



Face context interferes with local part processing in a prosopagnosic patient

Luc Boutsen*, Glyn W. Humphreys

Behavioural Brain Sciences Centre, University of Birmingham, Birmingham B15 2TT, UK

Received 14 September 2001; received in revised form 25 June 2002; accepted 28 June 2002

Abstract

We investigated the role of local and global information on perceptual encoding of faces in patient HJA, who shows prosopagnosia and visual agnosia following occipito-temporal damage. HJA and an age-matched control were tested in a simultaneous matching task which focused on detection of local changes in faces: the inversion of central parts (eyes and mouth) relative to their context (as in the Thatcher illusion). Same-different judgements were made to normal, “thatcherised” and mixed type face pairs. Whole faces (Experiment 1), or face parts (Experiment 2), were presented in upright and inverted orientations. Compared to the control, HJA was severely impaired at matching whole faces, but he improved dramatically when face parts were presented in isolation. This suggests an inhibitory influence of face context on HJAs processing of local parts and a relatively intact ability to process part-based information from a face (when context cannot interfere). Face inversion did not affect HJAs performance. A control experiment (Experiment 3) with non-face stimuli (houses) suggested that the inhibitory influence of context on HJAs performance was restricted to faces. These results indicate that contextual information in a face can have an adverse influence on the processing of local part-based information in prosopagnosia.

© 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Face context; Prosopagnosia; Visual agnosia

1. Introduction

Prosopagnosia is a deficit in face recognition following focal brain damage [2]. This face recognition deficit occurs in the presence of relatively intact low-level visual processes, though different forms of the disorder may be distinguished. For example, some patients appear to have a perceptual deficit in deriving particular types of visual information (see later), whilst in others the problem seems more one of explicit access to stored memories of faces (e.g. [23]). Our concern here is with perceptual forms of prosopagnosia. Although it has been questioned whether perceptual forms of prosopagnosia can be distinguished from other visual agnosias, there are grounds that face-specific processes can be affected. For example, patients can have deficits with faces but not individual, subordinate objects [8,33] whilst other patients can have deficits in object but not face recognition [20]. Specifically, it has been proposed that particular visual processes required for face recognition are affected in prosopagnosia. These usually concern the distinction be-

tween feature- or part-based processes on the one hand and configural or whole-based face processes on the other. For example, prosopagnosia has been related to a loss of specific modes of face processing in which the extraction and use of different types of information is disrupted. These include: configural information (face parts and their spatial relations [22]), holistic information (an integral representation of a face [11]) and a loss of within-category discrimination [24]. According to these proposals, face processing in prosopagnosia is more or less limited to an encoding of feature- or part-based information, with the extraction of any type of relational information between parts being absent or impaired.

Formal evidence for this “local processing” view of prosopagnosia comes from studies showing that prosopagnosic patients, contrary to normal observers, do not show the face inversion effect, i.e. better recognition with upright than inverted faces [5,6,10,32]. The face inversion effect in normal observers is attributed to the involvement of configural or holistic processing with upright faces. Inversion is thought to make any configural information less available, thereby prompting observers to adopt a part-based approach [28]. Therefore, prosopagnosic patients who do not show a face inversion effect may process upright and inverted faces alike, that is, in a local, part-based manner.

* Corresponding author. Tel.: +44-121-414-2863;

fax: +44-121-414-4897.

E-mail address: l.boutsen@bham.ac.uk (L. Boutsen).

Additional evidence for a failure to use configural information in prosopagnosia comes from studies of face context effects, that is, the better processing of face parts when they are presented in a normal face context, compared to when this context is disrupted (e.g. when the spatial relations between the parts are scrambled [13,34]). Some prosopagnosic patients do not show a face context effect (e.g. there is similar performance for normal and scrambled faces), suggesting again that they are insensitive to the face configuration and process face parts in a local manner [27].

Recently, however, some studies have questioned the assumption that configural information from a face is merely unavailable in prosopagnosia, suggesting instead that this information is processed (albeit abnormally) but is actively disruptive. The primary evidence for this comes from the finding of a “paradoxical face inversion effect”, where there is better performance with inverted than with upright faces. Such effects have been described in two patients, LH and RP in sequential and simultaneous matching tasks [5,6,10,32]. The finding of a paradoxical inversion effect cannot be explained by assuming that configural or contextual face information is simply lost in prosopagnosia; instead, it appears that such information is available and abnormally interferes with part-based processes. Thus, performance is better with inverted than with upright faces because the disruptive configural information is then not available. Moreover, the presence of a face context has also been shown to interfere with part-based processes in a direct way. For example, patients who show paradoxical inversion effects can also be impaired at matching face parts contained within a normal face configuration, compared to when parts appear in a “scrambled” face [32]. In other words, a normal face configuration interferes with part-based processing in these patients.

