SHORT REPORT

Separate visual pathways for perception of actions and objects: evidence from a case of apperceptive agnosia

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Abstract

Recognition of different kinds of visual stimuli was studied in a patient who acquired apperceptive visual agnosia after a bilateral occipitotemporal lesion which partially spared the primary visual cortex. Impairment in recognising static objects perceived visually sharply contrasts with the relatively well preserved ability to recognise objects from gestures illustrating their use, and to recognise actions shown in line drawings. It is suggested that the occipitoparieto-frontal pathway is involved in the recognition of actions, and in the recognition of objects when sensorimotor experience is evoked.

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Visual agnosia is the inability to recognise visual stimuli despite adequate elementary visual function. Visually agnosic patients are unable to produce gestures of object use or to show any recognition of the objects they fail to name. According to Lissauer,[1] visual agnosias can be classified as apperceptive, in which case the person never achieves a complete conscious percept of the stimulus, or associative, in which such an adequate percept is stripped of meaning.

Several studies[2-5] have shown that the recognition of a visually presented static object is mediated by a hierarchically organised occipitotemporal pathway that includes distinct regions for processing the visual features of objects. By contrast, recent work suggests that the occipitoparietofrontal stream might be involved not only in the spatial localisation of visual stimuli,[2] visually guided movements,[6] particularly grasping,[7] movement perception,[8] and visuospatial working memory,[9 10] but also in the recognition of goal oriented actions.[11-14]

The present study considers a case of apperceptive visual agnosia. It focuses on performance differences between recognition of actions represented by line drawings and recognition of objects presented visually. In the light of recent studies,[14-17] it is hypothesised that the anatomical structures involved in the acquisition of knowledge about a concept are essential to its

subsequent recognition. Therefore, the recognition of an object from a static visual presentation of it may essentially involve the occipitoinferotemporal pathway. By contrast, because actions are learned primarily through sensorimotor experience, the recognition of an action represented in a photograph, or the recognition of an object from a visual presentation of a gesture illustrating its use, may chiefly involve the occipitoparietofrontal stream.

Case report

The patient was a right handed 65 year old retired male engineer. He had a left occipitotemporal haemorrhage in 1981 and a right occipitotemporal haemorrhage in 1991 (fig 1).

His general neurological examination was normal. Neuropsychological assessment disclosed a verbal intelligence quotient of 150 (WAIS), a memory quotient of 85 (Wechsler R), and intact speech (BDAE). He was able to write, but he was forced to use a letter by letter strategy to read. He had complete achromatopsia (Ishiara test), and impaired visual recognition of objects and faces. He exhibited bilateral quadrantanopia (right inferior and left superior quadrants). P100 visual evoked potentials were spared. Visual acuity was normal in the preserved visual fields. His pupillary responses were normal and his voluntary eye movements were complete.

Despite the fact that he could describe a visually perceived object in detail, he failed to relate individual elements to the whole, and consequently, he was not able to identify it. He could produce accurate copies of line drawings of objects by implementing a piecemeal, line by line copying strategy that was extremely slow (for example, he took eight minutes to copy a drawing of a comb). He was unable to match objects seen from different views (13/23). In an object decision task in which he was required to determine whether line drawings corresponded to real objects (Snodgrass and Vanderwart set[18]) or to non-objects (Kroll and Potter set[19]), his performance was deficient (31/40), indicating that his ability to access structural object knowledge through visual presentation was impaired. The utilisation of silhouettes of these same stimuli did not improve performance

(26/40). His score on Benton's judgment of line orientation test was normal (23/30).

EXPERIMENTAL INVESTIGATION

To investigate the patient's visual object recognition deficit, we compared his object recognition performance in different modes including visual presentation of a static real object, visual presentation of a real object being moved in a non-specific way by the examiner (rotation and horizontal displacement), tactile presentation, verbal definition, examiner pantomime of how the object might be used, and examiner utilisa-

