

Impaired Picture Recognition with Preserved Object Naming and Reading

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A case study is reported on a left posterior cerebrovascular accident involving the infracalcarine cortex. The patient (HG) exhibited a marked color anomia and picture naming deficit (photograph anomia) without alexia. However, objects were named successfully from either visual or tactile inspection. Despite successful object categorization in several tasks, it is argued that HG's picture naming deficit is dependent on a disorder of recognition (access to the stored structural descriptions for objects). A similar functional impairment can account for HG's impaired color naming. The site of HG's cortical damage implies that recognition disorders can result from a unilateral left-sided lesion. © 1994 Academic Press, Inc.

INTRODUCTION

Most contemporary models for naming a visually presented object (Morton, 1979; Seymour, 1979) have their roots in those proposed by neurologists in the last century (Kussmaul, 1877; Broadbent, 1879; Charcot, 1883; Wernicke, 1886). The models consist of three main stages: the first is the formation of a temporary representation (sometimes called visual analysis), the second is activation of the corresponding representations within the "cognitive system," and the third is activation of a (phonological) description at a dictionary of lexical entries. The second stage may be divided into representations (stored structural descriptions) con-

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cerned with recognition and with the subsequent activation of associated knowledge.

Studies of object recognition disorders (Riddoch & Humphreys, 1987a) have shown that there are several routes to the representations used for recognition. The present case (HG) illustrates the consequent difficulties in assessing the intact status of the recognition stage. Further, it emphasizes the need for visual information to have proper access to structural descriptions during object naming. In the present paper, a stored structural description will be referred to as a pictogen (Seymour, 1979). A pictogen is the equivalent of Morton's (1979) word recognition device (logogen) in that it is activated by all views of the same object. A pictogen may even fire to grossly dissimilar visual versions of an object type (Warren & Morton, 1982). It will be argued that HG requires more information than in normals to access the pictogen. For HG, naming of real objects presented either visually or for tactile inspection was reliably better than naming photographs or line drawings of the same objects. Thus, as in other cases of naming impairment (Bisiach, 1966; Benton, Smith & Lang, 1972; Damasio, McKee & Damasio, 1979; De Renzi, Zambolin, & Crisi, 1987), naming performance was improved by providing the extra perceptual information that distinguishes a real object from the 2 D depiction.

The plan of the investigation was first to examine the status of processes involved in recognition. The examination included tasks that assessed apperception (i.e., perception that does not rely on object knowledge) and also those concerned with the address of the pictogen. Second, stimulus variables were assessed for their effect on naming performance (experiments 1-7). Object and color categorization were considered separately. Third, the patient's preserved reading and writing was studied.

CASE DESCRIPTION

HG is a right-handed German housewife with a middle-class education and 8 years of schooling. She was a native speaker of German with some knowledge of Italian. During the second world war, she had moved to Italy with her Italian husband but had returned to Germany with her two children after 5 years. In the first week of January, 1989, the 79-year-old patient noticed a sudden loss of orientation and that her vision had become blurred. The subsequent neurological examination in Luedenscheidt revealed a left posterior cerebrovascular accident. The report further mentions right-sided hemianopia, alexia, and an impairment of color naming. The patient's neuropsychological disorder was diagnosed as a posterior disconnection syndrome. The patient was referred to Aachen for a clinical examination at the end of February. She was wearing a hearing aid and had diabetes.

The CT-scan recorded 2 months postonset showed a circumscribed

lesion in the territory of the left calcarine artery. Moreover, there were signs of paraventricular cerebral microangiopathy as well as brain stem lacunae.

The CT-series consisted of 20 scans with a thickness of the slices of 4 mm in the basal and 8 mm in the dorsal planes. The localization of the structures and regions affected by the lesion was determined by a method of three-dimensional reconstruction of the scans using an averaged digital brain atlas (Niemann, Keyserlingk, & Wasel, 1988); this method takes into account the enormous variation in size and shape of the human cerebrum. The atlas is based on three-dimensional measurements of 50 brains and it contains about 200 structures together with their local variance. From the 20 scans, the surface of the patient's head is reconstructed, and structures in the series are automatically labeled using the digital brain atlas. The reconstructed CT-lesion was restricted to the mesial infracalcarine lingual portion of areas 18 and 19 with a patchy lesion in area 17. Thus, the fusiform and cuneus were not involved and the splenium seemed to be spared. The NMR-scan taken 24 months later fully confirmed the CT-diagnosis (see Fig. 1).