In the present study, we provide further support for the proposal that a face context can interfere with part-based processing in prosopagnosia, though in our case we argue that it is the presence of a face context rather than the configuration per se, that is disruptive for our patient. We report two studies of face and face-part matching in patient HJA. HJA suffers from visual agnosia and prosopagnosia and his object recognition deficits have been studied extensively [4,12,16,17,29]. His face recognition deficit has been studied rather less (though see [14]). Here we focused on HJAs processing of face parts and wholes. We asked whether face context would have a normal, beneficial, or an abnormal, detrimental influence on HJAs processing in a task requiring the matching of local face parts. To this end, we used a simultaneous matching task, in which two faces had to be compared for changes of local face parts. The local change that had to be detected was the inversion of the eyes and mouth. Local inversion of the eyes and mouth within a face creates the so-called Thatcher illusion, in which an upright face, but not an inverted face, is perceived as grotesque [35]. Research with normal observers suggests that the Thatcher illusion occurs because the extraction of configural informa-

tion in an upright face is disrupted by the inversion of the parts; this disruption is less salient in an inverted face, since configural processing is invoked less strongly [1,25,28,31].

Because the Thatcher illusion requires the detection of local changes in face parts relative to their context, this provides an opportunity to test the influence of face context and orientation on local face processing. HJA had to respond “same” to identical face pairs consisting of normal parts and to face pairs consisting of “thatcherised” parts. In contrast, he had to respond “different” to face pairs which contained normal parts in one and thatcherised parts in the other. In order to assess the effect of context, two factors were manipulated. First, performance on whole faces (Experiment 1) was contrasted with performance on face parts presented in isolation (Experiment 2). Second, within each experiment, performance with upright and inverted faces was compared.

We hypothesised that if HJAs processing deficit was merely related to an inability to extract configural information from the face, then we would expect him still to be able to distinguish between normal and thatcherised faces, since he could use local feature-based processing to make the matches (note that it is not necessary to encode spatial relations between parts to perform the task). However, there may be little difference between upright and inverted faces since he would fail to benefit from the configural/holistic information present in upright faces. Performance should also not differ when HJA is presented with whole faces and when he is given the face parts in isolation.

In contrast, if configural information disrupts HJAs processing of local face parts, then we might expect there to be a paradoxical face inversion effect with whole faces: matching performance may be better with inverted than with upright faces; since the disruptive configural information is more influential in the processing of upright faces (cf. [32]). Also, performance with (upright) face parts may be better than with (upright) whole faces, since configural information is reduced when parts are presented in isolation from the face context. With inverted whole faces, where configural information is reduced, matching should be similar to that with inverted face parts.

Finally, a third outcome is also possible. This is that HJAs processing is affected not by configural face information in particular, but simply by having to process multiple facial features together. In this case, he may be able to match face parts more accurately than whole faces, but his performance with upright and inverted faces may be disrupted to an equal degree (given that the perceptual load due to the presence of multiple features is about the same with upright and inverted stimuli).

In addition to the face matching tests of Experiments 1 and 2, we examined, in Experiment 3, whether any effects of face contexts observed with faces generalised to the effects of context on the processing of parts of non-face objects, such as house stimuli (see later). In other words, is any contextual interference face specific?

2. Case history

HJA is a right-handed male and was 80-year old at the time of testing. In 1981 he suffered bilateral ischaemia of the occipital cortex, extending anteriorly towards the temporal cortex and affecting the lingual and fusiform gyri (for an MRI scan, see [30]). HJA has a number of well-documented visual processing deficits, including: object agnosia, prosopagnosia, alexia (letter-by-letter reading) and achromatopsia [16,29,30]. He has intact visual acuity, but he has an upper altitudinal defect of both visual fields. HJA's most prominent visual impairments concern object agnosia and prosopagnosia. HJA often fails to recognise everyday objects from vision, although he is able to copy drawings from objects and to match pictures of objects from different viewpoints [15]. His long-term memory for objects is largely preserved, although some decline has been reported in a follow up study spanning 15 years [30].

HJA also has prosopagnosia: he cannot recognise people's faces, or his own face, by sight alone [14,16]. For instance, in tests of face identification conducted intermittently since 1981 HJA has failed to identify a single photograph of famous faces. His memory for specific facial features of people is, however, quite well preserved [36]. In addition to HJA, a 71-year old male, right-handed normal control was tested. He reported normal vision and was relatively inexperienced in participating in experimental psychology tests compared to HJA. Data from young control participants on this task are reported by Boutsen and Humphreys [3].

3. General method

Experiments 1 and 2 used identical designs and procedures, except for the stimuli; these consisted of whole faces in Experiment 1 and face parts in Experiment 2.

3.1. Apparatus

The experiments were run on a Gateway 2000 computer. Stimuli were presented on a 15 in. monitor in 800×600 graphics mode. Responses were collected by two keys mounted on a box and connected to the parallel port.

