

# Compensatory strategy in face processing: a case study of a prosopagnosic patient

Jean-Yves Baudouin, G. W. Humphreys

## ► To cite this version:

Jean-Yves Baudouin, G. W. Humphreys. Compensatory strategy in face processing: a case study of a prosopagnosic patient. Neuropsychologia, 2006, 44 (8), pp.1361-1369. 10.1016/j.neuropsychologia.2006.01.006. hal-00560989

## HAL Id: hal-00560989 https://u-bourgogne.hal.science/hal-00560989

Submitted on 14 Apr 2011

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

## **Compensatory strategies in processing facial emotions:**

## **Evidence fromprosopagnosia**

#### 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 happyfrom angry upright faces, but he performed at chance when the faces were inverted. Furthermore, with upright faces there was no configuralinterference effect on emotion judgements, when face parts expressing different emotions were aligned to express a new emergent emotion. Wepropose that H.J.A.'s emotion judgements relied on local rather than on configuralinformation, and this local information was disrupted byinversion. 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 peoplefrom their faces (Bodamer, 1947). The recognition of peoplefrom 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 kindsof facial information, such as emotional facial expressions andgender, 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 theprocessing of facial emotion but not identity is impaired, has alsobeen 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 facialinformation (identity, expression, gender, etc.; see, for example, Bruce & Young, 1986; Young, 1992; Young & Bruce, 1991). It is also established that facial information can be processedin a number of differentways. For instance, there is considerableevidence 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 factorssuch as the distances separating features (for a review, seeRakover, 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 faceprocessing, componential (parts-based) analyses can also play apart. For example, Cabeza and Kato (2000) compared the prototypeeffect in recognition memory for configural and featural prototypes (the tendency to make false positive responses tonovel faces that are prototypical within the range of stimuli presented). They reported a tendency for participants to commitfalse alarms for both featural and configural prototypes.Following brain lesion there can be deficits in processing configuralinformation 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 prosopagnosicpatients (e.g., Boutsen& Humphreys, 2002; Saumier etal., 2001), or by a paradoxical configuration effect (where faceprocessing is better when the saliency of configural informationis reduced, e.g., with upside-down faces, De Gelder&Rouw, 2000). Though such patients may be able to conduct parts-basedanalyses of faces, such analyses are either inefficient for the taskat hand or patients may be overwhelmed by impaired configuralinformation, which interferes with responses to local parts (e.g., Boutsen& Humphreys, 2002; De Gelder&Rouw, 2000, seealso De Gelder&Rouw, 2001). To date, most studies of configural processing in prosopagnosiahave concentrated either on recognition tasks or on tasksrequiring responses to the structural identity of faces (e.g., identitymatching). Consequently, we know little about the role thatconfigural 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 otherfacial properties might reflect the differential contribution of componential analyses to contrasting face processing tasks -for example, if componential analyses can support tasks such asgender or emotion discrimination even when they fail to supportface recognition. Indeed, Parry et al. (1991) state that "itis possible that some of the dissociations reported in the existingliterature might actually reflect the effect of different taskdemands, rather than the existence of dissociable face processingpathways" (p. 549). This point is particularly pertinent whenwe consider emotion recognition, which can involve the assignment of faces into a limited number of emotion categories (seeEkman, 1992; Ekman & Friesen, 1975). Here it is possible thatlocal information about the shape of the mouth or eyebrowsmay 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 hadnormal performance in identity matching when hairstyle wasvisible, 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 identifyingany 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 studiesof H.J.A.'s memory for facial information, since he canremember individual features of faces whilst being impaired atmaking 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 discriminationtasks, when required to discriminate 'normal' from'thatcherised' faces (where local parts have been inverted). Here, for example, he shows an (abnormal) advantage for face partsover whole faces, though face parts appearing in isolation lackimportant 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 earlierstudies 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 judgementsnevertheless remained above chance. It is possible thatthis 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 evidencesuggests 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 theinitial 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 visualinformation 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 processingremains impaired. This may reflect some compensatory recoveryalong with a stable perceptual impairment. In the present paper we tested H.J.A.'s ability to process facialemotion when we varied the information available for makingthe judgements. In Experiment 1, H.J.A.'s ability to processfacial emotion was assessed with upright whole faces, whereboth parts-based and configural information may be present. Subsequently, H.J.A. performed the same task with upside-downfaces. 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 configuralinformation (De Gelder&Rouw, 2000), then he may(paradoxically) improve when presented with inverted relativeto upright faces (though see Boutsen& Humphreys, 2002, forcontrary evidence in a tasks stressing the processing of structuralidentity). In a second study, H.J.A. performed an emotionrecognition task using composite faces (see Young, Hellawell&Hay, 1987). Calder et al. (2000) examined facial emotion judgementsto 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 thealignment of another half part that displayed another emotion. This effect was not observed when both parts were misaligned orwhen the faces were upside-down. Such results suggest that thealignment 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 configuralinformation is made less salient when faces are inverted, so the disruptive effect of alignment is reduced. Recently, Calderand 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 encodingstage), common to both facial identity and facial expressionprocessing. If H.J.A. is sensitive to configural information whenmaking emotion judgements, then, like normals, he should beimpaired when facial parts expressing different emotions arecombined, even when the response ought to be made to just onepart, and this effect should reduce under face inversion. However, previous testing of H.J.A.'s ability to process configuralinformation 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 notmanifest effects of configural information in a facial emotiontask, if the composite effect arises at a common level for bothidentity and emotion judgements (Calder & Jansen, 2005). Anyability to judge facial emotions would then not depend on 'normal'configural processes, but rather it would result from thecompensatory use of local information

