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# The Influence of Visual Field Disorders on Visual Identification Tasks

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**Summary.** Visual identification of shapes, figures, objects and faces was tested in a group of 26 patients with homonymous field defects due to unilateral "posterior" brain damage. In addition, a search test was used for evaluation of the effect of visual field loss on visual information acquisition. Of the patients, 5 performed entirely normally, i.e. errorless and within age-matched time limits, in all tests. The majority of patients ($n = 15$) also performed correctly but required significantly more time than normals. In contrast, 6 patients showed a rather specific impairment in visual identification tasks. It is argued that visual field loss per se does not impair visual identification but may affect visual search and, thus, information acquisition. Visual identification may be impaired, however, if brain damage involves the inferotemporal cortex.

**Key words:** Object recognition – Visual field defects – Visual search

## Introduction

Since the early work of Lissauer [5] and Siemerling [7] it has been known that brain damage can cause impairments in visual object identification. Lissauer interpreted the identification and recognition deficit in his patient as rather specific, i.e. not secondary to impaired visual sensory functions, and therefore termed it as "agnostic". Siemerling [7], in contrast, showed that disturbance of "primary" visual abilities (visual field, acuity, contrast and colour vision, visual search, etc.) can also lead to severe impairment in object identification, which can hardly be distinguished from "agnostic" disorders. Hence not all impairments in object identification can be termed agnosia.

Since these early contributions, disorders of visual identification have repeatedly been reported in the neuropsychological literature (for reviews see [10] and [12]). Most authors, following Lissauer's terminology, have interpreted impairments in object identification as "agnostic" even though these patients also suffered from severe "primary" visual deficits [12]. It is not yet clear, however, to what extent primary visual disorders can per se impair visual identification, and how one could differentiate between this type of impairment and specific disorders of object identification.

To throw some light on this question we examined a group of patients with visual field disorders due to unilateral brain damage using a series of visual matching and identification tasks. In addition, visual search was tested in order to evaluate in particular the influence of visual field loss on information acquisition.

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## Patients and Methods

*Patients.* In total 26 patients participated in this study all suffering from unilateral cerebrovascular brain damage. Side, site and extent of lesions were evaluated on the basis of cranial computerized tomography. Clinical details of patients are summarized in Table 1. All patients suffered from visual field loss; mean visual field sparing in the affected hemifield was about 3° visual angle. Visual acuity, colour vision (as tested by the Farnsworth-Munsell 100 hue test) and stereopsis were within normal limits.

Formal testing did not reveal any severe neuropsychological deficits (aphasic or memory disorders) which could interfere with the testing of object identification. It is important to note that none of the patients had difficulties in recognizing familiar objects or persons.

### *Methods*

All stimuli (shapes, figures, objects, faces) were presented as black and white photographs. Except for the test on face constancy, perspective of visual stimuli was kept constant. The patients were allowed to perform the tasks without time limit.

**Table 1.** Clinical details of patients ($n = 26$). A: Patients with left-sided ($n = 12$), B: with right-sided brain damage ($n = 14$). Inf: patients with infarction, IH: with intracerebral haemorrhage. M: mean, R: range

| | | A | B |
|---|---|---|---|
| Age (years) | M: | 51 | 54 |
| | R: | 21–77 | 24–78 |
| Sex | Females: | 05 | 06 |
| | Males: | 08 | 07 |
| Aetiology | Inf: | 10 | 09 |
| | IH: | 03 | 04 |
| Time since lesion | M: | 7.4 | 8.1 |
| (in months) | R: | 4–20 | 2–23 |
| Visual field defects | | | |
| Hemianopia | | 10 | 12 |
| Quadranopia | | 02 | 01 |
| Paracentral scotoma | | 01 | 00 |
| Residual field | M: | 2.5 | 2.8 |
| (in deg) | R: | 1–3.5 | 1–8 |

*Identification of overlapping figures* was examined using a modified version of Poppelreuter's test [6]. Six stimulus displays were presented containing 5 overlapping figures each. Thus, the "ground" in these displays did not consist of "visual noise" but of other figures serving alternately as test stimulus or ground. The subjects were instructed to name or outline all figures they could identify.

*Matching of Random Shapes.* A total of 40 random shapes, differing in various shape properties (size, spatial orientation, number of corners etc.) were taken from a shape association test [9]. Then 10 shapes were selected by chance as test stimuli and each was shown as a separate photograph. The subjects were asked to identify the test stimuli on the stimulus array containing the 40 shapes by matching.