3.2. Stimuli

The stimuli consisted of six high-resolution colour images of three male and three female faces, seen from a frontal viewpoint. These images were part of a set created at the Max Planck Institute of Cybernetics (Tübingen, Germany) and appearing on a CD-ROM distributed by Brown University (Object Databank, Version #1.0.1., Providence, USA, 1996). Hairlines were removed from all the faces. The faces appeared in 800×600 resolution (256 colours) on a black background. At a viewing distance of 100 cm each face subtended approximately (height \times width) $4.92 \times 4.29^\circ$

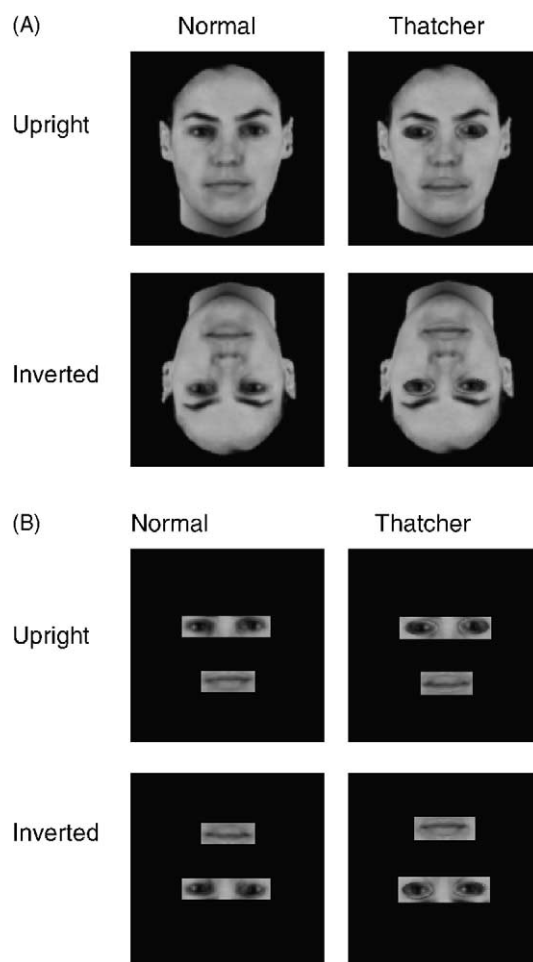


Fig. 1. Example displays illustrating the different orientation and face type conditions for (A) whole faces and (B) face parts.

of visual angle; face parts subtended $2.29 \times 2.75^\circ$. Each face was presented in one of four conditions (Fig. 1): upright-normal, upright-thatcherised, inverted-normal and inverted-thatcherised. Inverted faces were rotated 180° from the upright. Thatcherised faces were created by rotating the eyes and mouth of a normal upright face through 180° by using graphics software. All the images (i.e. including the normal ones) were then mildly blurred to mask any edge discontinuities which, in the thatcherised images, might act as low-level visual cues on which responses could be based.

The six faces were used to create a set of 48 face pairs. Each pair depicted two images of the same person presented side-by-side at 2 cm (for whole faces) or 3 cm (for face parts) from the centre of the display. The images in 24 pairs were identical ("same" judgements) and different ("different" judgements) in the other 24 pairs. For "same pairs", half of the pairs depicted the faces in their upright orientation and the other half in an inverted orientation. For each orientation in the "same" set, half of the pairs depicted normal faces and the other half depicted thatcherised faces. Each "different pair" consisted of one normal and one

thatcherised face. The left–right position of each face type was counterbalanced such that half of the pairs showed a normal face on the left and a thatcherised face on the right and this order was reversed for the other half. Half of the different pairs depicted upright faces and the other half inverted faces.

3.3. Procedure

HJA and the age-matched control were given the same tests. They first took part in Experiment 1 and several weeks later in Experiment 2. The tests were run in a dimmed room; viewing distance was 100 cm from the monitor. The participants were given oral instructions stressing that on each trial two faces depicting the same person would be presented and that the task was to indicate whether the two faces “looked identical or not”. No explicit mention was made of which changes in the face would occur on different trials. HJA and the control made bimanual responses to indicate “same” and “different” judgements by pressing, respectively, the right and left keys on the response box. Twelve practice trials with feedback on incorrect responses were followed by 240 experimental trials (arranged in five blocks of 48 trials) without feedback. On each trial a pair was presented until response and was followed by a 1 s blank interval. Accuracy was recorded as a function of response type (same/different), face type (normal/thatcher; on same pairs only) and orientation. Because HJA's responses were very slow (often between 5 and 10 s), RTs were not analysed. The data were analysed using χ^2 -tests with the criterion for significance set at 0.05.

4. Experiment 1: whole faces

4.1. Results

Results for HJA and the control are presented in Table 1.

4.1.1. HJA

Overall, HJA made only 50% (120/240) correct responses, which is at chance level. Moreover, he had a bias towards responding “same”: On “same” trials he made 75% (90/120) correct responses and on “different” trials only 25% (30/120), $\chi^2(1) = 86.77$, $P < 0.001$. This further

indicates that HJA was poor at detecting the difference between normal and thatcherised faces in a pair.

4.1.2. Control

The control participant made overall 88.7% (213/240) correct responses, which is reliably better than HJA, $\chi^2(1) = 84.81$, $P < 0.001$ (Table 1). He performed better on different than on same trials (99% versus 78%), $\chi^2(1) = 26.08$, $P < 0.001$. Further, the control showed a face inversion effect for normal and thatcherised faces on same trials (Table 1): upright faces were matched more accurately than inverted faces (92% versus 65% correct; $\chi^2(1) = 12.57$, $P < 0.001$).

