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## Compensatory strategies in processing facial emotions:

### Evidence from prosopagnosia

Jean-Yves Baudouin & Glyn W. Humphreys

*We report data on the processing of facial emotion in a prosopagnosic patient (H.J.A.). H.J.A. was relatively accurate at discriminating happy from angry upright faces, but he performed at chance when the faces were inverted. Furthermore, with upright faces there was no configural interference effect on emotion judgements, when face parts expressing different emotions were aligned to express a new emergent emotion. We propose that H.J.A.'s emotion judgements relied on local rather than on configural information, and this local information was disrupted by inversion. A compensatory strategy, based on processing local face parts, can be sufficient to process at least some facial emotions.*

Prosopagnosia is a disability in recognising familiar people from their faces (Bodamer, 1947). The recognition of people from other cues – such as their voice or their gait – is generally preserved, and the ability to recognise other visual categories of objects can sometimes be spared (for reviews, see Benton, 1990; De Renzi, 1997; Young, 1992). Many studies also indicate that prosopagnosic patients can sometimes process other kinds of facial information, such as emotional facial expressions and gender, whilst the matching of unfamiliar faces can be performed accurately (for a review, see Nachson, 1995; Young & Bruce, 1991). Reversed patterns of impairment, for example where the processing of facial emotion but not identity is impaired, has also been reported (e.g., Humphreys, Donnelly, & Riddoch, 1993; Kurucz & Feldmar, 1979; Parry, Young, Saul, & Moss, 1991). Such data provide support for face recognition models where different mechanisms are held to process contrasting types of facial information (identity, expression, gender, etc.; see, for example, Bruce & Young, 1986; Young, 1992; Young & Bruce, 1991). It is also established that facial information can be processed in a number of different ways. For instance, there is considerable evidence that face recognition mainly relies on the processing of configural or holistic information rather than on componential analysis of the parts of faces; this configural representation takes into account not only the identity of features but also factors such as the distances separating features (for a review, see Rakover, 2002). Configural processing can also be observed when processing facial emotions (see Calder & Jansen, 2005; Calder, Young, Keane, & Dean, 2000). However, whilst configural processing may be dominant and more efficient for face processing, componential (parts-based) analyses can also play a part. For example, Cabeza and Kato (2000) compared the prototype effect in recognition memory for configural and featural prototypes (the tendency to make false positive responses to novel faces that are prototypical within the range of stimuli presented). They reported a tendency for participants to commit false alarms for both featural and configural prototypes. Following brain lesion there can be deficits in processing configural information in faces (e.g., Boutsen & Humphreys, 2002; De Gelder & Rouw, 2000; Levine & Calvanio, 1989; Saumier, Arguin, & Lassonde, 2001). These deficits are demonstrated either by the absence of an usual configural effect in prosopagnosic patients (e.g., Boutsen & Humphreys, 2002; Saumier et al., 2001), or by a paradoxical configuration effect (where face processing is better when the saliency of configural information is reduced, e.g., with upside-down faces, De Gelder & Rouw, 2000). Though such patients may be able to

conduct parts-based analyses of faces, such analyses are either inefficient for the task at hand or patients may be overwhelmed by impaired configural information, which interferes with responses to local parts (e.g., Boutsen & Humphreys, 2002; De Gelder & Rouw, 2000, see also De Gelder & Rouw, 2001). To date, most studies of configural processing in prosopagnosia have concentrated either on recognition tasks or on tasks requiring responses to the structural identity of faces (e.g., identity matching). Consequently, we know little about the role that configural or local part processing might play in the analysis of non-identity information by patients with face processing impairments. Indeed, it is possible that some of the dissociations reported between processing facial identity and other facial properties might reflect the differential contribution of componential analyses to contrasting face processing tasks – for example, if componential analyses can support tasks such as gender or emotion discrimination even when they fail to support face recognition. Indeed, Parry et al. (1991) state that “it is possible that some of the dissociations reported in the existing literature might actually reflect the effect of different task demands, rather than the existence of dissociable face processing pathways” (p. 549). This point is particularly pertinent when we consider emotion recognition, which can involve the assignment of faces into a limited number of emotion categories (see Ekman, 1992; Ekman & Friesen, 1975). Here it is possible that local information about the shape of the mouth or eyebrows may be sufficient to assign a face to an emotion category. There is prior evidence that componential analyses can be used to support identity judgements in a limited set of circumstances (e.g., Newcombe, 1979; Young & Ellis, 1989). For example, Newcombe (1979) observed that prosopagnosic patients had normal performance in identity matching when hairstyle was visible, but not when it was cancelled. Such effects may be even more pronounced when facial emotions have to be categorized. In the present study, we report the case of a severely prosopagnosic patient, H.J.A., who is impaired at identifying any famous or familiar faces by sight (Humphreys & Riddoch, 1987; Humphreys et al., 1993). H.J.A. also shows poor discrimination of gender and facial emotion (Humphreys et al., 1993). Humphreys and Riddoch (1987) initially reported that H.J.A. tended to use individual features rather than configural representations to recognise faces. This is supported by studies of H.J.A.’s memory for facial information, since he can remember individual features of faces whilst being impaired at making judgements from memory about the configural properties (Young, Humphreys, Riddoch, Hellawell, & De Haan, 1994). More recent investigations have confirmed that H.J.A. does not benefit from configural information in perceptual discrimination tasks, when required to discriminate ‘normal’ from ‘thatcherised’ faces (where local parts have been inverted). Here, for example, he shows an (abnormal) advantage for face parts over whole faces, though face parts appearing in isolation lack important configural cues (Boutsen & Humphreys, 2002). Tests of H.J.A.’s ability to discriminate facial emotion are of interest because H.J.A. is able to use different forms of information to support task performance. For example, in earlier studies H.J.A. performed normally when he had to recognize facial emotion from a pattern of moving points placed on faces. Also, though impaired with static images, his emotion judgements nevertheless remained above chance. It is possible that this residual ability with static faces is based on local facial features. Such a pattern would be consistent with arguments made from studies of object processing in H.J.A., where the evidence suggests that local features are extracted but not well integrated (see Humphreys, 1999). This was investigated here. It should also be noted that the study took place some ten years after the initial study of H.J.A.’s processing of facial emotion. Studies of H.J.A.’s object processing have revealed that, over a protracted period following his lesion, H.J.A. improved at using visual information for some tasks even though basic visual processing

