visual information from the contralesional field, and that such processing can influence which region of space will be eventually attended or neglected [13,45]. They further extend this idea by showing that this may go well beyond early segmentation [15,37,52] and grouping [19,53,55] mechanisms. The advantage of faces and other “good” meaningful objects in extinction imply that substantial analysis and categorization may precede the allocation of spatial attention, and modulate the abnormal bias towards ipsilesional objects caused by parietal damage. In some cases, even extinguished stimuli appear to be processed up to the point where high-level objects properties such as shape, color, or semantic attributes can be extracted in the absence of conscious detection [5,6,38,51]. Such findings demonstrate that attentive vision and awareness can operate at a late level of selection on the product of elaborate preattentive processing within the visual system.

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