4.2. Discussion

The main finding of Experiment 1 is that HJA was unable to match whole faces. Since the task required attention to local parts only, this shows either that HJA cannot process and make the required judgements on face parts, or that he finds it difficult to segment and attend to the face parts in the context of the whole face. These two possibilities are separated in Experiment 2 where we presented face parts alone. For HJA, there was also no difference between upright and inverted faces. In contrast, the control subject was able to perform the task well above chance level and he showed an advantage for upright over inverted faces. For the control, configural information exerts a positive effect on perceptual matching. These data from the control, using an accuracy measure, match reaction time and accuracy data from young participants reported by Boutsen and Humphreys [3]. The normal pattern of performance is for upright faces to be matched more efficiently than inverted faces.

5. Experiment 2: face parts

Experiment 2 was identical to Experiment 1, except that stimulus pairs now depicted just the critical face parts (eyes and mouth) in isolation (Fig. 1B).

5.1. Results

Accuracy data for HJA and the control are shown in Table 2.

Table 1

Experiment 1: performance of HJA and an age-matched control with whole faces

	Same trials		Different trials	
	Upright	Inverted	Upright	Inverted
HJA	41/60 (68)	49/60 (82)	21/60 (35)	9/60 (15)
Control	55/60 (92)	39/60 (65)	60/60 (100)	59/60 (98)

Note: percentage correct responses appear between brackets.

Table 2

Experiment 2: performance of HJA and an age-matched control with face parts

	Same trials		Different trials	
	Upright	Inverted	Upright	Inverted
HJA	57/60 (95)	56/60 (93)	45/60 (75)	51/60 (85)
Control	57/60 (95)	57/60 (95)	55/60 (92)	51/60 (85)

Note: percentage correct responses appear between brackets.

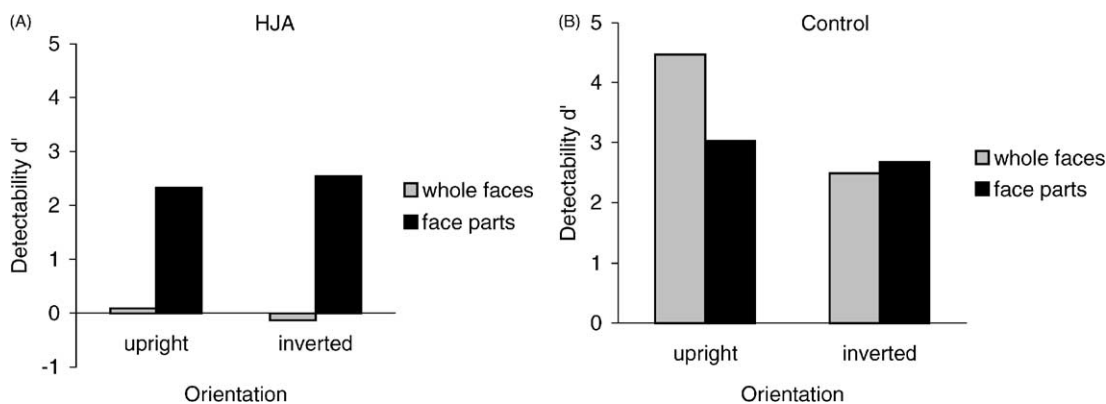


Fig. 2. Sensitivity performance (d') of HJA (A) and the control (B) with whole faces and face parts as a function of orientation.

5.2. HJA

HJA made 87% (209/240) correct responses, which is better than his performance with whole faces ($\chi^2(1) = 76.53$, $P < 0.0001$). He again performed better on same than on different trials (94.1% versus 80%, $\chi^2(1) = 10.70$, $P < 0.001$). On same trials, HJA showed no inversion effects ($\chi^2 < 1$); on different trials, he tended to performed better with inverted faces (by 10%) but this difference was not reliable, $\chi^2(1) = 1.87$, $P > 0.17$.

5.3. Control

The control made 99.6% (220/240) correct responses, which is similar to HJAs performance with face parts ($\chi^2(1) = 2.65$, $P > 0.10$) and to the control's own performance with whole faces, $\chi^2(1) = 1.15$, $P > 0.28$. He was equally accurate on same pairs and on different pairs (95% versus 88.3%), $\chi^2(1) = 3.49$, $P > 0.06$. There were no inversion effects.

5.4. Discussion

HJAs performance in part-based matching improved significantly when the face context was removed; indeed, his performance was now similar to that of the control. This shows, first, that face context (shown in either an upright or an inverted orientation) interfered with the processing of local part-based information in Experiment 1. Secondly, the result shows that HJA is able to use feature-based information in the perceptual encoding of faces (since he was now able to discriminate between normal and thatcherised face parts).

