

Research report

Visual search for facial expressions of emotion is less affected in simultanagnosia

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ABSTRACT

Evidence in healthy human subjects has suggested that angry faces may be enhanced during spatial processing, perhaps even "popping-out" of a crowd. These contentions have remained controversial, but two recent reports in patients suffering from unilateral spatial neglect have lent some support to these views, suggesting that emotional faces capture attention more efficiently than neutral stimuli in the neglected field.

Here, we investigate this phenomenon in a patient suffering from severe Balint's syndrome and consequent simultanagnosia. Using a visual search paradigm, we studied differences in the detection of angry, happy and neutral faces, as well as non-emotional stimuli.

Results revealed that emotionally expressive faces, in particular anger, were detected more efficiently than other stimuli.

These findings corroborate claims that facial expressions of emotion constitute a specific category of stimuli that attract attention more effectively, and are processed prior to attentional engagement.

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1. Introduction

In 1988, Hansen and Hansen (1988) reported that healthy control subjects could detect an angry face among a series of distracters consisting of happy or neutral faces more rapidly than the converse condition (i.e., detecting happy or neutral faces in an angry crowd). This so-called "face in the crowd effect" led to the contention that faces were processed pre-attentively for characteristics of threat, and consequently produced a pop-out phenomenon for angry faces. Subsequent research (Hampton et al., 1989; Nothdurft, 1993) refuted the pop-out effect due to the observation that subjects' reaction times in these visual search tasks varied with the position of the target in the crowd, or with its size. Indeed, an increase in visual search time with a greater number of distracters is taken as an indication of attention being allocated to each element of the population in serial succession. Pre-attentive processing, or "pop-out", requires the absence of any effect of population size on reaction time, denoting simultaneous processing of all elements in parallel (Treisman and Gelade, 1980). Since the findings with emotional faces demonstrated a serial search, a pop-out phenomenon for angry faces was ruled out. Further

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evidence (Purcell et al., 1996) demonstrated that the pop-out phenomenon obtained in Hansen and Hansen's original experiment was due to a low-level visual artefact that had appeared in the black on white versions of the (originally grey-scale) photographs used in the experiment. Indeed, when replicating the paradigm, this time with the original grey-scale pictures, happy and angry faces were detected after a self-terminating visual search.

Fox et al. (2000) suggested a possible alternative while maintaining a special status for angry faces. Based on the reaction time data of a control population, these investigators noted that angry faces were searched at an estimated 16 msec per item and happy faces at 29 msec per item, compared to an expected <10 msec per item in automatic search. This, they pointed out, implied that angry face detection was not carried out in a fully automatic manner, although these stimuli were searched for and detected more efficiently.

Clearly though, the effect of angry faces on attention remains controversial (see also Fox et al., 2000; Suzuki and Cavanagh, 1992; White, 1995). However, two recent studies (Fox, 2002; Vuilleumier and Schwartz, 2001), in patients suffering from unilateral spatial neglect following right hemisphere damage, suggested that brain damage did not affect attention for emotional faces and neutral stimuli to the same degree, again suggesting that emotional faces might constitute a particular category of stimuli.

In this investigation, we examined whether a similar conclusion could be arrived at in a patient suffering from another spatial disorder, simultanagnosia, which occurred in the context of acute Balint's syndrome following bilateral parietooccipital injury.

This syndrome is relatively rare and was first described by Balint himself at the turn of the last century (Balint, 1909). It includes three major symptoms: optic ataxia, oculomotor apraxia and, of particular interest here, simultanagnosia (see Coslett and Chatterjee, 2003 or Rafal, 2001 for reviews). In simultanagnosia, patients are unable to perceive more than one object at a time, even though single stimuli are generally perceived correctly. This deficit occurs independently of the size of the objects, and is present even when they are in close proximity, or indeed superimposed (e.g., Luria, 1959; Luria et al., 1963). Contrary to unilateral spatial neglect, simultanagnosia appears as an object-based constriction of the attentional field and is independent of the spatial location of the stimulus (Rafal, 2001). Obviously, this disorder produces severe difficulties in visual search and target detection tasks, and occurs independently of the visual field (Coslett and Saffran, 1991).