remained at a constant level (Riddoch, Humphreys, Gannon, Blott, & Jones, 1999). It is possible, then, that at the time of the present investigation, H.J.A. may be able to use local features to perform emotion judgements even if his configural processing remains impaired. This may reflect some compensatory recovery along with a stable perceptual impairment. In the present paper we tested H.J.A.'s ability to process facial emotion when we varied the information available for making the judgements. In Experiment 1, H.J.A.'s ability to process facial emotion was assessed with upright whole faces, where both parts-based and configural information may be present. Subsequently, H.J.A. performed the same task with upside-down faces. Face inversion is known to interfere with the processing of configural and relational information in faces (for reviews, see Hancock, Bruce, & Burton, 2000; Valentine, 1988). If H.J.A. was disrupted in emotion judgements by the presence of configural information (De Gelder & Rouw, 2000), then he may (paradoxically) improve when presented with inverted relative to upright faces (though see Boutsen & Humphreys, 2002, for contrary evidence in a task stressing the processing of structural identity). In a second study, H.J.A. performed an emotion recognition task using composite faces (see Young, Hellawell & Hay, 1987). Calder et al. (2000) examined facial emotion judgements to composite faces and reported evidence for a role of configural processing. They found that recognition of the emotion of one facial part (top or bottom) was interfered with by the alignment of another half part that displayed another emotion. This effect was not observed when both parts were misaligned or when the faces were upside-down. Such results suggest that the alignment of parts expressing different emotions creates a new, emergent emotional configuration, that interferes with access to the emotions present in the separate parts. This interfering configural information is made less salient when faces are inverted, so the disruptive effect of alignment is reduced. Recently, Calder and Jansen (2005) have further studied the composite effect on the recognition of facial emotions, suggesting that it arises at an early stage in face processing (i.e., at a structural encoding stage), common to both facial identity and facial expression processing. If H.J.A. is sensitive to configural information when making emotion judgements, then, like normals, he should be impaired when facial parts expressing different emotions are combined, even when the response ought to be made to just one part, and this effect should reduce under face inversion. However, previous testing of H.J.A.'s ability to process configural information has shown that he is impaired at using this information to perform both recognition and discrimination tasks (Boutsen & Humphreys, 2002; Humphreys & Riddoch, 1987; Young et al., 1994). We can then predict that H.J.A. would not manifest effects of configural information in a facial emotion task, if the composite effect arises at a common level for both identity and emotion judgements (Calder & Jansen, 2005). Any ability to judge facial emotions would then not depend on 'normal' configural processes, but rather it would result from the compensatory use of local information

## **1. Case history**

H.J.A., born in 1920, was an executive in an American company before he suffered a peri-operative posterior cerebral artery stroke in 1981. Previous investigations have demonstrated that H.J.A. has visual agnosia, prosopagnosia, alexia without agraphia, achromatopsia, and topographical impairments (for detailed neurological and psychological reports, see Humphreys & Riddoch, 1987; Riddoch et al., 1999). The stroke resulted in bilateral lesions to the occipital lobe extending towards the anterior temporal lobe. An MRI scan in 1989 revealed bilateral lesions of the inferior temporal gyrus, the lateral occipitotemporal gyrus, the fusiform gyrus, and the lingual gyrus. In prior studies of his face processing abilities (Humphreys et al., 1993; see also Boutsen & Humphreys, 2002; Young et al., 1994),