Perimetric examination showed a right-sided homonymous hemianopia. Visual evoked cortical potentials measured by hemifield presentation showed stimulation in the left visual field but severely reduced potentials when the right visual field was stimulated. Visual acuity was corrected (.2 in the right eye, .3 in the left eye). Color vision measured with the Ishihara test was normal. The results of Lanthony's desaturated 15 hue test showed a mild blue/yellow impairment for each eye normal for the patient's age. Stereopsis, as measured by the TNO test for stereoscopic vision (1972) was good.

PRELIMINARY NEUROPSYCHOLOGICAL EXAMINATION

The patient was given routine neuropsychological examinations to investigate her sensory discrimination and the alexia initially reported. HG showed perfect size discrimination (26/26) and line length discrimination (9/9) from arrays of two, three, and four stimuli. In an adaptation of the Poppelreuter Overlapping Figures Test, 11 simple line drawings were superimposed on one another in different combinations two or three at a time. HG was able to match all figures consisting of two shapes (14/14) and (8/10) of those containing three shapes. Her copying of shapes was within normal limits (17/20) in De Renzi's test (1977) for constructional apraxia, but she had some difficulty representing three-dimensionality in both geometric shapes and real objects. Her copy of the Rey-Osterrieth Figure was relatively accurate but performed very slowly. The test was abandoned after 25 min at which point HG had completed 3/4 of the copy.