*Matching of Composite Parts with the Complete Object or Face.* Subjects were asked to match a fragment of a photograph of an object (e.g. a key, pliers, an electric bulb) with the complete figure of this object. In addition to the object containing the fragment, two other objects of the same category (e.g. keys) with similar features as the fragment were shown so that the subjects had to choose between 3 alternatives for each fragment. A similar task was performed with faces using 6 fragments of unfamiliar faces, showing approximately one-quarter of a face each. Subjects were asked to match these fragments with 8 complete faces (4 females, 4 males). Face fragments were selected in such a way that the subjects had to choose between two alternatives.

*Recognition of Incomplete Objects.* Some 15 incomplete familiar objects (e.g. a banana, a hammer, a shoe) were shown to subjects who were asked to identify them by naming.

*Face Constancy.* To test face constancy we used the face recognition test of Benton and van Allen [2]. This test includes matching of identical front-view photographs of a face (Part A), matching of a front-view with views from different angles (Part B), and matching of front-view photographs under different lighting conditions (Part C). The "test" faces differed between and within the three parts of the test. Subjects were asked to identify the "test" face, shown separately, in a display of 6 different faces containing the "test" face either once (Part A) or three times (Parts B and C).

*Visual Search.* Visual search was tested using a modified version of Poppelreuter's visual search test [6]. The test consisted of 40 different letters, numbers and two-dimensional geometric forms, distributed quasi-randomly so that each quadrant of the display contained 10 stimuli. Then 10 test items were shown separately in the centre of the display. The subject's task was to discover the test stimuli as quickly as possible.

Before examining the patients, all tests, except that for face constancy, were administered to 2 groups of 20 normal subjects differing in age (mean age of young group: 33 years, range: 20–40; mean age of older group: 56 years, range 41–78). The performance of these subjects was taken as a reference for patients with regard to errors and time required to perform a particular test. For recognition of incomplete objects and face constancy only responses were recorded. Normative values for the test of face constancy were taken from the literature [2].

**Table 2.** Mean search time and mean time required to perform the different identification tasks (in min, range in brackets). Results of normal subjects and of patients unimpaired in object identification tasks (A: with left-sided brain damage, $n = 9$; B: with right-sided brain damage, $n = 11$)

| | | Normals | | Patients |
|---|---|---|---|---|
| Visual search | < 40 | 1.3 (0.9–1.7) | A: | 4.6 (2.9–8.2) |
| | > 40 | 1.7 (1.2–2.5) | B: | 4.3 (2.8–9.3) |
| Idenfication of overlapping figures | | 1.1 (0.7–1.4) | A: | 2.7 (1.8–8) |
| | | | B: | 2.9 (2–11) |
| Matching of random shapes | | 2.1 (1.2–3.1) | A: | 8.2 (3.5–12) |
| | | | B: | 7.9 (3.8–11.3) |
| Matching part-whole, objects | | 3.5 (2.2–4.1) | A: | 7.8 (3.7–15.6) |
| | | | B: | 9.3 (4.1–18.6) |
| Matching part-whole, faces | | 2.4 (1.4–3.2) | A: | 9.7 (2.7–24.2) |
| | | | B: | 9.3 (3–26.1) |

Data were statistically analysed using the *t*-test (two-tailed critical values) and the Pearson correlation coefficient.

## Results

*Normal Subjects.* Both groups of normals performed all tests errorr-free. Regarding performance time, the older group required significantly more time than the younger only in the visual search test ($P < 0.01$).

### *Patients*

*(1) Visual Search.* The performance of all patients was error-free in the visual search task. In contrast, search time was significantly increased in the majority of patients (21 cases) as compared to age-matched normals ($P < 0.01$; see Table 2). Although they also suffered hemianopia with field sparing of less than 3° visual angle, 5 patients performed within the normal age-matched range of time.

As for normals, we also found a significant correlation between search time and age in brain-damaged patients ($r = 0.56$, $P < 0.05$). Furthermore, in the group of cases with impaired visual search, search time correlated significantly with the amount of field sparing ($r = -0.78$, $P < 0.02$) indicating that patients with small field sparing required, as a rule, more time for search. However, as indicated previously, 5 hemianopic patients also performed normally despite field sparing of less than 3° visual angle. Time since lesion also seemed to play a role since correlation between search time and this variable was significant ($r = -0.83$, $P < 0.02$) indicating that patients who were tested earlier after brain damage performed more slowly than patients tested later. Search times did not, however, differ significantly between patients with left- and right-sided brain damage ($P > 0.50$).