The conclusion that face context affected HJAs detection of local changes is further supported by a comparison of his performance in terms of signal sensitivity. Using d' as a measure of sensitivity, Fig. 2 presents signal sensitivity of HJA (Fig. 2A) and that of the control (Fig. 2B) with whole faces and face parts as a function of orientation. Overall, HJA performed at chance level ($d' = 0.00$) with whole faces,

but his sensitivity increased markedly with face parts ($d' = 2.21$); in fact, although his sensitivity with parts was below that of the control (parts, $d' = 2.84$; wholes, $d' = 2.99$), it was still well above chance level.

To what extent is the effect of context observed on HJAs perceptual matching performance face-specific? HJA is visual agnostic as well as prosopagnosic. It may be that the context effects on parts matching, present in Experiment 1, may reflect a general visual processing deficit and not one particular to faces. That is, HJAs perception of non-face parts may be detrimentally affected when these are presented in the context of an object, as compared to when they are presented in isolation. (We thank an anonymous reviewer for raising this issue.) In order to address this, we conducted a control experiment in which HJA had to detect local changes (equivalent to those made to the face parts in Experiments 1 and 2) in non-face stimuli, houses (cf. [34]). The parts which were presented either in the context of a house, or in isolation. We hypothesised that if the effect of context on HJAs matching performance with faces reflected a general perceptual deficit, then it should extend to non-face stimuli like houses. In contrast, a failure to observe an effect of context with non-face stimuli would suggest that context affects HJAs perception of face stimuli in particular.

6. Experiment 3: matching houses

6.1. Method

6.1.1. Stimuli

The stimuli consisted of six schematic line drawings of houses (Fig. 3), which were presented in black on a white background. Each drawing matched the size of a whole face as shown in Experiment 1 and the spatial configuration of the parts (a door and two windows) matched that of the eyes/mouth configuration in faces. Each house drawing occurred in four versions: upright-normal; upright-inverted features; inverted-normal and inverted-inverted features. In the "inverted features" condition, the inner parts of the

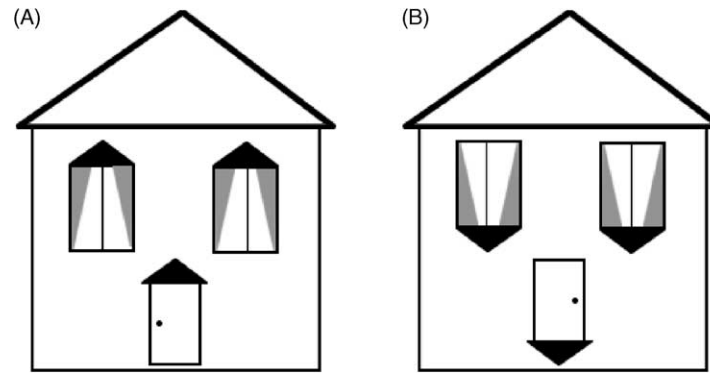


Fig. 3. Example displays of stimuli for Experiment 3A: a normal house (A) and a house with inverted features (B).

house (i.e. the door and two windows) were inverted relative to their surround (as was the case with the thatcherised faces). The six house drawings were used to create a set of 48 house pairs, with 24 pairs depicting identical houses (“same” judgements) and 24 pairs depicting different houses (“different” judgements). Additionally, a set of 48 pairs were created in which the inner parts (door and windows) were presented in isolation.

6.1.2. Design and procedure

The design was identical to that of the previous experiments. HJA was tested in two experiments. Each experiment consisted of two blocks: matching pairs of whole houses was followed by a block of matching house parts. Each block consisted of 12 practice trials (with feedback on incorrect responses) followed by five blocks of 48 experimental trials (without feedback). In Experiment 3A, HJA had to match house pairs which were presented on the screen until a response was made (as with the face pairs). In Experiment 3B, the presentation duration of the house pairs was limited to 1 s (unmasked). This experiment was run because HJA showed near ceiling performance in Experiment 3A (see results below) and we wished to examine performance on house stimuli when the matching of house parts was matched to the level found with the matching of face parts, in Experiment 2. Experiments 3A and 3B were run on consecutive days.

6.2. Results

Accuracy data for Experiment 3 are presented in Table 3. Sensitivity (in terms of d') for Experiment 3B is shown in Fig. 4.

6.2.1. Experiment 3A

HJA made 92% (442/480) correct responses. His performance with wholes (94%, 225/240) and with parts (90%, 217/240) was similar, $\chi^2(1) = 1.83$, $P > 0.17$. With *whole houses*, HJA performed better on different than on same trials (98% versus 89%, $\chi^2(1) = 8.60$, $P < 0.003$); his performance to upright houses was similar to inverted ones (93% versus 94%, respectively; $\chi^2 < 1$). The same pattern

results was observed with *house parts*: HJA performed better on different than on same trials (94% versus 87%, $\chi^2(1) = 3.89$, $P < 0.05$) and similarly with upright and inverted parts (91% versus 90%, $\chi^2 < 1$).

HJAs overall performance in this experiment was near ceiling (see Table 3), not only compared to whole faces (94% versus 50%) but also with face parts (90% versus 87%). In order to equate performance with part-stimuli, we repeated the experiment but limited the presentation duration of the images to 1 s (unmasked).