it has been found that H.J.A. is severely impaired at both face identification (he failed to name or provide any semantic information about 20 famous faces) and familiarity discrimination (he was 50% correct – i.e., at chance level – when he was told to decide whether the 20 famous faces mixed with 20 unknown faces were familiar or not). He is also impaired at using facial configurations in discrimination tasks. For example, unlike normal subjects, H.J.A. was better at judging whether a face was normal or ‘thatcherised’ (had its eyes and mouth inverted) when presented with the face parts in isolation relative to when he was presented with a full face. In contrast, normal participants use configural information in whole faces to facilitate discrimination relative to when face parts are shown in isolation (Boutsen & Humphreys, 2002). Consistent with H.J.A. having a perceptual form of prosopagnosia, there was no evidence for implicit recognition (e.g., Lander, Humphreys & Bruce, 2004), and his semantic knowledge about people familiar before his lesion is reasonably spared (Young et al., 1994). Similarly, H.J.A.’s conceptual knowledge about emotions is intact, and he can access knowledge about emotions from moving facial expressions (Humphreys et al., 1993). H.J.A. was 81 years old at the time of testing.

## **2. General method**

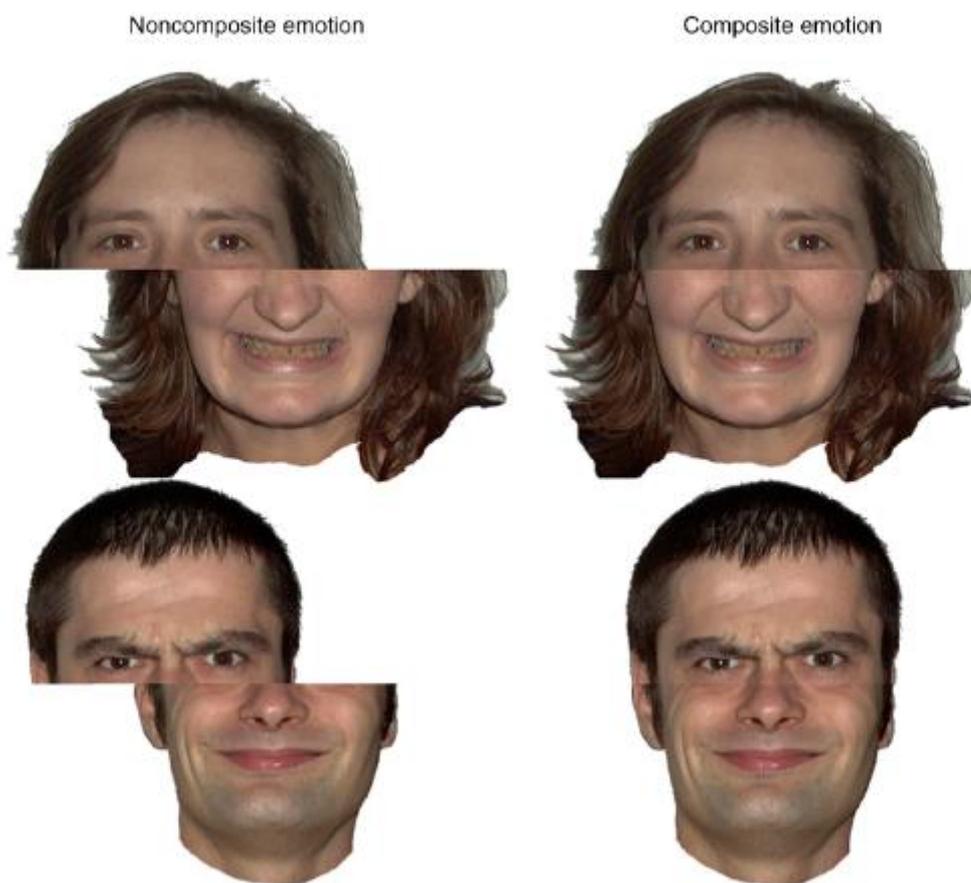
### *2.1. Controls*

H.J.A.’s performance was compared with that of four age-matched male controls, aged from 74 to 86 years old (control A: 86, control B: 74, control C: 81, control D: 74). The controls reported no antecedent neurological or psychiatric disorders. They also had either normal or corrected-to-normal vision, with the exception of control A, who reported some problems in seeing distant stimuli, whilst control C had a small blind area off field. All the controls performed the upright versus upside-down facial-emotion recognition task. Controls A and B performed the composite task on the top halves, controls A and C on the bottom halves. There was no evidence of any differential performance between the controls as a function of their age.