The present study required that the simultanagnosic patients perform a series of visual search tasks in which emotional or non-emotional targets had to be detected among a series of distracters. The aim was to establish if target detection was impaired differentially for non-emotional stimuli or emotional faces despite severe simultanagnosia.

2. Case history

The patient MC was a 48 year-old right-handed woman, who had followed a normal education until the age of 15. She had

then pursued an apprenticeship as a watch-case maker and had worked in this field until her cerebrovascular accident.

She was admitted to hospital after sudden onset of violent headaches and vomiting with a score of 10 on the Glasgow Coma scale due to a subarachnoid haemorrhage. By the 15th day, her condition had improved (Glasgow Coma scale 15) and was stable, and she was transferred to the neurology clinic for further evaluation.

A CT scan performed on the 20th day, and a subsequent MRI scan the following week, showed the presence of bilateral occipito-parietal lesions (Fig. 1), as well as a left cerebellar lesion.

MC was oriented to time and place. She was cooperative but showed a certain slowing of her mental functions. She was worried by her difficulties, complaining mainly of visual disturbances that she described as a "deformation of space". Indeed, she stated that she saw persons and objects in places that were "different from where they really were", an observation that she based on the fact that she could not grasp or touch them. She also later described that she could not establish the direction or speed of moving objects, and preferred closing her eyes and relying on hearing alone.

Her neurological examination revealed brisk tendon reflexes, more marked on the right, a slight decrease in vibration sense in the inferior limbs, and a positive Hoffman response bilaterally. Graphesthesia was impaired on the right. Cranial nerve testing suggested both left ear and left visual field extinction. Cerebellar tests were unimpaired.

The neuropsychological evaluation showed no aphasic signs in oral comprehension and expression, and MC scored within normal limits (see Table 1 for details of scores on neuropsychological tasks) on an abridged French version of the Boston naming task (Colombo-Thuillard and Assal, 1992). Written language was, by contrast, severely impaired. She

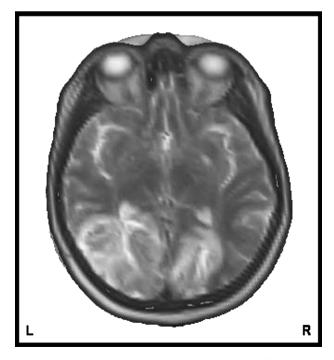


Fig. 1 – MRI axial image showing part of MC's bilateral parieto-occipital damage.

Tests	Score	Norms	
Boston naming task (Colombo-Thuillard and Assal, 1992)	30/34	Cut-off: 26/34	
Visual object and space perce Screening	ption battery (Warrin 5/20	gton and James, 1991) Cut-off: 15 (fail)	
Incomplete letters Silhouettes	17/20 18/30	Cut-off: 17 (pass) Cut-off: 16 (pass)	
Object decision Progressive silhouettes	15/20 16/20	Cut-off: 15 (pass) Cut-off: 14 (fail) ^a	
Dot counting Position discrimination	2/10 11/20	Cut-off: 8 (fail) Cut-off: 18 (fail)	
Number location Cube analysis	0/10 4/10	Cut-off: 7 (fail) Cut-off: 6 (fail)	
Birmingham object recognitio	n battery (Riddoch an	d Humphreys, 1993)	
Single line drawings Paired overlapping line drawings	10/10 10/20	Normal Severely impaired	
Face perception battery (Bruy	er and Schweich, 1993	1)	
Facial decision Analysis of facial features	23/24	M = 22.8 (19) M = 9 (9)	
Gender decision	20/20	M = 9(9) M = 19.4 (18)	
Age decision	30/30	M = 28.8 (24)	
Expression analysis	12/12	M = 11.4 (10)	
Famous faces	43/48	M = 44.8 (42)	
Benton face recognition task (Benton et al., 1994)	16/27 (short form)	Severely impaired	

Induce column shows MC s raw score on the test specified in the left column. Column on the right indicates limits of non-pathological performance established from healthy controls. Cut-off scores are given for the Boston naming and visual object and space perception battery. In the face perception battery, the mean value (M) and the lowest score produced by controls (in parentheses) are indicated for each subtest.

a Patient must score less than the cut-off score to pass in the progressive silhouettes task.

was incapable of reading strings of more than two consecutive words. Isolated single words were read correctly. Writing was impaired by a severe spatial dysgraphia, but the patient could spell words correctly. Similarly, oral calculation was unimpaired, but written calculation was impossible due to spatial dyscalculia. Furthermore, although MC could write numbers of up to three digits correctly, she was incapable of finding them on the sheet once she had completed the task of writing them. There were no clinical signs of ideational or ideomotor apraxia.