## 1. Case history

H.J.A., born in 1920, was an executive in an Americancompany before he suffered a peri-operative posterior cerebralartery stroke in 1981. Previous investigations have demonstrated that H.J.A. has visual agnosia, prosopagnosia, alexia withoutagraphia, achromatopsia, and topographical impairments (fordetailed neurological and psychological reports, see Humphreys&Riddoch, 1987; Riddoch et al., 1999). The stoke resulted inbilateral lesions to the occipital lobe extending towards the anterior temporal lobe.AMRI scan in 1989 revealed bilateral lesions of the inferior temporal gyrus, the lateral occipitotemporalgyrus, the fusiform gyrus, and the lingual gyrus. In prior studies of face processing abilities (Humphreys et al., 1993; see alsoBoutsen& Humphreys, 2002; Young et al., 1994),

it has beenfound that H.J.A. is severely impaired at both face identification(he failed to name or provide any semantic information about 20famous faces) and familiarity discrimination (he was 50% correct– i.e., at chance level – when he was told to decide whetherthe 20 famous faces mixed with 20 unknown faces were familiaror not). He is also impaired at using facial configurations in discriminationtasks. For example, unlike normal subjects, H.J.A.was better at judging whether a facewas normal or 'thatcherised'(had its eyes and mouth inverted) when presented with the faceparts in isolation relative to when he was presented with a fullface. In contrast, normal participants use configural informationin whole faces to facilitate discrimination relative to when faceparts are shownin isolation (Boutsen&Humphreys, 2002). Consistentwith 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 aboutpeople familiar before his lesion is reasonably spared (Young etal., 1994). Similarly, H.J.A.'s conceptual knowledge about emotionsis intact, and he can access knowledge about emotions frommoving facial expressions (Humphreys et al., 1993). H.J.A. was81 years old at the time of testing.