tion of the object. The same set of 30 real objects was used for all tasks. As the table shows, visually presented object recognition was impaired. By contrast, recognising objects on tactile presentation (McNemar symmetry $\chi^2 = 19.0$, p<0.0001), verbal definition (McNemar symmetry $\chi^2 = 21.0$, p<0.0001), pantomimes of object use (McNemar symmetry $\chi^2 = 14.2$, p<0.001), and utilisation of real objects (McNemar symmetry $\chi^2 = 17.0$, p<0.0001) were significantly better. These results confirmed that he was particularly
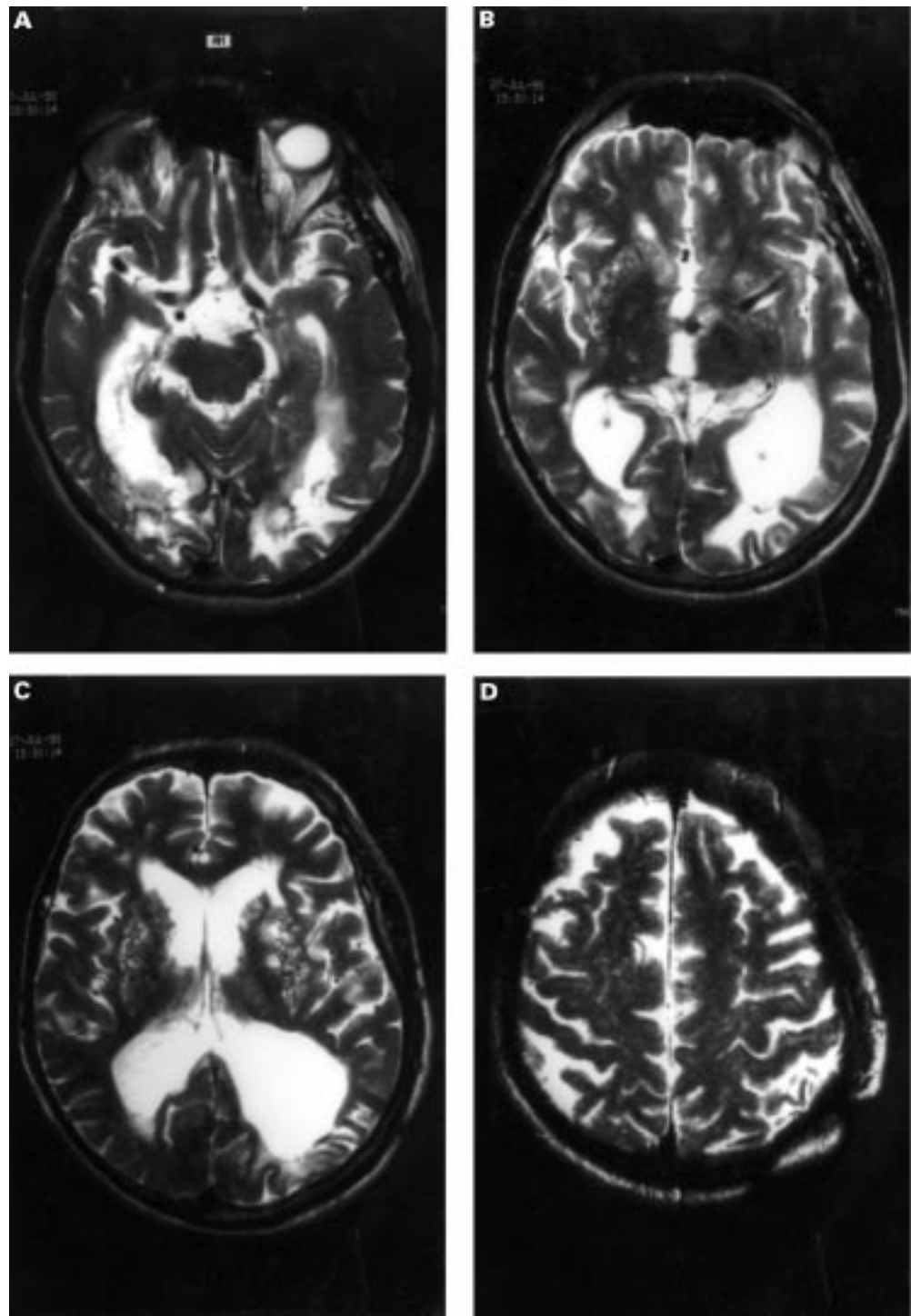

Figure 1   Representative horizontal MRI cross section of the patient.

Table 1 The patient's results on naming tests

Type of presentation	Stimuli (n)	Correct responses (n (%))
Visual, real objects:		
Static	30	7 (23)
Non-specific movement	30	3 (10)
Tactile: real objects	30	26 (87)
Verbal	30	28 (93)
Pantomime of use	30	23 (77)
Object use	30	24 (80)
Line drawings of objects	122	3 (2.5)
Line drawings of actions	42	24 (57)

impaired in object recognition on visual presentation.

Two experiments were conducted to verify the potential dissociation between object and action naming on static visual presentation.

The first experiment required recognition of line drawings of objects (n=122) taken from the Snodgrass and Vanderwart set.[18] The drawings were presented on a screen (25×19 cm) connected to a microcomputer. Each drawing was displayed in the middle of the screen and remained there until a response was given, after which it disappeared. The screen was blank for 10 seconds between presentations. The stimuli included tools, fruits, vegetables, and animals.

The second experiment involved retrieving an action verb when looking at a line drawing depicting that action (n=42). The line drawings of the actions were presented under the same conditions as the line drawings of the objects. Each drawing was obtained by modifying a black and white photograph using Adobe Photoshop™ 2.5.1 software. The final drawing essentially retained the contour of the picture and a few details (example in fig 2).

As shown in the table, the patient's ability to name actions when looking at the corresponding line drawings was markedly different from his ability to name line drawings of objects taken from the Snodgrass and Vanderwart set (χ^2 = 67.9, p<0.001). These findings indicate that the severity of this patient's visual perception deficit depends on the type of stimulus being recognised.