Objects and line drawings placed in line with her gaze were correctly identified. On the visual object and space perception battery (Warrington and James, 1991), she failed on the initial screening test. However, her score on other parts of the object perception tests was within normal range, with the exception of the progressive silhouettes that just failed to reach the 5% cut-off level. As expected, she failed dramatically on all spatial perception subtests. On the superimposed figure tests of the Birmingham object recognition battery (Riddoch and Humphreys, 1993), she could easily identify line drawings of single objects, but when two line drawings were superimposed, she never succeeded in identifying more than one. No prosopagnosia was observed. On a number of subtests taken from a face perception battery (Bruyer and Schweich, 1991), the patient could correctly identify faces of famous characters, distinguish faces from non-faces, identify isolated facial features (nose, eyes, etc.), determine gender and age based on facial characteristics, and identify emotional expressions. By contrast, her score on the Benton face recognition task (Benton et al., 1994) was severely impaired, although this appeared to be due to task requirements (i.e., targets had to be identified among a series of distracters).

Optic ataxia was severe in both visual half fields with both hands. When reaching or pointing to objects held up by the examiner, she would invariably miss the object and perform unsuccessful exploratory movements with her hand while attempting to grasp it. Her performance did not improve considerably when she was asked to observe the object, and then reach for it with her eyes closed, nor did she improve significantly when she reached for sound emitting sources with her eyes closed. By contrast, pointing to locations indicated by touch on her arms and legs did not lead to any difficulties. Finally, the presence of deficits in voluntary eye movements was observed, consistent with oculomotor apraxia.

Balint's syndrome was therefore clearly at the forefront of her deficits with optic ataxia, oculomotor apraxia and simultanagnosia present to a severe extent.

Of interest in this study, however, was the importance of her simultanagnosia. Indeed, this was immediately obvious as soon as she was asked to attend to more than one object in her visual field. For example, when presented with pencil on a sheet of paper and asked to write, she saw the corner of the pencil but failed to see the sheet itself. When served her meal, MC would focus on one object, e.g., the fork, but then fail to find the knife or plate. On numerous occasions, we presented coloured tokens on the table in front of her, but during the course of this investigation, she never succeeded in counting them, although she would report the colour of the first token on which her attention initially fell on.

During the following month, in agreement with the patient, we decided to test her capacity to detect visual stimuli that differed in their emotional significance. Our aim was to establish whether the search for emotionally expressive faces might be impaired to a lesser extent than other types of stimuli. The patient gave her informed consent to participate in this study in accordance with the requirement of the local Ethics Committee.

3. Methods

3.1. Control population

Eleven right-handed female participants matched for age (mean: 49.6 years, SD: \pm 6.6) and level of education (completion of secondary school only) served as controls in the experiments. One subject was subsequently removed due to a poor performance in Experiment 1 (i.e., numerous omissions leading to

a score over 2 standard deviations below the group mean). All subjects gave their informed consent before participating.

3.2. Materials and procedure

The tasks were run on a laptop PC running E-prime v.1.1, a commercial software for psychological testing. Screen was placed at approximately 60 cm from the subjects' eyes.

The experiments consisted of seven simple visual search tasks. In each of these tasks, the subjects were presented with a visual scene composed of randomly dispersed elements (distracters), all of which were identical. The instructions were to detect a single target that differed from the others. Due to the difficulty of the task for the patient, the target was clearly specified beforehand (e.g., "can you see a happy face in this display?"). In Experiments 1 and 2, 136 stimuli were presented, of which half contained 6 distracters and half contained 11 distracters. In each of these two conditions, 16 items were used as catch trials and contained no target. In Experiments 3–7, the number of items was reduced to 108 with 12 catch trials. Again half the trials contained 6 and half contained 11 distracters.