*(2) Patients Without Impairment in Visual Identification Tasks.* In the visual identification tasks 21 out of 26 patients performed without errors in all tests. However, only those 5 cases who had performed within normal time limits in the visual search task, also did so in the identification tasks, except in the part-whole matching task. The other patients of this group ($n = 15$) required significantly more time than normals in all tests ($P < 0.01$). Data are shown in Table 2 for those tests for

**Table 3.** Performance of patients (mean number of errors, and mean time in min, range in brackets) showing impairment in object identification tasks ($n = 6$)

| | Errors | Time (in min) |
|---|---|---|
| Visual search | 00 | 5.2 (3–8.6) |
| Identification of overlapping figures | 5.5 (4–8) | 4.8 (2.1–7) |
| Random shape matching | 3.2 (2–5) | 6.8 (4–12.2) |
| Matching part-whole, objects | 5.8 (3–8) | 10.5 (5.7–16.6) |
| Matching part-whole, faces | 4.7 (3–6) | 9.7 (8–11) |
| Recognition of incomplete objects | 6.7 (3–8) | — |
| Face constancy | 6.3 (3–8) | — |

**Table 4.** Reduction in test performance in 6 patients with "posterior" brain damage showing specific object identification impairment

| | |
|---|---|
| Matching part-whole, objects | 85% |
| Matching part-whole, faces | 78% |
| Face constancy | 68% |
| Recognition of incomplete objects | 45% |
| Matching of random shapes | 30% |
| Identification of overlapping figures | 18% |

which time was recorded. Again, there was no difference between patients with left- or right-sided brain damage with respect to time required to perform the tests ($P > 0.20$).

*(3) Patients with Impairment in Visual Identification Tasks.* A small group of patients ($n = 6$; 3 with left-, and 3 with right-sided lesions) showed a relatively high number of errors in the identification tasks (Table 3). They did not differ significantly, however, from the unimpaired group with respect to search time and time required to perform the tasks ($P > 0.10$). Taking into account the number of items in each test, the percentage of failures differed widely as shown in Table 4. Matching part-whole for objects and faces was, on average, most severely impaired, followed by face constancy. In these 3 tasks, all patients failed to some extent. A less severe performance deficit, not present in all cases, was found for identification of incomplete objects and for matching of random shapes.

Qualitative analysis of errors revealed that patients mainly had difficulties in selecting all the properties required for correct identification, e.g. 1 patient assigned a screwdriver to one of three other screwdrivers using only the shape of the handle but disregarding differences in the tip. Another patient, in contrast, matched a female face only on the basis of the earring. It is interesting to note that these patients did not benefit from additional instructions or cues. They were convinced that their performance was correct and refused to reconsider their decision.

## Discussion

Our observations indicate that unilateral "posterior" brain damage can affect visual identification performance in two different ways: either patients need more time to perform the tests correctly because of difficulty with information acquisition or they may be impaired in selecting appropriate properties for identification.

Homonymous visual field defects were, at least in our group of patients, presumably the most relevant factor impairing visual information acquisition. Especially when involving the central portion of the visual field, field loss may impair patients' view over a stimulus array. As a consequence, they had to shift their gaze more often than normals between and within objects in order to perceive them completely and, thus, be able to identify and match them. Furthermore, as the outcome of the visual search test suggests, visual search was also very often impaired in patients with field defects [4, 6]. Another factor which might, at least in part, also be responsible for the elevated search and recognition times in these patients is mental slowness [3].

Summarizing these observations, it can be concluded that visual field loss per se does not impair object identification if sufficient time is given to the patient to perform the task. However, with limited testing time, incorrect responses might occur.

In contrast to the patients with increased identification time but otherwise unimpaired object identification performance, a small group of cases had difficulties in selecting and using the object properties required for correct identification. These patients used, as a rule, only a few (global or local) object properties. It seems as if these patients match shapes, figures, objects or faces merely on the basis of correspondence of single properties, not taking into consideration whether or not these properties are sufficient for correct matching. This failure may be interpreted as evidence for a rather specific impairment, since identification and selection of object features obviously represent essential processes in object recognition. It is important to note, however, that none of these patients failed in recognizing objects; their impairment was only discovered by tasks demanding highly specific selection of stimulus properties.

With regard to brain pathology, all patients with specific impairment in object identification showed, in addition to occipital damage, damage to the inferotemporal region supporting the hypothesis that this brain region plays an essential role in object identification [1, 8, 11]. In contrast, none of the patients with error-free performance in the identification tasks suffered from inferotemporal damage. It remains, however, open to further investigations which parts of the inferotemporal region are critically involved in visual identification.

In conclusion, for testing patients with "posterior" brain damage one should take into account difficulties in visual search, especially in cases with visual field defects which, as a rule, impair visual information acquisition. In contrast to this "unspecific" impairment however, specific identification disorders as characterized, e.g. by the inability to select all the properties required for correct identification exist. The ability to identify and select the "critical" object features requires perceptual as well as cognitive components which should, therefore, be considered as interactive and not as separate processes.

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