## 2. General method

## 2.1. Controls

H.J.A.'s performance was compared with that of four agematchedmale controls, aged from 74 to 86 years olds (controlA: 86, control B: 74, control C: 81, control D: 74). The controlsreported no antecedent neurological or psychiatric disorders. They also had either normal or corrected-to-normal vision, withthe exception of control A, who reported some problems in seeing distant stimuli, whilst control C had a small blind area offield. All the controls performed the upright versus upside-downfacial-emotion recognition task. ControlsAandBperformed thecomposite task on the top halves, controlsAand C on the bottomhalves. 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 threekinds of emotion; happiness, anger, and fear. The head sizes werestandardised (15 cm from top to bottom). Photographs were ofvolunteers from 18 to 31 years old, who were instructed to posewith various emotional facial expressions. These photographswere presented with another set of emotional photographs to agroup of 11 young control subjects who were asked to classifythe emotions into six categories ("happiness", "sadness", "fear", "disgust", "anger", "neutral", and "other"). For each emotion here was at least 82% agreement for the classification across the control subjects. The experimental task was a two-choiceemotion-discrimination, requiring participants to judge whetherhappiness or anger was being expressed. Happiness and angerwere preferred to other possible pairs of emotions because (i) they are visually easy to discriminate, with various distinctivecues on both the bottom and the top parts, (ii) in the study byCalder et al. (2000), participants made similar proportions of errors when identifying the emotion displayed in the top parts offaces for happiness and anger (respectively, .20 and .28). Theseproportions 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), butthis emotion had the disadvantage of being hard to recognize from the top part (.62). To rule against angry emotions beingparticularly difficult to identify from the bottom halves of thefaces we used, we pre-selected faces so that the two emotionswere equally discriminable. The top and bottom halves of eachface were separated by cutting the face horizontally at the levelof the bridge of the nose. These half faces were presented toa new group of eight young control subjects who had to say ifthe faces were happy, angry, or fearful.We selected 20 top partsand 20 bottom parts, and within each set 10 were judged happyand the other 10 were judged angry by at least 6/8 control subjects. Five top and five bottom angry parts as well as four topand four bottom happy parts were from the same original fullphotographs. 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 thehappy 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. Thiswas done in order to stop participants from guessing the criticalexpression after detecting the expression in the irrelevant part of the face; both happy and angry faces were equally likely to bepaired 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. Composite versus of the faces were created by aligning the top and bottomhalves of the faces (to create

a composite emotion) or by shifting the top photograph to the left or right of the bottom one by abouthalf the face's width (the noncomposite emotion condition, see Fig. 1 for an illustration). The side of the shift was varied acrossstimuli 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 approximately1m from the subject's eye, with Eprime. A trial consisted in the presentation of a fixation cross for 500 ms, followed by ablank screen for 500 ms. After this a photograph appeared andremained on the screen until the subjects responded. For all thetasks, subjects were required to press one key on a keyboardfor a happy face or half face, and another key for an angry faceor half face. Participants were instructed to respond as fast aspossible, but without neglecting accuracy.

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

The 31 full photographs were presented in a random order intwo separate sessions; the faces were upright in one and inverted in the other session. H.J.A. as well as controls A, B, and Dperformed the upright session first. Control C performed theupside-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 tothe 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 inan upright orientation, in a random order in each session, with theface 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 effectfrom the counterpart emotion was observed in the composite condition (i.e., lower accuracy or/and longer response time thanfor noncomposite emotions), subjects were required to perform the same task with upside-down stimuli. This last task was carriedout to ensure that any interference with upright compositefaces was due to configural information that should be strongerin upright than in inverted faces.

## 2.6. Data analysis

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

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

3.1. Results

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

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 corre	ect 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)

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

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

b S.D. between brackets.

