PERGAMON

Neuropsychologia 41 (2003) 702–712

NEUROPSYCHOLOGIA

www.elsevier.com/locate/neuropsychologia

Implicit face perception in a patient with visual agnosia? Evidence from behavioural and eye-tracking analyses

Sandra Lê [a,*], Eric Raufaste [b], Sophie Roussel [c], Michèle Puel [a], Jean-François Démonet [a]

[a] INSERM U455, Federation of Neurology, CHU Purpan, 31059 Toulouse Cedex, France
[b] Work and Cognition Laboratory, University of Toulouse, Toulouse, France
[c] Laboratoire Jacques Lordat, University of Toulouse, Toulouse, France

Received 14 May 2002; received in revised form 30 September 2002; accepted 30 September 2002

Abstract

This paper investigates face perception in a visual agnosic and prosopagnosic patient (SB). Despite very extensive lesions of visual areas, SB remains capable of some visual processing [Brain 125 (2002) 58]. However, in everyday situations SB does not exhibit signs of specific face recognition. To investigate how SB may process faces, we tested two hypotheses. According to the 'spared module hypothesis,' SBs abilities come from spared modules of implicit face processing. According to the 'general strategy hypothesis,' SB may have developed some deliberate compensatory strategies. A two-session experimental design was constructed. In both sessions, face and non-face pictures were shown to participants. In Session 1 (implicit condition), participants had to decide whether each picture was a vegetable. In Session 2 (explicit condition), participants had to decide whether each picture was a face. Verbal reports showed that SB was not aware of faces in Session 1. However, behavioural results showed that (1) SB could process faces; (2) even when SB was not aware of faces, he processed them differently than non-faces; (3) when knowing the presence of faces, he did not process faces better. In addition, eye-tracking data suggested that SB did not change the nature of his processing from Sessions 1 to 2. Pupil diameters showed that fixated facial features were processed similarly as in control participants. Together, these results are not compatible with a general compensatory strategy hypothesis and suggest sparing of an implicit face processing module in SB.

Keywords: Face perception; Prosopagnosia; Visual areas; Eye movements

1. Introduction

This paper addresses, in a patient with a face perception deficit, the notion of covert face processing in the absence of the patient's awareness, and the possible involvement of specific cortical areas in such processes.

Prosopagnosia is a neurological deficit characterised by the inability to recognise the faces of previously known persons in the absence of severe intellectual, sensory or cognitive impairments. Although prosopagnosic patients usually experience a total absence of a feeling of familiarity with faces of known individuals and a failure of overt recognition of these faces, it has been shown that the processing of familiar faces can still take place in the absence of the patient's awareness. This was demonstrated by physiological (skin conductance [3,46], pupillometry [19], and event related potentials [37,42]) and behavioural indices [8,12,39] of recognition showing significant differences in response to familiar and unfamiliar faces (see [9] for a review). Bruyer [9] defines a further area of behavioural study for the covert recognition of faces, namely, the recording of eye movements [9]. Neurologically-intact perceivers tend to adopt a facial feature scanning strategy [30], i.e. they explore preferentially the 'eyes', 'nose', and 'mouth' [48]. The recording of eye movements in two patients with impaired facial learning and recognition showed that fixation, pursuit, saccades, and scanning of salient features of scenes and faces were normal [38]. However, the study of the transitional properties of scanning revealed that the scan paths of personally meaningful familiar faces, whether or not they were consciously recognised, were less predictable than those of other faces [38]. This suggested that as autonomic studies of covert recognition in prosopagnosia, the properties of scanning can be used as an index of higher neural processing.

Evidence from cognitive psychology [7,44,51], computational vision [47], neuropsychology [5,11], and neurophysiology [16,36] suggests that face and object recognition

* Corresponding author. Tel.: +33-5-61-77-9500; fax: +33-5-61-49-9524.
E-mail address: sandrale@toulouse.inserm.fr (S. Lê).

0028-3932/02/$ – see front matter © 2002 Elsevier Science Ltd. All rights reserved.
PII: S0028-3932(02)00204-X

involve qualitatively different processes that may occur in distinct brain areas. At a neuroanatomical level, prosopagnosia is commonly associated with bilateral damage to the region below the calcarine fissure, in the region of the fusiform gyrus [10,20,33,41,50]. However, it has been demonstrated that unilateral damage to the right fusiform gyrus [13–15,28,34,45,49] is sufficient to induce a similar deficit, whilst object recognition (of same difficulty level) may remain more or less spared. On the other hand, impaired object recognition along with relatively spared face recognition can be found after damage to the left inferotemporal cortex, although visual object agnosia is quite often associated with bilateral damage [20,26,32,35].