Target placement was pseudo-randomised so that it always appeared an equal number of times in all four visual quadrants. The display remained visible until a response was given. In the patient's case, this was to state verbally if the target was present in the visual array. The examiner then recorded the response and the following trial began. Resting breaks were observed throughout the procedures whenever the patient asked for them.

In control subjects, the procedure was identical to the patient's, despite its obvious simplicity. Participants were asked to respond as precisely as possible without prioritising speed. The control group carried out seven tasks in one single session commencing either by Experiment 1 followed by Experiment 2 (half the subjects), or the reverse. The order of succession of the remaining five experiments was counterbalanced across subjects using a balanced Latin-square (Fig. 2).

3.2.1. Experiment 1

Serial search (baseline): In the baseline task, distracters were capital letter Q and the target was a capital letter O. The letters used in this experiment and the following were Arial font (size 60) and produced oval shapes measuring 1.4×1.6 cm.

3.2.2. Experiment 2

Parallel search (pop-out): Distracters were capital letter O and the target a capital letter Q.

3.2.3. Experiment 3

Face detection: The stimuli in this and the following experiments were composed of photographs of the same actor taken from the Ekman–Friesen series (Ekman and Friesen, 1975). Using Adobe Photoshop v. 6.0, the stimuli were prepared by extracting an oval surface measuring 2×3 cm, centred on the face.

In this task, the target was the actor's neutral face presented in the upright position while the distracters consisted of the same neutral faces presented upside down.

3.2.4. Experiment 4

Joy detection control task: Distracters and target all represented the same person but the distracters showed a neutral expression while the target face bore a happy expression. As this task was to serve as control for the joy detection task, all faces were presented upside down. The task was to detect if an inverted happy face was present.

3.2.5. Experiment 5

Anger detection control task: Experiment 5 was similar to Experiment 4 but the target was an upside down angry face to be detected amidst upside down neutral faces representing the same person (Fig. 2, left panel).

3.2.6. Experiment 6

Joy detection: As in Experiment 4, both distracters and target represented the same person. Distracters were again neutral

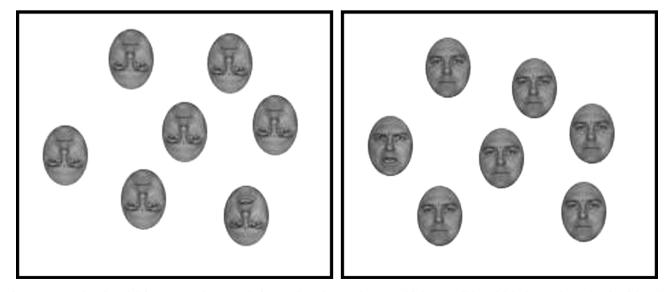


Fig. 2 – Example of a trial from Experiment 5 (left panel) and Experiment 7 (right panel) in which the patients (and subjects) were asked to detect the presence of an angry face.

faces while the target was a happy face, this time in an upright position.

3.2.7. Experiment 7

Anger detection: This experiment was again the same as Experiment 5 but the target was an upright angry face to be detected among a series of upright neutral photographs of the same actor (Fig. 2, right panel).

3.3. Data analysis

The performance in these tasks depends not only on the patient's capacity to detect the presence of a target stimulus, but also on the bias or criterion, i.e., the tendency to respond "present" or "absent" more easily, independently of the actual discriminatory capacity. Signal detection theory (SDT) allows both these aspects, i.e., detection (or sensitivity) and criterion, to be measured. Briefly, SDT assumes that the target must be detected from a background of perceptual noise (Green and Swets, 1966; Macmillan and Creelman, 1991). Both target and noise are represented as two normal distributions. The more overlap in the two distributions, the lower the sensitivity. Sensitivity, d', is then measured as the distance between the means of the two distributions. Greater values of d' therefore indicated a greater ease of discrimination, while a complete overlap of signal and noise distributions produces a *d'* of 0.

Within the area of overlap of the signal and noise distributions, subjects might adopt a more or less conservative response criterion, favouring an "absent" or "present" response. This would result in a varying proportion of misses (responding "absent" when the stimulus is present) or of false alarms (responding "present" when the stimulus is absent). This bias, c, is equal to 0 when false alarms and misses are identical, but adopts a negative value when false alarms are greater than misses, and positive value in the reverse condition. In this investigation, d' and c values were computed in the different detection tasks for the patient and controls.