#### 3.1.1. H.J.A.

H.J.A. performed at a better than chance level with uprightfaces (83.9% correct,  $\chi^2(1) = 14.23$ , p < .001), but not withupside-down faces (38.7% correct,  $\chi^2(1) = 1.58$ ). The differencebetween upright and inverted faces was reliable (38.7% versus83.9% correct,  $\chi^2(1) = 46.74$ , p < .0001). RTs for upright versusupside-down faces were not analysed because of H.J.A.'s chancelevel of performance with inverted faces. Although better thanwith inverted faces, H.J.A.'s accuracy for upright faces was significantlylower than that of the mean of the controls (83.9% versus 95.2% correct,  $\chi^2(1) = 8.58$ , p < .01), though it did notdiffer significantly from the least accurate control (83.9% versus90.0%,  $\chi^2(1) = 1.48$ ). H.J.A.'s performance with inverted faceswas 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 withboth upright and upside-down faces. For upright faces, controlsA and C: 100% correct,  $\chi^2(1) = 31.00$ , p < .0001; controlB: 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, controlsA 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 faceswhen compared with upright faces (control A: 90.3% versus100%,  $\chi^2(1) > 4.13$ , 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% versus96.8%,  $\chi^2(1) = 4.13$ , p < .05), whereas controls B–D, but notcontrol A, were significantly slower with inverted faces (controlA: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 versus1022 ms, U(27, 31) = 0, z = 6.52, p < .0001; control D: 946 msversus 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 judgingemotion from static facial images (Humphreys et al., 1993). Nevertheless, H.J.A. was able to make the forced-choice judgementsat a reasonable level, when presented with upright faces.He also showed a strong effect of inversion, with performancedropping to chance level when faces were inverted. With controls inversion lowered accuracy and increased RTs, performancewas always substantially above chance. The detrimental effectof inversion here mirrors prior data with H.J.A. when he wasrequired to make judgements about the structural properties offaces (Boutsen& Humphreys, 2002). In each case, there is noevidence for a paradoxical, beneficial effect of face inversion, aswould be expected if H.J.A. was disrupted by configural informationpresent in faces (cf. De Gelder&Rouw, 2000). Insteadthe data suggest that the information used by H.J.A. to classifyfacial emotion in the images was strongly degraded by inversion. From Experiment 1, however, we cannot tell if H.J.A. wasusing configural information to make the emotion judgementsor whether his judgements were based on face parts, which weredegraded by inversion along with any degradation of the configural information present (for a report on an inversion effectin participants performing a featural-change detection task, seeMondloch, Le Grand, & Maurer, 2002). Whether local part orconfigural information was being used by H.J.A. was tested inExperiment 2, where we compared performance with compositeand noncomposite faces. If there is configural processing, judgementsto 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 bottomFig. 2.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) and noncomposite and noncomposite emotions. RTs for correct responses were analysed when attending to the bottom part: there was no significant difference between composite 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 thefaces, controls A and B responded better than chance withnoncomposite 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 noncompositeemotions 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, controlsA 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 moreaccurate 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 configuralinformation in upright but not inverted faces when theyhad to recognise the emotion of the top half of composite stimuli. When attending to the bottom parts of the faces, controlsA and C were better than chance for both composite (controlA: 85% correct,  $\chi 2(1) = 19.60$ , p < .0001; control C: 85% correct,  $\chi 2(1) = 19.60$ , p < .0001) and noncomposite faces (controlA: 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 withcomposite than with noncomposite faces (control A: 85% versus97.5%,  $\chi 2(1) = 25.64$ , 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 betterthan 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 betweencomposite and noncomposite faces (control A:  $\chi 2(1) = .16$ ; controlC:  $\chi 2(1) = .50$ ). There were no reliable RT differences across the conditions with inverted faces.