Recent neuroimaging studies on normal subjects have demonstrated that faces and objects activate different loci in the same cortical area, usually the right fusiform gyrus [1,2,24,27,31,40]. This specific cortical area is called the "Fusiform Face Area" or FFA [27,31]. In a study with fMRI, Kanwisher et al. [27] concluded that the FFA is selectively involved in the perception of faces. However, fMRI studies where subjects viewed faces as opposed to non-face objects (tasks usually used to reveal the right FFA) showed activations in several occipito-temporal areas, including areas in the left middle fusiform gyrus [21,22], bilaterally in the anterior fusiform gyrus [21,40] and a region in the occipital lobe [17,23,25]. As suggested by Gauthier et al. [22], it appears that the area of the occipital lobe that they called the "Occipital Face Area" or OFA, shows the same kind of selectivity to faces (albeit weaker) as FFA. As a part of the early visual areas mediating the first stages of object perception, OFA could be considered as a good candidate for specific detection of faces.

The present study reports the case of a 31-year-old patient (SB) with a severe pattern of visual agnosia following a meningoencephalitis at the age of 3 years [29]. The ensuing cerebral damage was extensive enough to destroy the right and left ventral streams as well as the right dorsal stream (see detailed description in Section 2). As a result, SB became unable to recognise colours, objects, faces, or letters. But strikingly, he is very good at many everyday visually guided actions (see [29] for more details).

With the noticeable exception of OFA, the cortical areas supposedly involved in face perception are lesioned or disconnected in SB. It is perhaps unsurprising, therefore, that SB shows a severe prosopagnosia. On the other hand, despite the severity of his visual deficits, SB is able to demonstrate, in experimental contexts, unexpected visual abilities (particularly visuomotor [29]) including in face perception. As the lesions occurred when SB was a 3-year-old child, one should consider the possibility of an unusual maturation of some brain areas as well as of compensatory adaptations to the primary deficits, in addition to normal properties of undamaged areas (e.g. OFA).

The present study combines behavioural testing and eye-movement analyses to further investigate implicit and explicit face processing in SB.

2. The patient SB

SB is a 31-year-old right-handed man who suffered brain damage as a result of a meningoencephalitis sustained at the age of 3. MRI conducted in 1998 revealed lesions of occipito-parietal and occipito-temporal regions in the right hemisphere, and mainly of the occipito-temporal junction in the left hemisphere (Fig. 1). The lesions were localised according to atlases from Talairach and Tournoux [43], and Duvernoy [18].

In the right hemisphere, lesions involve most of the ventral visual areas (i.e. the inferior temporal gyrus, the inferior occipital gyrus, the fusiform gyrus, and the inferior lingual gyrus). In the dorsal visual areas, lesions involve the middle occipital gyri and, to a lesser extent, the superior occipital gyrus. In the temporal lobe, the lesions involve the middle temporal gyrus as well as a limited portion of the superior temporal gyrus. Partial damage to the right inferior parietal lobule is also present in the region of the supra-marginal gyrus. The spared regions in the right occipital pole involve the posterior inferior part of V2, the primary visual cortex at least in its rostral and superior aspects and presumably the area involving the OFA. Among the right parietal regions, the greater part of the angular gyrus and a limited portion of the posterior part of T2 are spared.

In the left hemisphere, lesions are much smaller and concern mainly the ventral visual cortex, involving a complete destruction of the ventral part of the occipital-temporal junction (fusiform gyrus). The lesion spreads further dorsally and partially involves the middle occipital gyrus. On the contrary to the right hemisphere, occipito-parietal areas are largely spared by the lesions.

Neuropsychological investigation (see [29] for details) revealed a profound visual agnosia, where patient SB showed an inability to recognise faces, colours, words and objects by sight. The recognition of objects was flawless through other sensory modalities. SB obtained a verbal IQ of 98 on the WAIS-R. SBs perception of motion was preserved, as well as his vision for action, and to a lesser extent his visual imagery and ability to copy certain drawings. In general SB resorts to a slow, feature-by-feature visual strategy when attempting to identify objects.

With regard to face recognition, SB showed a severe prosopagnosia. Apart from contextual guessing, SB used other visual cues to recognise people, such as gait, or silhouette. He was not able to readily discriminate between human faces and non-face stimuli. It was only after a certain time and a lot of efforts that SB eventually perceived the characteristic features of a face, such as 'eyes', 'nose', 'mouth', etc. Despite this, SB remained totally unable to recognise facial expressions, nor to discriminate familiar faces from those unfamiliar to him. In a face matching task (with images from different viewpoints), like the Benton facial recognition test [6], SB obtained a score of 35/54 (65%). These performances are just above chance, which according to the Benton's test scoring, corresponds to a severe deficit in face