6.2.2. Experiment 3B

HJA made overall 85% (410/480) correct responses; this is lower than his performance in Experiment 3A, $\chi^2(1) = 10.68$, $P < 0.001$ and it was similar to his performance with face parts (Experiment 2, 87%), $\chi^2 < 1$. Nevertheless, as in Experiment 3A, HJA performed similarly with wholes (86%, 207/240) and parts (85%, 203/240), $\chi^2 < 1$. With *whole houses*, HJA performed better on same than on different trials (92% versus 81%, $\chi^2(1) = 5.93$, $P < 0.015$); performance with upright houses did not differ with inverted houses (87.5% versus 85%, $\chi^2 < 1$). The same pattern occurred with *house parts*: performance was better on same than on different trials (95% versus 74%, $\chi^2(1) = 88.63$, $P < 0.0001$) and similar with upright as with inverted parts (87% versus 82.5%, $\chi^2 < 1$). Fig. 4 presents HJAs sensitivity to the local changes in houses in terms of d' ; overall his detection performance with whole houses ($d' = 2.25$)

Table 3
Experiment 3: performance of HJA with houses and house parts

	Same trials		Different trials	
	Upright	Inverted	Upright	Inverted
Experiment 3A				
Wholes	52/60 (87)	55/60 (92)	60/60 (100)	58/60 (97)
Parts	52/60 (87)	52/60 (87)	57/60 (95)	56/60 (93)
Experiment 3B				
Wholes	56/60 (93)	54/60 (90)	49/60 (82)	48/60 (80)
Parts	57/60 (95)	57/60 (95)	47/60 (78)	42/60 (70)

Note: percentage correct responses appear between brackets.

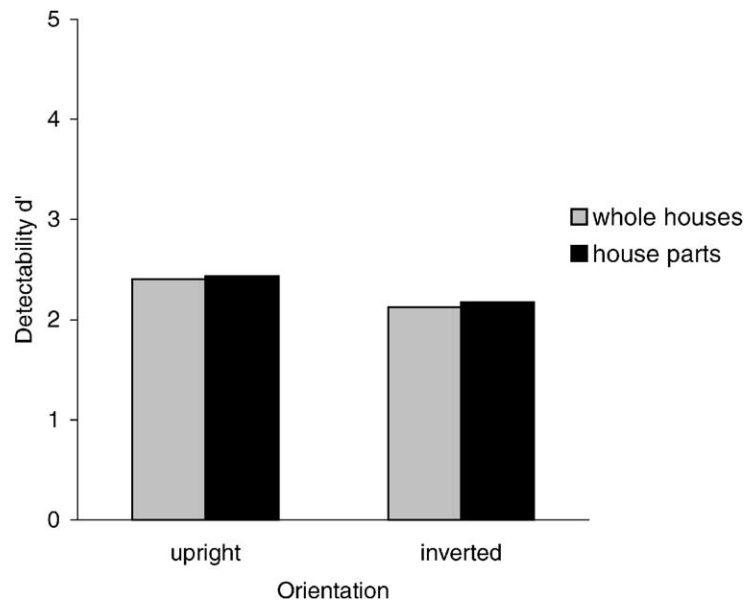


Fig. 4. Detectability performance (d') of HJA with house stimuli in Experiment 3B.

was similar to that with house parts ($d' = 2.24$); moreover, his sensitivity to house stimuli was very similar to his sensitivity to face parts ($d' = 2.21$). There was also no effect of inversion on sensitivity (Fig. 4).

6.3. Discussion

When HJA had to detect local changes to parts of houses, his performance was not affected when the house parts were presented in context; he performed equally well with whole houses as with house parts, even when task difficulty was increased (in Experiment 3B) to make HJAs overall performance similar to that with the face parts in Experiment 2A. Furthermore, a comparison of HJAs performance in terms of signal sensitivity showed that he was equally sensitive to local differences in house parts when they were presented in context or in isolation and that his signal sensitivity with house parts did not differ from that with face parts in Experiment 2. Given the many differences between the face and the house stimuli, HJAs equivalent performance with both face parts and houses (wholes and parts alike), suggests that the marked effect of face context in Experiment 1 cannot be attributed to a general inhibitory influence of context across object categories (also see Section 7), but instead that this effect seems to be specific to faces.

7. Conclusion

The main result from these experiments is clear: HJA is unable to discriminate between normal and Thatcherised facial features in whole faces (Experiment 1), though he can discriminate the features when they are presented in isolation (Experiment 2; Fig. 2). There was no influence of inversion

in Experiment 2 (neither a normal benefit for upright faces nor a paradoxical benefit for inverted faces). The control, however, showed no overall difference in accuracy between whole faces and face parts, along with a benefit for some responses with upright, whole faces. In terms of signal sensitivity (d'), HJA performed at chance level when matching whole faces, but his sensitivity increased dramatically with face parts, although it was still below that of the control. Thus, there was a marked inhibitory effect of face context on HJAs detection of local changes in faces. Moreover, this effect of context seemed to be restricted to face stimuli, as was investigated in Experiment 3 where HJA had to detect local changes with houses. Although the task was equivalent to that with whole faces, HJA showed no effect of context on matching object (house) parts, neither in terms of accuracy nor in terms of signal sensitivity (Fig. 4). Furthermore, when task difficulty was increased (by limiting stimulus duration) to equate performance to that found with face parts (Experiment 2), there was no effect of context. This contrast between HJAs matching performance with houses and faces, suggests that the negative effect of context was particular to faces and therefore, in particular related to his prosopagnosia. However, given that HJA also demonstrates visual agnosia (as well as prosopagnosia) and given the many visual differences between the particular house and face stimuli, we cannot rule out the possibility that in some circumstances object context will affect HJAs perception of object parts (see also below).