### *2.2. Material*

We used 75 high-resolution colour photographs of 25 individuals, all seen from a frontal viewpoint and expressing three kinds of emotion; happiness, anger, and fear. The head sizes were standardised (15 cm from top to bottom). Photographs were of volunteers from 18 to 31 years old, who were instructed to pose with various emotional facial expressions. These photographs were presented with another set of emotional photographs to a group of 11 young control subjects who were asked to classify the emotions into six categories (“happiness”, “sadness”, “fear”, “disgust”, “anger”, “neutral”, and “other”). For each emotion there was at least 82% agreement for the classification across the control subjects. The experimental task was a two-choice emotion-discrimination, requiring participants to judge whether happiness or anger was being expressed. Happiness and anger were preferred to other possible pairs of emotions because (i) they are visually easy to discriminate, with various distinctive cues on both the bottom and the top parts, (ii) in the study by Calder et al. (2000), participants made similar proportions of errors when identifying the emotion displayed in the top parts of faces for happiness and anger (respectively, .20 and .28). These proportions were not equivalent for the bottom part (respectively, .01 and .49), but the only emotion with a low proportion of errors for the bottom halves of faces was disgust (.14), but this emotion had the disadvantage of being hard to recognize from the top part (.62). To rule against angry emotions being particularly difficult to identify from the bottom halves of the faces we used, we pre-selected

faces so that the two emotions were equally discriminable. The top and bottom halves of each face were separated by cutting the face horizontally at the level of the bridge of the nose. These half faces were presented to a new group of eight young control subjects who had to say if the faces were happy, angry, or fearful. We selected 20 top parts and 20 bottom parts, and within each set 10 were judged happy and the other 10 were judged angry by at least 6/8 control subjects. Five top and five bottom angry parts as well as four top and four bottom happy parts were from the same original full photographs. Consequently, the 40 selected parts were derived from 31 full photographs. These 31 photographs were also used in the emotion recognition tasks with full faces. Overall, from the original 25 people photographed, 5 were used for both the happy and angry conditions, 10 for the happy condition only, and 10 for the angry condition only.



*Fig. 1. Illustration of composite and noncomposite emotions*

The selected half faces expressing each emotion were associated with the counterpart of the same person with another emotion. In addition, we used faces expressing fear as the alternative (irrelevant) part of the critical faces on half the trials. This was done in order to stop participants from guessing the critical expression after detecting the expression in the irrelevant part of the face; both happy and angry faces were equally likely to be paired with a fearful part face. For the critical 10 angry half parts, 5 were associated with a happy counterpart and 5 with a fearful one; for the critical 10 happy half parts, 5 were associated with an angry counterpart and 5 with a fearful one. Composite versus noncomposite faces were created by aligning the top and bottom halves of the faces (to create

a composite emotion) or by shifting the top photograph to the left or right of the bottom one by about half the face's width (the noncomposite emotion condition, see Fig. 1 for an illustration). The side of the shift was varied across stimuli with an equal proportion of each shift in each response category. From this we obtained 20 composite and 20 noncomposite emotions, half with a happy top and an angry bottom half, and half with an angry top half and a happy bottom half.

### 2.3. Procedure

The photographs were presented on a monitor approximately 1m from the subject's eye, with E-prime. A trial consisted in the presentation of a fixation cross for 500 ms, followed by a blank screen for 500 ms. After this a photograph appeared and remained on the screen until the subjects responded. For all the tasks, subjects were required to press one key on a keyboard for a happy face or half face, and another key for an angry face or half face. Participants were instructed to respond as fast as possible, but without neglecting accuracy.

### 2.4. Experiment 1: emotion judgements to full upright or upside-down faces

The 31 full photographs were presented in a random order in two separate sessions; the faces were upright in one and inverted in the other session. H.J.A. as well as controls A, B, and D performed the upright session first. Control C performed the upside-down session first.

### 2.5. Experiment 2: emotion judgements to composite versus noncomposite faces

There were two sessions. In one the subject had to respond to the top face part, and in the other session the task was to respond to the bottom half, without paying attention to the other part. The 20 composite and 20 noncomposite emotions were presented in an upright orientation, in a random order in each session, with the face part required for the decision being placed at the centre of the screen. H.J.A. and two controls performed each session two times on different days. Controls A and B performed the task on the top halves of the faces, whereas controls A and C performed the session on the bottom halves. When an interference effect from the counterpart emotion was observed in the composite condition (i.e., lower accuracy or/and longer response time than for noncomposite emotions), subjects were required to perform the same task with upside-down stimuli. This last task was carried out to ensure that any interference with upright composite faces was due to configural information that should be stronger in upright than in inverted faces.

### 2.6. Data analysis

For all tasks, we tested whether H.J.A. and controls significantly differed from chance level by computing  $\chi^2$  statistical tests. H.J.A. and individual controls were considered as single cases. H.J.A.'s accuracy was also contrasted with that of the controls in Experiment 1 to see if he was impaired at recognizing emotions from full faces.  $\chi^2$  statistical tests were also used for each participant to compare the critical conditions in Experiment 1 (upright versus upside-down) and Experiment 2 (composite versus noncomposite). RTs were analysed by items by Mann-Whitney  $U$  statistic between latencies for correct responses in contrasting conditions.