4. Results

On initial pilot trials involving a serial search, it was obvious that the patient was rarely confident about the presence of a target, unless she accidentally came upon it at the onset. On occasions, she would continue exploring the scene seemingly endlessly, without reaching any definite conclusion. This, of course, reflected the erratic nature of the patient's visual search. Her visual exploration difficulties precluded any systematic search, leading to a continuous "open-ended" exploration of the visual scene.

On the following trials, we therefore reassured the patient by emphasising the fact that a number of trials lacked targets and encouraging her to respond as quickly as possible, based on her general impression rather than certainty.

With these instructions, the task became less arduous (roughly between 5 and 10 sec per item). However, since the search generally appeared incomplete, we surmised that the size of the set would not affect the correct response rate.

The number of hits in 6 and 11 distracter conditions in each experiment was therefore compared to a "no difference" situation using chi square statistics with a significance level of .05. For 6 distracters, Experiments 1–7 yielded, respectively, 26/52; 48/52; 26/48; 26/48; 28/48; 34/48; 40/48 correct responses. For 11 distracters, these values were 31/52; 49/52; 38/48; 23/48; 30/48; 34/48; 42/48. Statistical comparisons between 6 and 11 distracter conditions using chi square tests were not significant and the data were subsequently collapsed across set size for analysis.

The patient's and the control subjects' individual scores (correct responses and false alarms) were then used to compute d' and c in each experiment. In the control group, several participants obtained response rates of 0 or 1; on these occasions, the rates were replaced by .01 and .99 in order to permit computation.

4.1. Stimulus detection: control subjects

The results of the control subjects are presented in Table 2. These show the means and standard deviations of hits and

	Serial search	Parallel search	Face detection	Joy control	Anger control	Јоу	Anger
Patient MC							
Hit rate	.55	.93	.67	.51	.60	.71	.85
FA rate	.09	.03	.08	.17	.17	.08	.08
d′	1.44	3.36	1.81	.99	1.23	1.93	2.44
с	.6	.18	.48	.47	.35	.42	.16
Controls							
Hit rate (SD)	.98 (.03)	.99 (.01)	.99 (.02)	.98 (.01)	.97 (.03)	.98 (.02)	.98 (.02)
FA rate (SD)	.03 (.03)	.01 (.02)	.0 (.01)	.01 (.02)	.01 (.03)	.0 (.0)	.01 (.02)
ď (SD)	4.10 (.41)	4.47 (.27)	4.42 (.27)	4.32 (.48)	4.23 (.43)	4.42 (.30)	4.35 (.31)
Range	3.63-4.65	3.93-4.67	3.99-4.65	3.40-4.65	3.57-4.59	3.89-4.65	3.79-4.65
c (SD)	06 (.25)	05 (.11)	.06 (.17)	01 (.1)	.06 (.25)	.11 (.15)	.03 (.21)
Range	5151	2313	333	303	4454	.0–.38	343

Top row: Hits and false alarm rate for patient MC as well as the corresponding d' and c values obtained in each experiment. Bottom row: Mean hit rate, false alarms, d' and c for the control group. Standard deviations are given in parenthesis. Minimum–maximum d' and c values produced by the control group are also indicated.

false alarms, as well as the means, standard deviations and ranges of *d'* and *c*. As can be noted, control participants showed excellent discrimination capacities with a mean *d'* above 4 on all seven tasks. Response biases were all situated around 0.

In order to test for possible differences between experimental conditions in controls, an analysis of variance for repeated measures was performed on d' and c values. Compared to baseline serial search (Experiment 1), the pop-out task (Experiment 2) showed a marginally significant advantage (F(1,9) = 4.2; p = .07) for sensitivity. On the other hand, the response criterion did not differ between the two procedures (F(1,9) = .01; p = .91).

The comparison of the sensitivities and response biases between serial search (Experiment 1), upright faces (Experiment 3), happy faces (Experiment 6) and angry faces (Experiment 7) showed no significant difference (F(3,27) = 1.93; p = .15 and F(3,27) = .81; p = .5, respectively).