In sum, the controls showed an interference effect from compositefaces, both when attending to the top and the bottom halfof the faces. This interference effect was eliminated when thefaces were inverted, providing converging evidence that it wasdue to configural information in upright faces. These results with elderly controls match those reported with young controls 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 fromparts of a face. At least for the bottom half of the face he was asaccurate for composite as for noncomposite faces. In contrast, controls showed a composite effect in the processing of bothparts with upright faces, with the discrimination of emotion forpart of the face being affected by the irrelevant part of a compositeface, making them less accurate for facial composites thanfor noncomposite faces. This composite effect appears to resultfrom the creation of a new emotional configuration, since it wasnot evidenced with upside-down faces. The finding that H.J.A. was only better than chance withjudgements to the bottom half of faces suggests that he is stronglydependent on features such as the form of the mouth, whenmaking emotion judgements. The effect is unlikely to be due to H.J.A.'s upper altitudinal field defect, given that the stimuliwere present for unlimited durations and H.J.A. is perfectly ableto 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 compositeand noncomposite faces, in Experiment 2, were lower than hisjudgements to whole faces in Experiment 1 (respectively, 67.5% versus 83.9%). This suggests that features in the top half of thefaces were processed and contributed to his decision when theywere consistent with features in the bottom half (in whole faces in Experiment 1, but not in composites and noncomposites inExperiment 2).

## 5. Conclusion

The prosopagnosic patient H.J.A. was able to discriminatebetween happy and angry emotions in static, full faces when hey were upright, though performance was impaired relative to controls. He also showed an inversion effect, with performancefalling to chance when faces were inverted. With facial compositesH.J.A.'s emotion judgements were less accurate again, though he still performed above chance when judging the emotionsexpressed in the bottom halves of faces. However, hisemotion judgements were not influenced by whether the halveswere presented within a composite or noncomposite face. The control participants were also affected by inversion with fullfaces, but, unlike H.J.A., they were also disrupted when facehalves 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 configuralcues emerging from composite, upright faces. These data indicate that there can be a residual ability to judgefacial emotions at an above chance level, even with a patientwith severe prosopagnosia who is apparently unable to accessany stored knowledge based on the structural identity of faces(e.g., in familiarity judgements, or in tests sensitive to implicitknowledge about faces; e.g., Lander et al., 2004). However, thisdoes not mean that facial information about emotions is processed normally in such a case. Our study indicates that H.J.A.'sprocessing of facial emotion differed qualitatively from that of control participants. Control participants appeared sensitive toconfigural information present in whole, upright faces (see alsoCalder et al., 2000). H.J.A. did not, since he was unaffectedby our manipulation contrasting composite with noncompositefaces. Instead, we suggest that H.J.A. based his emotionjudgements on the presence of critical local features. There wasparticular weight placed on features in the lower half of the face, but there was also some contribution from features in the upperregion when they matched features in the lower region. Thismay represent a residual, feature-based process that is presentwhen normal participants make judgements to facial emotion, with the process being revealed when the extraction of configuralinformation 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 tomake emotion judgements (Humphreys et al., 1993). For example, movements of the mouth may be particularly salient whenpeople change emotional expression, leading to H.J.A. weightingthat 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 separateprocesses for extracting facial emotion and identity from acase such as H.J.A.'s, where identity judgements are at floor butemotion judgements are above chance. This does not mean thatemotion 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 interestthat 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 familiarorientation. The degree to which a feature-based strategy canplay a role in emotion judgement probably also depends on thechoice of emotions being tested. Here we examined the contrastbetween angry and happy faces, and feature-based cues may be 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 requiresempirical testing. Another point is the fact that H.J.A. mainly relied on thebottom half of the face to recognise facial emotion. In recentstudies, 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 main observe a 'local expertise effect' inprosopagnosia, suggesting configural processing but over a local region. The question raised by such observations is whether HJA did process local configural information from the mouthregion, which would explain why there is an inversion effect. This hypothesis needs further investigation. Nevertheless, evenif this assumption is verified, it remains the case that he used anabnormal 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 theway facial features can be used to makecontrasting judgements, but there is not necessarily a differencebetween processing facial identity and emotion. A failure todemonstrate qualitative similarities between a residual ability ina patient and the normal process in controls means that it is possible to challenge the view that two distinct and/or independentregions 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).