## 3. Experiment 1: recognition of emotions from full upright and upside-down faces

### 3.1. Results

The results for H.J.A. and the age-matched controls are presented in Table 1.

Table 1  
H.J.A.'s and controls' accuracy and RTs to recognise emotional expression of upright vs. upside-down faces

Face orientation	Upright	Upside-down
Correct responses <sup>a</sup>		
H.J.A.	26/31 (83.9)	12/31 (38.7)
Control A	31/31 (100)	28/31 (90.3)
Control B	28/31 (90.3)	26/31 (83.9)
Control C	31/31 (100)	27/31 (87.1)
Control D	30/31 (96.8)	28/31 (90.3)
Mean latency for correct recognition <sup>b</sup>		
H.J.A.	2687 ms (1131)	5990 ms (2322)
Control A	2202 ms (1808)	2575 ms (2233)
Control B	1366 ms (227)	2963 ms (2830)
Control C	1022 ms (263)	3124 ms (610)
Control D	662 ms (137)	946 ms (240)

<sup>a</sup> Percentage between brackets.

<sup>b</sup> S.D. between brackets.

### 3.1.1. H.J.A.

H.J.A. performed at a better than chance level with upright faces (83.9% correct,  $\chi^2(1) = 14.23$ ,  $p < .001$ ), but not with upside-down faces (38.7% correct,  $\chi^2(1) = 1.58$ ). The difference between upright and inverted faces was reliable (38.7% versus 83.9% correct,  $\chi^2(1) = 46.74$ ,  $p < .0001$ ). RTs for upright versus upside-down faces were not analysed because of H.J.A.'s chance level of performance with inverted faces. Although better than with inverted faces, H.J.A.'s accuracy for upright faces was significantly lower than that of the mean of the controls (83.9% versus 95.2% correct,  $\chi^2(1) = 8.58$ ,  $p < .01$ ), though it did not differ significantly from the least accurate control (83.9% versus 90.0%,  $\chi^2(1) = 1.48$ ). H.J.A.'s performance with inverted faces was impaired relative to both the mean of the controls (38.7% versus 87.1%,  $\chi^2(1) = 64.58$ ,  $p < .0001$ ) and to the worst control (38.7% versus 83.9%,  $\chi^2(1) = 46.74$ ,  $p < .0001$ ).

### 3.1.2. Controls

All controls performed at a better than chance level with both upright and upside-down faces. For upright faces, controls A and C: 100% correct,  $\chi^2(1) = 31.00$ ,  $p < .0001$ ; control B: 90.3% correct,  $\chi^2(1) = 20.16$ ,  $p < .0001$ ; control D: 96.8% correct,  $\chi^2(1) = 27.13$ ,  $p < .0001$ . For inverted faces, controls A and D: 90.3% correct,  $\chi^2(1) = 20.16$ ,  $p < .0001$ ; control B: 83.9% correct,  $\chi^2(1) = 14.23$ ,  $p < .001$ ; control C: 97.1% correct,  $\chi^2(1) = 17.06$ ,  $p < .0001$ . Controls A, C, and D, but not control B, were significantly less accurate for upside-down faces when compared with upright faces (control A: 90.3% versus 100%,  $\chi^2(1) > 4.13$ ,  $p < .05$ ; control B:  $\chi^2(1) = 1.48$ ; control C: 87.1% versus 100%,  $\chi^2(1) > 9.30$ ,  $p < .01$ ; control D: 90.3% versus 96.8%,  $\chi^2(1) = 4.13$ ,  $p < .05$ ), whereas controls B–D, but not control A, were significantly slower with inverted faces (control A:  $U(28, 31) = 363$ ,  $z = 1.08$ ; control B: 2963 ms versus 1366 ms,  $U(26, 28) = 97$ ,  $z = 4.62$ ,  $p < .0001$ ; control C: 3124 ms versus 1022 ms,  $U(27, 31) = 0$ ,  $z = 6.52$ ,  $p < .0001$ ; control D: 946 ms versus 662 ms,  $U(28, 30) = 129$ ,  $z = 4.53$ ,  $p < .0001$ ).