The two emotionally expressive face detection tasks (Experiments 6 and 7) were further compared each with their own specific control paradigms (Experiments 4 and 5, respectively). Neither the inverted versus upright happy face comparison, nor the inverted versus upright angry face comparison showed any difference in sensitivity (F(1,9) = .55; p = .48 and F(1,9) = .45; p = .52, respectively) or response criterion (F(1,9) = 1.89; p = .2 and F(1,9) = .07; p = .8, respectively).

4.2. Stimulus detection: comparison between MC and controls

MC's hit rate, false alarm rate, d' and c values are summarised in Table 2 (top). The results demonstrate that the patient's discriminative capacities were severely below normal limits in all visual search tasks, with d' values situated over six standard deviations below the mean and well below the minimum value obtained in controls. One notable exception, however, was the pop-out task where she showed a less marked deficit (d' = 3.36), although her score remained nonetheless ~4 standard deviations below the mean.

MC's response criteria, c, were generally more positive than in controls, situated at respectively (Experiments 1–7) 2.6, 2.1, 2.5, 4.8, 1.2, 2.1 and .6 standard deviations above the mean. Of note is the fact that only anger detection task showed a criterion within normal limits. The more positive c values on the tasks indicated a tendency towards a more conservative response bias, i.e., a global tendency to respond negatively more often than controls.

4.3. Stimulus detection: effect of stimulus-type in MC

Although MC's scores were globally impaired in all tasks with respect to a group of matched controls, her performance did not appear to be homogenous throughout the seven experiments. In order to evaluate differences in MC's performance between experimental procedures, her d' and c values were compared two by two in the different conditions (Macmillan and Creelman, 1991).

4.3.1. Comparisons with baseline serial search

MC's discriminative capacity on the pop-out task was significantly better than that in the serial search task (cumulative z-score = 3.31, p < .001) and the difference in response criterion was marginally significant (cumulative z-score = 1.432, p = .08). Compared to serial search, detection for neutral faces showed no statistically significant difference, either for sensitivity (cumulative z-score = .594, p = .28) or response criterion (cumulative z-score = .39, p = .35). Regarding the comparisons between serial search and the detection of emotionally expressive faces; no significant differences were observed for sensitivity (cumulative z-score = .78, p = .22) or response bias (cumulative z-score = -.574, p = .72) for joy compared to serial search. On the other hand, a marginally significant advantage in sensitivity in angry face detection was found when compared with the baseline serial search (cumulative z-score = 1.568, p = .058). These two conditions also showed a marginally significant difference when comparing the c values (cumulative z-score = 1.364, p = .09).

Emotional faces compared to control conditions. The difference in sensitivity in the detection of upright happy faces (Experiment 6) compared to its corresponding inverted control condition (Experiment 4) was marginally significant (cumulative z-score = 1.339, p = .09), showing that the patient tended to detect happy faces more easily.

In the case of angry faces, the patient was clearly better at detecting the upright angry faces, compared to the inverted control task (Experiment 5) (cumulative z-score = 1.709, p = .04). The response criterion did not differ in either of these comparisons (joy: cumulative z-score = -.152, p = .44; anger: cumulative z-score = -.531, p = .3).

Finally, a comparison of d' obtained in Experiments 6 and 7 (joy and anger upright) showed no significant difference (cumulative z-score = .662, p = .75).

5. Discussion

In this study, we investigated visual detection capacities for emotional and non-emotional stimuli in a patient who presented a severe simultanagnosia in the context of Balint's syndrome. In order to assess the performance of non-braindamaged subjects, the same tasks were performed by a group of age-matched female controls. Control subjects showed no difficulty in carrying out these simple detection paradigms, scoring at near ceiling levels in all cases and consequently showing no major difference between experiments. Nevertheless, as could be expected, a slight tendency was observed towards a higher performance on the parallel search task.