Figure 2 Example of an action line drawing correctly identified by the patient.

The line drawings of objects from the Snodgrass and Vanderwart set and the black and white photographs corresponding to an action were presented to a group of 17 normal subjects matched by age and educational level to the patient. The experimental conditions were the same as those used for the patient. Vocal response time was directly recorded by the computer with a microphone linked to it. For this group, the vocal response time recorded for verb evocation (t=1447 ms (SD 1008)) was significantly longer than it was for object name evocation (t=1244 ms (SD 868)) (repeated measurement analysis of variance (ANOVA) $F(1,96)$ = 8.0, p<0.01). This suggests that, for the control group, verb evocation was not easier than object name evocation. Nevertheless, with such a task, we cannot determine which level(s) of visual information processing and/or name evocation is (are) responsible for the significant differences obtained in the response time of the control group. Note also that even when the patient's ability to recognise a line drawing of an action was compared with that of a real object, action recognition was significantly better (χ^2=8.2, p<0.01).

Discussion

The patient had apperceptive visual agnosia after a bilateral occipitotemporal lesion which partially spared the primary visual cortex (fig 1). He exhibited a deficit in recognising real objects presented visually and object line drawings. This deficit is accompanied by a visual perception disorder characterised by a piecemeal, line by line copying strategy, and impairment in matching objects from different views and performing an object decision task. By contrast, he was able to name objects on tactile presentation and verbal definitions, showing that the deficit solely concerned visual input. Moreover, he was able to recognise actions shown in line drawings, in addition to objects from pantomimes depicting how they are used (table).

This case is of particular interest because the patient was able to recognise actions presented in line drawings and objects the use of which is pantomimed by the examiner. His ability to recognise action drawings should be a consequence of the extracontextual information contained in this type of stimulus compared with object drawings. In a case study of a patient with apperceptive visual agnosia, Riddoch and Humpreys (1987)[20] showed that their patient was better at identifying objects when paired with an appropriate context than when shown in isolation. Such a finding suggests that semantic information can be used to decide between alternative interpretations of visual input. Nevertheless, when the scene context was given along with two visually similar objects, the results did not differ from those of isolated object identification. This suggests that visual object identification is sensitive to the effects of context, but, as those authors claim, "contextual input does not override an early deficit in the integration of visual form". Therefore, extracontextual input of action line

drawings might facilitate recognition of the action, but it remains undetermined whether context is the main cause of the patient's good performance on action drawing recognition.

An alternative way of interpreting the patient's preserved ability to recognise actions presented in line drawings and objects the use of which is pantomimed by the examiner, and the patient's impaired ability to recognise visually presented objects, would be that the visual pathways required to perceive actions are different from those required to perceive objects. Over the past 20 years, many different visual areas have been described. In 1982, Mishkin and Ungerleider[2] distinguished two visual cortical pathways. The occipitotemporal stream was shown to be mostly involved in object identification, whereas the occipitoparietal pathway was shown to be implicated in the spatial localisation of visual stimuli. Later, the occipitoparietofrontal pathway was found to be involved in visually guided movements[6] and especially in grasping,[7] movement perception,[8] visuospatial working memory,[9 10] and recognition of a goal oriented action.[11–14] The present findings suggest the involvement of the occipitoparietofrontal pathway in the visual perception of hand and body position and movement.

It was recently shown in monkeys that a group of F5 neurons (region considered to be the homologue of the caudal part of the human inferior frontal gyrus[21]) responds selectively to the sight of actions carried out by others.[13] It is important to note that the main cortical input of F5 comes from anterior intraparietal area 7b,[22] where a neuron coding action has been reported.[23] Frontal neurons selectively responding to the sight of actions were also described in humans by Fadiga *et al*[11] and Rizzolatti *et al*.[12] These authors suggest the existence of a system that matches action observation and execution, and suspect that the motor system is not devoted solely to the production of movements but is also involved in their recognition. Therefore, we speculate that the patient was able to identify objects from a gesture illustrating their use because this type of visual information is processed in the occipitoparietofrontal stream.

Studies on patients with ideomotor apraxia after parietal lesion support this hypothesis.[24] Such patients, who are unable to make symbolic gestures or act out the use of an object on verbal request or imitation, are sometimes also incapable of recognising a correctly produced gesture given a stationary (photograph) or moving visual presentation. Other studies[25] have shown that these patients are also unable to use the mental reconstruction of a gestural image to predict the amount of time it would take to make finger movements and visually guided pointing gestures, compared with normal subjects and patients with a lesion in the primary motor area. These findings thus suggest that the neural network involved in gestural programming is also involved in gesture recognition and mental reconstruction.

The results obtained in the present study, in which the patient's impairment in visually recognising static objects contrasts with his preserved ability to recognise objects from gestures illustrating their use and to recognise actions shown in line drawings, suggest that the occipitoparietofrontal pathway is involved in conscious visual perception and in the interpretation of goal oriented actions, even when shown in a static way.

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