### 3.2. Discussion

H.J.A. generally performed at a lower level than the controls, confirming prior reports of H.J.A. being impaired at judging emotion from static facial images (Humphreys et al., 1993). Nevertheless, H.J.A. was able to make the forced-choice judgements at a reasonable level, when presented with upright faces. He also showed a strong effect of inversion, with performance dropping to chance level when faces were inverted. With controls inversion lowered accuracy and increased RTs, but performance was always substantially above chance. The detrimental effect of inversion here mirrors prior data with H.J.A. when he was required to make judgements about the structural properties of faces (Boutsen & Humphreys, 2002). In each case, there is no evidence for a paradoxical, beneficial effect of face inversion, as would be expected if H.J.A. was disrupted by configural information present in faces (cf. De Gelder & Rouw, 2000). Instead the data suggest that the information used by H.J.A. to classify facial emotion in the images was strongly degraded by inversion. From Experiment 1, however, we cannot tell if H.J.A. was using configural information to make the emotion judgements or whether his judgements were based on face parts, which were degraded by inversion along with any degradation of the configural information present (for a report on an inversion effect in participants performing a featural-change detection task, see Mondloch, Le Grand, & Maurer, 2002). Whether local part or configural information was being used by H.J.A. was tested in Experiment 2, where we compared performance with composite and noncomposite faces. If there is configural processing, judgements to a face half should be disrupted when the half is part of a face composite compared with when it is in a noncomposite image.

## 4. Experiment 2: recognition of composite versus noncomposite facial emotion

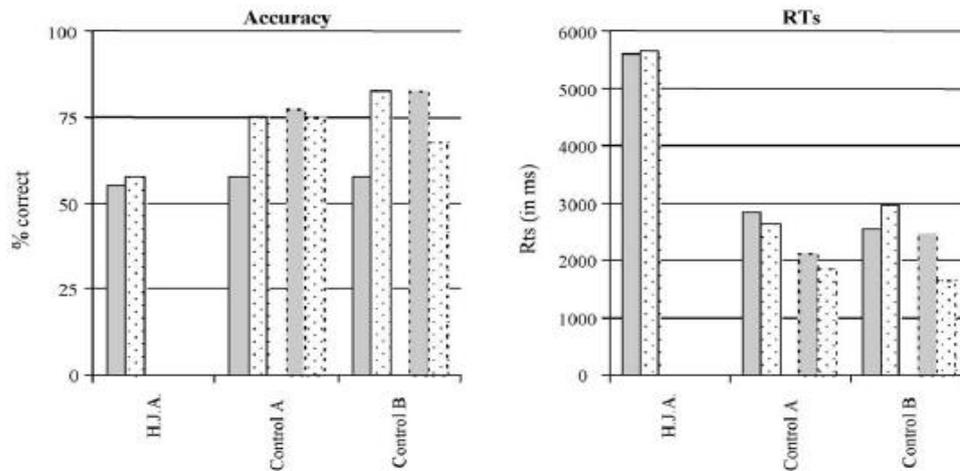
### 4.1. Results

The results are illustrated in Fig. 2.

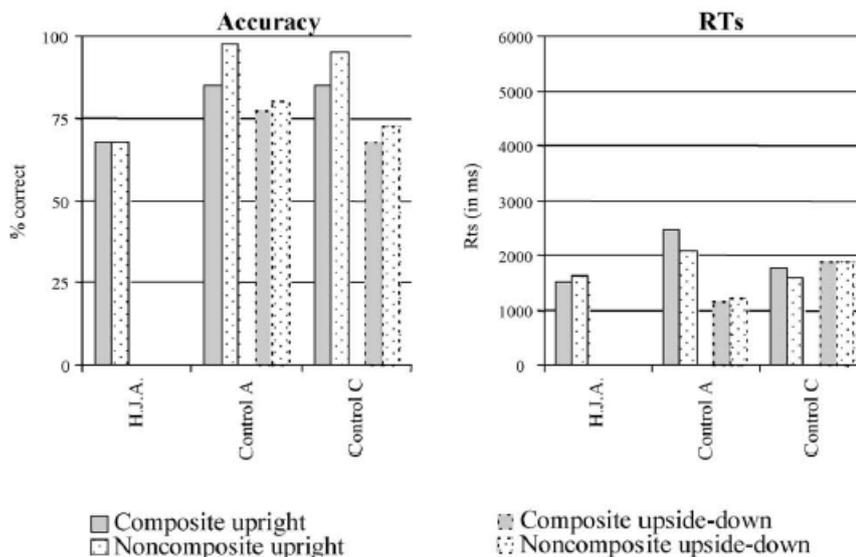
#### 4.1.1. H.J.A.

H.J.A. performed at chance level when attending to the emotion of the top parts of the faces for both composite (55% correct,  $\chi^2(1) = .40$ ) and noncomposite faces (57.5% correct,  $\chi^2(1) = .90$ ). When attending to the emotion of the bottom part, H.J.A. performed better than chance for both composite (67.5% correct,  $\chi^2(1) = 4.90$ ,  $p < .05$ ) and noncomposite emotions (67.5% correct,  $\chi^2(1) = 4.90$ ,  $p < .05$ ). There was no significant difference between composite and noncomposite emotions. RTs for correct responses were analysed when attending to the bottom part: there was no significant difference between composite and noncomposite faces ( $U(27, 27) = 321$ ,  $z = .75$ ). Thus, H.J.A. showed no interference from configural information from the whole face when attending to a half part to make an emotion decision. For this reason, he did not perform the tasks with upside-down stimuli.