## Acknowledgements

This work was supported by a grant from the FyssenFondation the first author and by grants from the Medical ResearchCouncil and the Stroke Association (UK) to the second author.

#### References

Baudouin, J.-Y., Martin, F., Tiberghien, G., Verlut, I., & Franck, N.(2002). Selective attention for facial identity and emotional expressionin schizophrenia.*Neuropsychologia*, *40*, 518–526.

Benton, A. L. (1990). Facial recognition. Cortex, 26, 491–499.

Bodamer, J. (1947). Die Prosopagnosie. Archiv fur Psychiatrie une Nervenkrank, 179, 6–53.

Boutsen, L., & Humphreys, G. W. (2002). Face context interferes withlocal part processing in a prosopagnosic patient. *Neuropsychologia*, 40,2305–2313.

Bruce, V., & Young, A. W. (1986). Understanding face recognition. *BritishJournal of Psychology*, 77, 305–327.

Bukach, C. M., Bub, D. N., Gauthier, I., &Tarr, M. J. (2006). Perceptualexpertise effects are not all or none: Spatially limited perceptual expertisefor faces in a case of prosopagnosia. *Journal of Cognitive Neuroscience*, *18*, 48–63.

Cabeza, R., & Kato, T. (2000). Features are also important: Contributionsof featural and configural processing to face recognition. *PsychologicalScience*, *11*, 429–433.

Caldara, R., Schyns, P., Mayer, E., Smith, M. L., Gosselin, F., &Rossion, B. (2005). Does prosopagnosia take the eyes out of face representations? Evidence for a defect in representing diagnostic facial information followingbrain damage. *Journal of Cognitive Neuroscience*, *17*, 1652–1666.

Calder, A. J., & Jansen, J. (2005).Configural coding of facial expressions:The impact of inversion and photographic negative. *Visual Cognition*, *12*,495–518.

Calder, A. J., Young, A. W., Keane, J., & Dean, M. (2000).Configuralinformation in facial expression perception. *Journal of ExperimentalPsychology:Human Perception and Performance*, *26*, 527–551.

De Gelder, B., &Rouw, R. (2000). Paradoxical configuration effects for facesand objects in prosopagnosia. *Neuropsychologia*, *38*, 1271–1279.

De Gelder, B., &Rouw, R. (2001). Beyond localisation: A dynamical dualroute account of face recognition. *Acta Psychologica*, *107*, 183–207.

De Renzi, E. (1997). Prosopagnosia.In T. E. Feinberg & M. J. Farah (Eds.), *Behavioural neurology and neuropsychology* (pp. 245–255). New York:McGraw-Hill.

Ekman, P. (1992). Facial expressions of emotion: An old controversy andnews findings. In V. Bruce, A. Cowey, A. W. Ellis, & D. I. Perrett (Eds.), *Processing the facial image* (pp. 63–69). Oxford: Alden Press.

Ekman, P., & Friesen, W. V. (1975). Unmasking the face. Englewood Cliffs, NJ: Prentice-Hall.

Ganel, T., & Goshen-Gottstein, Y. (2004). Effects of familiarity on the perceptualintegrity of the identity and expression of faces: The parallel-routehypothesis revisited. *Journal of Experimental Psychology: Human Perceptionand Performance*, *30*, 583–597.

Hancock, P. J., Bruce, V., & Burton, A. M. (2000).Recognition of unfamiliarfaces.*Trends in Cognitive Sciences*, *4*, 330–337.

Humphreys, G. W. (1999). Case studies in the neuropsychology of vision.London: Psychology Press.

Humphreys, G. W., Donnelly, N., &Riddoch, M. J. (1993). Expression iscomputed separately from facial identity, and it is computed separately formoving and static faces: Neuropsychological evidence. *Neuropsychologia*, *31*, 173–181.

Humphreys, G. W., & Riddoch, M. J. (1987). *To see but not to see: A casestudy of visual agnosia*. Hove (UK): Lawrence Erlbaum.