By contrast, MC's performance revealed a major impairment in all serial search tasks. However, a differential impairment was found depending on the type of stimuli. First, as in control subjects, MC's performance was significantly better in the pop-out task than in the serial search tasks, although her score remained deficient. Of particular interest in our investigation, the patient's sensitivity was found to be significantly higher in the search for angry faces compared to baseline serial search task (Experiment 1) suggesting that these stimuli were detected more efficiently. In this comparison, however, a marginally significant change in response criterion was also observed, leading to the possibility that the difference in performance might actually have resulted from a change in response bias (in this case a general tendency to respond "target absent" less often in the anger upright condition). However, the comparison of the patient's performance with angry and inverted angry faces also revealed a significantly greater sensitivity for the upright stimuli. The fact that in this case no change in response criterion was seen indicates that MC's performance cannot be interpreted solely in terms of response strategy. Since inverted emotional faces are identical to their upright counterparts in their low-level visual characteristics, yet at the same time are thought to lose their emotional value (see for example, Thompson, 1980), the comparison between upright and inverted expressions can also be considered more appropriate. This comparison thus also provides a more reliable demonstration of the efficiency of angry expressions in capturing attention.

Although only marginally significant, the comparison of happy faces, this time with their corresponding inverted control stimuli, also showed a greater sensitivity for upright happy expressions, suggesting that these stimuli might also be efficient in capturing attention. This interpretation is further supported by the fact that the sensitivities for upright happy and angry faces did not differ statistically.

These findings, to our knowledge the first in a simultanagnosic patient, indicate that both happy and angry facial expressions are detected more easily and thus lend further support to the view that emotional expressions constitute a specific category in terms of neural processing. Our findings also substantiate previous claims that brain damage impairs attention differentially, depending on the emotional content of the stimulus. Indeed, similar conclusions have been made in studies of patients suffering from right parietal damage. Vuilleumier and Schwartz (2001) studied patients with mild left unilateral spatial neglect and extinction, using schematic happy, angry or neutral faces, as well as shapes. Due to the presence of visual extinction, the patients generally did not report the stimuli presented in the contralesional (left) visual half field. However, extinction was significantly less marked when an emotional (happy or angry) face appeared in the left hemispace than when a simple shape was shown. This observation was further replicated by Fox (2002) in another neglect patient, using fearful, happy and neutral faces, as well as pictures of fruit. Again, extinction was clearly observed with fruit, whereas emotional faces, both happy and fearful, appeared least affected.

This attentional bias may not be limited to facial expressions of emotion, however. Recent evidence from an investigation in healthy control participants suggests that other types of stimuli can produce similar results. Indeed, Mack et al. (2002) used different attentional paradigms to establish whether meaningful stimuli, in this case one's own name or a happy face icon, affected attention differently from neutral ones. In all paradigms, evidence showed that meaningful stimuli captured attention more efficiently than stimuli that were unimportant. Thus, it could be argued that attention is biased not only towards emotional faces, but also to a broader category of meaningful stimuli that includes facial expressions.

With respect to our observation, an important question arises concerning the mechanisms that produce the attentional bias towards emotional faces. Although the present findings cannot provide a definite response, some insight can be gained from our understanding of simultanagnosia. One account (Farah, 1990; Verfaellie et al., 1990) states that simultanagnosia is due to an incapacity to disengage attention once it has been engaged on a visual stimulus, producing what Balint called the "psychic paralysis of gaze" (Balint, 1909). The patient's attention would be initially captured by an object from which he could no longer turn away, giving rise to a pathological 'stickiness' of visual attention (Farah, 1990). An interpretation of our patient's results along these lines would therefore claim that, although deficient, the "disengage" process is partially facilitated when the emotional faces are presented alongside an engaged stimulus.

However, this implies that a certain amount of processing must take place prior to attention. This suggestion is far from implausible and has in fact been previously suggested in another report of a simultanagnosic patient. Coslett and Saffran (1991) studied this in their patient by presenting her simultaneously with two line drawings or two words. In spite of obvious difficulties in "seeing" multiple objects, her identification rate was higher when the two stimuli were semantically related than when they were not. This showed that the stimuli were accessed by cognitively higher levels of processing prior to attention orienting.

In summary, although parietal damage impaired patient MC's capacity to detect more than one stimulus at a time, the presence of angry or happy faces was found to reduce the deficit. This may have occurred by facilitating the disengagement of attention from previously engaged stimuli through pre-attentive processing. Clearly, further evidence is required to substantiate these claims and to verify whether this type of facilitation can be generalised to other meaningful stimuli.

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