## RECOGNITION OF TOP EMOTION



## RECOGNITION OF BOTTOM EMOTION



2. H.J.A. and controls accuracy (in % correct) and RTs (in ms) for composite vs. noncomposite emotion recognition of the top and bottom parts.

### 4.1.2. Controls

When attending to the emotion in the top parts of the faces, controls A and B responded better than chance with noncomposite stimuli (control A: 75% correct,  $\chi^2(1) = 10.00, p < .01$ ; control B: 82.5% correct,  $\chi^2(1) = 16.90, p < .0001$ ), but not to composite stimuli (both controls: 57.5% correct,  $\chi^2(1) = 1.80$ ). The difference between composite and noncomposite emotions was reliable (control A: 57.5% versus 75%,  $\chi^2(1) = 6.53, p < .05$ ; control B: 57.5% versus 82.5%,  $\chi^2(1) = 17.32, p < .0001$ ). With upside-down stimuli, controls A and B responded better than chance for both composite (control A: 77.5% correct,  $\chi^2(1) = 12.10, p < .001$ ; control B: 82.5% correct,  $\chi^2(1) = 16.90, p < .0001$ ) and noncomposite stimuli (control A: 75% correct,  $\chi^2(1) = 10.00, p < .01$ ; control B: 67.5% correct,  $\chi^2(1) = 4.90, p < .05$ ). There was no significant difference between the judgement to composite and noncomposite stimuli, with the exception of control B who was more accurate for composite faces, i.e., the reverse of the

usual composite effect (control A:  $\chi^2(1) = .13$ ; control B: 82.5% versus 67.5%,  $\chi^2(1) = 4.10$ ,  $p < .05$ ). There were no differences in RTs across the conditions, though there was a tendency for control B to be slower with composite than with noncomposite emotions (2463 ms versus 1628 ms,  $U(27, 33) = 322$ ,  $z = 1.84$ ,  $p < .07$ ), suggesting that his better accuracy for inverted composite faces resulted from a speed accuracy trade-off effect.

Thus, controls exhibited a strong interference effect from configural information in upright but not inverted faces when they had to recognise the emotion of the top half of composite stimuli. When attending to the bottom parts of the faces, controls A and C were better than chance for both composite (control A: 85% correct,  $\chi^2(1) = 19.60$ ,  $p < .0001$ ; control C: 85% correct,  $\chi^2(1) = 19.60$ ,  $p < .0001$ ) and noncomposite faces (control A: 97.5% correct,  $\chi^2(1) = 36.10$ ,  $p < .0001$ ; control C: 95% correct,  $\chi^2(1) = 32.40$ ,  $p < .0001$ ), but they were less accurate with composite than with noncomposite faces (control A: 85% versus 97.5%,  $\chi^2(1) = 25.64$ ,  $p < .0001$ ; control C: 85% versus 95%,  $\chi^2(1) = 8.42$ ,  $p < .01$ ). RTs did not differ across the conditions. With upside-down stimuli, controls A and C responded better than chance for both composite (control A: 77.5% correct,  $\chi^2(1) = 12.10$ ,  $p < .001$ ; control C: 67.5% correct,  $\chi^2(1) = 4.90$ ,  $p < .05$ ) and noncomposite stimuli (control A: 80% correct,  $\chi^2(1) = 14.40$ ,  $p < .001$ ; control C: 72.5% correct,  $\chi^2(1) = 8.10$ ,  $p < .01$ ), and there was now no significant difference between composite and noncomposite faces (control A:  $\chi^2(1) = .16$ ; control C:  $\chi^2(1) = .50$ ). There were no reliable RT differences across the conditions with inverted faces.

In sum, the controls showed an interference effect from composite faces, both when attending to the top and the bottom half of the faces. This interference effect was eliminated when the faces were inverted, providing converging evidence that it was due to configural information in upright faces. These results with elderly controls match those reported with young controls by Calder et al. (2000).

#### 4.2. Discussion

Contrary to controls, H.J.A. showed no interference from configural information when he had to judge emotions from parts of a face. At least for the bottom half of the face he was as accurate for composite as for noncomposite faces. In contrast, controls showed a composite effect in the processing of both parts with upright faces, with the discrimination of emotion for part of the face being affected by the irrelevant part of a composite face, making them less accurate for facial composites than for noncomposite faces. This composite effect appears to result from the creation of a new emotional configuration, since it was not evidenced with upside-down faces. The finding that H.J.A. was only better than chance with judgements to the bottom half of faces suggests that he is strongly dependent on features such as the form of the mouth, when making emotion judgements. The effect is unlikely to be due to H.J.A.'s upper altitudinal field defect, given that the stimuli were present for unlimited durations and H.J.A. is perfectly able to scan across the visual field (e.g., see Humphreys, Riddoch, Quinlan, Price, & Donnelly, 1992). Also, it should be noted that H.J.A.'s judgements to the bottom half of both composite and noncomposite faces, in Experiment 2, were lower than his judgements to whole faces in Experiment 1 (respectively, 67.5% versus 83.9%). This suggests that features in the top half of the faces were processed and contributed to his decision when they were consistent with features in the bottom half (in whole faces in Experiment 1, but not in composites and noncomposites in Experiment 2).