Humphreys, G. W., Riddoch, M. J., Quinlan, P. T., Price, C. J., & Donnelly, N.(1992). Parallel pattern processing and visual agnosia. *Canadian Journal of Psychology*, *46*, 377–416.

Kurucz, J., & Feldmar, G. (1979). Prosopo-affective agnosia as a symptom of cerebral organic disease. *Journal of the American Geriatrics Society*, *27*, 225–230.

Lander, K., Humphreys, G. W., & Bruce, V. (2004).Exploring the role ofmotion in prosopagnosia: Recognizing, learning and matching faces.*Neurocase*,10, 462–470.

Levine, D. N., &Calvanio, R. (1989). Prosopagnosia: A deficit in visualconfigural processing. *Brain Cognition*, *10*, 149–170.

Martin, F., Baudouin, J.-Y., Tiberghien, G., & Franck, N. (2005). Processing of faces and emotional expression in schizophrenia. *Psychiatry Research*, *134*, 43–53.

Mondloch, C. J., Le Grand, R., & Maurer, D. (2002).Configural face processingdevelops more slowly than featural face processing. *Perception*, *31*, 553–566.

Nachson, I. (1995). On the modularity of face recognition: The riddle ofdomain specificity. *Journal of Clinical and Experimental Neuropsychology*, *17*, 256–275.

Newcombe, F. (1979). The processing of visual information in prosopagnosiaand acquired dyslexia: Functional versus physiological interpretation. InD. J. Oborne, M. M. Gruneberg, & J. R. Reiser (Eds.), *Research inpsychology and medicine: vol. 1* (pp. 315–322). London: Academic Press.

Parry, F. M., Young, A. W., Saul, J. S. M., & Moss, A. (1991). Dissociableface processing impairments after brain injury. *Journal of Clinical andExperimental Neuropsychology*, *13*, 545–558.

Rakover, S. S. (2002). Featural vs. configural information in faces: A conceptualand empirical analysis. *British Journal of Psychology*, *93*, 1–30.

Riddoch, M. J., Humphreys, G. W., Gannon, T., Blott, W., & Jones, V.(1999). Memories are made of this: The effects of time on stored visualknowledge in a case of visual agnosia. *Brain*, *122*, 537–559.

Saumier, D., Arguin, M., &Lassonde, M. (2001). Prosopagnosia: A casestudy involving problems in processing configural information. *Brain andCognition*, *46*, 255–316.

Schweinberger, S. R., Burton, A. M., & Kelly, S. W. (1999). Asymmetricdependencies in perceiving identity and emotion: Experiments with morphedfaces. *Perception &Psychophysics*, *61*, 1102–1115.

Tiberghien, G., Baudouin, J.-Y., Guillaume, F., & Montoute, T. (2003). Should the temporal cortex be chopped in two? *Cortex*, *39*, 121–126.

Valentine, T. (1988). Upside-down faces: A review of the effect of inversionupon face recognition. *British Journal of Psychology*, *79*, 471–491.

Young, A. W. (1992). Face recognition impairments. In V. Bruce, A. Cowey, A. W. Ellis, & D. I. Perrett (Eds.), *Processing the facial image* (pp.47–54). Oxford: Alden Press.

Young, A. W., & Bruce, V. (1991).Perceptual categories and the computation of "Grandmother".*European Journal of Cognitive Psychology*, *3*, 5–49.

Young, A. W., & Ellis, H. D. (1989). Childhood prosopagnosia. Brain and Cognition, 9, 16–47.

Young, A. W., Hellawell, D. J., & Hay, D. C. (1987). Configural informationin face perception. *Perception*, *16*, 747–759.

Young, A. W., Humphreys, G. W., Riddoch, M. J., Hellawell, D. J., & DeHaan, E. H. (1994). Recognition impairments and face imagery. *Neuropsychologia*, *32*, 693–702.