HJAs advantage for face parts suggests that face context had an inhibitory influence on his encoding of local part-based information. In addition, since a benefit for upright relative to inverted faces can be considered a hallmark of normal configuration-based processing [9,21], the absence of any reliable effect of inversion on HJAs

performance suggests that configuration-based face processing is impaired in HJA. The form of this impairment is of some interest. The fact that matching was better with parts in isolation demonstrates that information from facial contexts is not simply absent; face contexts disrupt an otherwise relatively intact ability to make local perceptual matches on face parts (as in Experiment 2). However, this disruption does not seem to be due specifically to the configural information present in upright faces, since HJA was impaired with both inverted and upright whole faces. This distinguishes his problem from that found in prosopagnosics showing a paradoxical effect of face inversion [5–7,32]. For HJA, there may be an early perceptual impairment which leads to him being relatively insensitive to local information presented within more global contexts (with upright and inverted faces alike). Other prosopagnosic patients, while still having a perceptual deficit, can process whole faces to some degree, but are disrupted by the configural codes that can be extracted from upright faces.

This contrast in HJAs performance when global face information is present, relative to that when local features are shown in isolation, suggests that his deficit in face processing can be related to either a selective disruption of global processing, or to the impaired integration of part based and contextual information from a face (with part-based processing being relatively intact). This conclusion is similar to that reached from studies of HJAs performance on tasks requiring discriminations to local and global components of compound shapes [26]. For example, Humphreys et al. [18] reported that HJA showed a large global advantage, indicating that he could derive information from across whole shapes. However, despite the large global advantage, HJA did not demonstrate any global–local interference. Humphreys et al. [18] proposed that HJA failed to integrate the global information with the local part descriptions, so that he could attend to local letters without suffering interference from conflicting global information. The derivation of local parts also appeared to be impaired when they were contained within compound wholes, as RTs to local elements in compounds were considerably slower than RTs to the same stimuli presented in isolation [15,16]. As with faces, there appeared to be both poor integration of wholes and parts and a detrimental effect of the whole on responses to parts. Similarly, in studies of visual search HJA is impaired at tasks dependent on the grouping of local forms, requiring that multiple elements be processed in parallel. When elements group he can make far more errors than when he processes each local form serially [19]. Apparently, HJA cannot refrain from processing elements in parallel when grouping cues are available, but his performance is impaired when he does so.

There are thus qualitative similarities between HJAs problems in form processing and his impairments in face perception. The data are consistent with the view that there is an early perceptual deficit in integrating parts with wholes, which impinges on both face and object recognition. Face recognition is particularly disrupted, though,

because it depends strongly on the derivation of configural information. The data also add further weight to the proposal that perceptual forms of prosopagnosia do not merely result in an inability to use information from whole facial contexts, but rather that this information can be disruptive to the processing of local parts.

Acknowledgements

This research was supported by the Medical Research Council. Portions of the data were presented at the Eighth Cognitive Neuroscience Society Meeting, New York City on March 2001. We thank HJA for his kind participation and two anonymous reviewers for comments on a previous version of the manuscript.