#### 5. Conclusion

The prosopagnosic patient H.J.A. was able to discriminate between happy and angry emotions in static, full faces when they were upright, though performance was impaired relative to controls. He also showed an inversion effect, with performance falling to chance when faces were inverted. With facial composites H.J.A.'s emotion judgements were less accurate again, though he still performed above chance when judging the emotion expressed in the bottom halves of faces. However, his emotion judgements were not influenced by whether the halves were presented within a composite or noncomposite face. The control participants were also affected by inversion with full faces, but, unlike H.J.A., they were also disrupted when face halves were part of a composite relative to a noncomposite image. The disruptive effect of the composite was eliminated when faces were inverted, linking the disruptive effect to configural cues emerging from composite, upright faces. These data indicate that there can be a residual ability to judge facial emotions at an above chance level, even with a patient with severe prosopagnosia who is apparently unable to access any stored knowledge based on the structural identity of faces (e.g., in familiarity judgements, or in tests sensitive to implicit knowledge about faces; e.g., Lander et al., 2004). However, this does not mean that facial information about emotions is processed normally in such a case. Our study indicates that H.J.A.'s processing of facial emotion differed qualitatively from that of control participants. Control participants appeared sensitive to configural information present in whole, upright faces (see also Calder et al., 2000). H.J.A. did not, since he was unaffected by our manipulation contrasting composite with noncomposite faces. Instead, we suggest that H.J.A. based his emotion judgements on the presence of critical local features. There was particular weight placed on features in the lower half of the face, but there was also some contribution from features in the upper region when they matched features in the lower region. This may represent a residual, feature-based process that is present when normal participants make judgements to facial emotion, with the process being revealed when the extraction of configural information is disrupted by a brain lesion. Alternatively, it may represent a compensatory strategy developed by H.J.A., perhaps even linked to his spared ability to use facial motion to make emotion judgements (Humphreys et al., 1993). For example, movements of the mouth may be particularly salient when people change emotional expression, leading to H.J.A. weighting that region strongly even when asked to make emotional judgements to static images. Whatever the case, the important point is that we should be cautious to infer functionally separate processes for extracting facial emotion and identity from a case such as H.J.A.'s, where identity judgements are at floor but emotion judgements are above chance. This does not mean that emotion judgements operate in a normal manner. Given that H.J.A. showed no sign of using configural information (Experiment 2; see also Boutsen & Humphreys, 2002; Humphreys & Riddoch, 1987; Young et al., 1994), it is of interest that he was strongly affected by face inversion, in Experiment 1. This in turn suggests that inversion effects are not solely due to the loss of configural cues, but they can also come about because the processing of local facial features is sensitive to their familiar orientation. The degree to which a feature-based strategy can play a role in emotion judgement probably also depends on the choice of emotions being tested. Here we examined the contrast between angry and happy faces, and feature-based cues may be a relatively reliable means of distinguishing these two emotions. As finer distinctions are required, we may expect that emergent, configural cues will play a more important part. This requires empirical testing. Another point is the fact that H.J.A. mainly relied on the bottom half of the face to recognise facial emotion. In recent studies, Caldara et al. (2005) have reported a similar observation with another prosopagnosic patient engaged in face recognition. Moreover, Bukach, Bub, Gauthier, and Tarr (2006) reported that it is possible to mainly observe a 'local expertise effect' in prosopagnosia, suggesting configural

processing but over a local region. The question raised by such observations is whether HJA did process local configural information from the mouth region, which would explain why there is an inversion effect. This hypothesis needs further investigation. Nevertheless, even if this assumption is verified, it remains the case that he used an abnormal strategy to perform the task. The data reported here emphasise the importance of showing that face processing is qualitatively similar in patients and controls, before judgements are made about whether dissociations reflect a difference between the computational uses to which common information is put (e.g., for accessing facial identity relative to facial emotion). In the present case, we suggest that there is a difference in the way facial features can be used to make contrasting judgements, but there is not necessarily a difference between processing facial identity and emotion. A failure to demonstrate qualitative similarities between a residual ability in a patient and the normal process in controls means that it is possible to challenge the view that two distinct and/or independent regions sustain identity and emotion processing (e.g., Baudouin, Martin, Tiberghien, Verlut, & Franck, 2002; Ganel & Goshen-Gottstein, 2004; Martin, Baudouin, Tiberghien, & Franck, 2005; Schweinberger, Burton, & Kelly, 1999; Tiberghien, Baudouin, Guillaume, & Montoute, 2003).

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