References

- [1] Bartlett JC, Searcy J. Inversion and configuration of faces. *Cognitive Psychology* 1993;25:281–316.
- [2] Bodamer J. Die prosop-agnosie. *Archiv für Psychiatrie und Nervenkrankheiten* 1947;179:6–53.
- [3] Boutsen L, Humphreys GW. The effect of inversion on encoding of normal faces and the Thatcher illusion. *Quarterly Journal of Experimental Psychology (A)*, in press.
- [4] Chainay H, Humphreys GW. The real-object advantage in agnosia: evidence for a role of surface and depth information in object recognition. *Cognitive Neuropsychology* 2001;18:175–91.
- [5] de Gelder B, Rouw R. Paradoxical configuration effects for faces and objects in prosopagnosia. *Neuropsychologia* 2000a;38:1271–9.
- [6] de Gelder B, Rouw R. Structural encoding precludes recognition of face parts in prosopagnosia. *Cognitive Neuropsychology* 2000b;17:89–102.
- [7] de Gelder B, Rouw R. Beyond localisation: a dynamical dual route account of face recognition. *Acta Psychologica* 2001;107:183–207.
- [8] De Renzi E. Prosopagnosia in two patients with CT scan evidence of damage confined to the right hemisphere. *Neuropsychologia* 1986;24:385–9.
- [9] Farah MJ, Tanaka JN, Drain M. What causes the face inversion effect. *Journal of experimental psychology: human perception and performance* 1995;21:628–34.
- [10] Farah MJ, Wilson KD, Drain M, Tanaka JN. The inverted face inversion effect in prosopagnosia: evidence for mandatory, face-specific perceptual mechanisms. *Vision Research* 1995;35:2089–93.
- [11] Farah MJ, Wilson KD, Drain M, Tanaka JN. What is special about face perception? *Psychological review* 1998;105:482–98.
- [12] Giersch A, Humphreys GW, Boucart M, Kovács I. The computation of occluded contours in visual agnosia: evidence for early computation prior to shape binding and figure-ground coding. *Cognitive Neuropsychology* 2000;17:731–59.
- [13] Homa DB, Haver B, Schwartz T. Perceptibility of schematic face stimuli: evidence for a perceptual gestalt. *Memory Cognition* 1976;4:176–85.
- [14] Humphreys GW, Donnelly N, Riddoch MJ. Expression is computed separately from facial identity and it is computed separately for moving and static faces: neuropsychological evidence. *Neuropsychologia* 1993;31:73–81.
- [15] Humphreys GW, Riddoch MJ. Routes to object constancy: implications from neurological impairments of object constancy. *Quarterly Journal of Experimental Psychology* 1984;36A:385–415.
- [16] Humphreys GW, Riddoch MJ. To see but not to see: a case study of visual agnosia. Hove, UK: Erlbaum, 1987.

- [17] Humphreys GW, Riddoch MJ. The fractionation of visual agnosia. In: Humphreys GW, Riddoch MJ, editors. *Visual object processing: a cognitive neuropsychological approach*. Hillsdale, NJ: Erlbaum, 1987. p. 281–306.
- [18] Humphreys GW, Riddoch MJ, Quinlan PT. Interactive processes in perceptual organisation. In: Posner MI, Marin OSM, editors. *Attention and performance XI*. Hillsdale, NJ: Erlbaum, 1985.
- [19] Humphreys GW, Riddoch MJ, Quinlan PT, Price CJ, Donnelly N. Parallel pattern processing and visual agnosia. *Canadian Journal of Psychology* 1992;46:377–416.
- [20] Humphreys GW, Rumiaty RI. Agnosia without prosopagnosia or alexia: evidence for stored visual memories specific to objects. *Cognitive Neuropsychology* 1998;15:243–77.
- [21] Leder H, Bruce V. When inverted faces are recognized: the role of configural information in face recognition. *Quarterly Journal of Experimental Psychology* 2000;53A:513–36.
- [22] Levine DN, Calvanio R. Prosopagnosia: a deficit in visual configural processing. *Brain Cognition* 1989;10:149–70.
- [23] McNeil JE, Warrington EK. Prosopagnosia: a reclassification. *Quarterly Journal of Experimental Psychology* 1991;43A:267–87.
- [24] Moscovitch M, Winocur G, Behrmann M. What is special about face recognition? Nineteen experiments on a person with visual object agnosia and dyslexia but normal face recognition. *Journal of Cognitive Neuroscience* 1997;9:555–604.
- [25] Murray JE, Yong E, Rhodes G. Revisiting the perception of upside-down faces. *Psychological Science* 2000;11:492–6.
- [26] Navon D. Forest before trees: the precedence of global features in visual perception. *Cognitive psychology* 1977;9:353–83.
- [27] Perrett DI, Mistlin AJ, Chitty AJ, Harries MH, Newcombe F, De Haan E. Neuronal mechanisms of face perception and their pathology. In: Kennard C, Rose FC, editors. *Physiological aspects of clinical neuro-ophthalmology*. London: Chapman & Hall, 1988. p. 137–54.
- [28] Rhodes G, Brake S, Atkinson AP. What's lost in inverted faces? *Cognition* 1993;47:25–57.
- [29] Riddoch MJ, Humphreys GW. A case of integrative visual agnosia. *Brain* 1987;110:1431–62.
- [30] Riddoch MJ, Humphreys GW, Gannon T, Blott W, Jones V. Memories are made of this: the effects of time on stored visual knowledge in a case of visual agnosia. *Brain* 1999;122:537–59.
- [31] Rock I. On Thompson's inverted-face phenomenon research note. *Perception* 1988;17:815–7.
- [32] Rouw R, de Gelder B. Impaired face recognition does not preclude intact whole face perception. *Visual Cognition* 2002;9:689–718.
- [33] Sergent J, Signoret JL. Varieties of functional deficits in prosopagnosia. *Cerebral Cortex* 1992;2:375–88.
- [34] Tanaka JW, Farah MJ. Parts and wholes in face recognition. *Quarterly Journal of Experimental Psychology* 1993;46:225–45.
- [35] Thompson P. Margaret Thatcher: a new illusion. *Perception* 1980;9:483–4.
- [36] Young AW, Humphreys GW, Riddoch MJ, Hellowell DJ, de Haan EH. Recognition impairments and face imagery. *Neuropsychologia* 1994;32:693–702.