HG also showed preserved ability to match identical colors. HG was

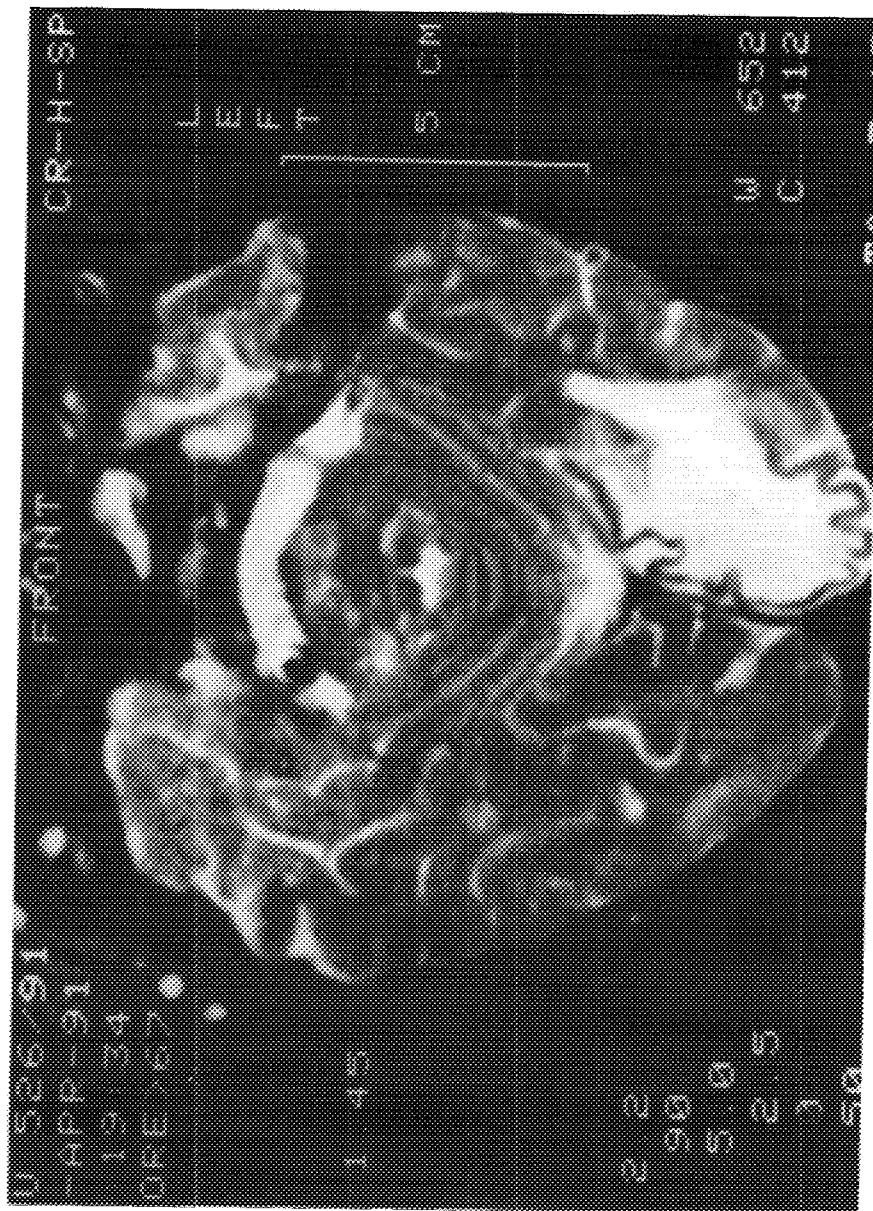


Fig. 1. NMR-scan of HG's lesion. Left hemisphere stroke in the territory of the *A. cerebri* posterior with sparing of the corpus callosum.

asked to find the five identical pairs within a random spatial array of 10 color patches of closely similar hues. She found them without error in four separate tests covering "red," "yellow," "green," and "blue" colors.

Examination with a standardized German aphasia test (AAT) 1 month postonset showed no aphasic symptoms in spontaneous speech, mild disturbances on the Token Test, repetition, reading and writing, and language comprehension, but a medium to severe disturbance in picture naming. Misnomers were generally semantically unrelated to the target, e.g., suitcase: bible; cigar: door with a lock; typewriter: ashtray. Presentation of 15 real objects for naming (nonstandardized task) that the patient could see and touch led to a flawless performance; this result was then amplified by a comparison of 50 objects named first from touch and subsequently as photographs. There were no errors in tactile naming but 21 errors to the photographs. There was only 1/27 errors in naming to description (nonstandardized test). On a subtest (oral or written word to picture matching) of the PALPA battery (Kay, Lesser & Coltheart, 1992) she made only 3/40 errors on both versions. The alexia mentioned in the examination carried out close to onset was no longer present.

HG was also asked to produce proper nouns. She was given 30 very familiar items to be named by a proper noun. These consisted of 6 city names shown, for example, by a picture of the Eiffel Tower to which the response was Paris, 6 countries shown in an unlabeled map with a red blob on the country to be named, 6 cars, 6 entertainers, 6 politicians. The photographs of the people and the other stimuli were given in a randomized block. After an interval of 1 week, the photographs were presented in a multiple choice to an auditorily presented name with 5 distractors from the same category.

HG correctly named 13/30 items with 6 further accurate identifying descriptions. She made 6 within-category errors and 5 no responses. The correct scores were cities (4/6), countries (2/6), cars (2/6), entertainers (2/6), politicians (3/6). The correct identifying descriptions were for cars (1), entertainers (4), politicians (1). 23/30 of the stimuli were correctly identified in the multiple choice. The errors were cities (2), countries (3), and cars (2).

On the Raven's standard progressive matrices, HG had a percentile rank of 50. On the German version of the Wechsler intelligence test (HAWIE), the patient had an IQ of 87, scoring higher on the verbal (91) than the nonverbal (84) section. In the (nonverbal) figure completion task, it was striking that the patient produced wild misnamings (e.g., a woman in front of the mirror: a cow in the grass; a crab: a flock of sheep) and that she tried to complete her verbal response (e.g., the shepherd is missing). HG never gave any indication that she understood the true functions of objects that she named incorrectly. For example, her ges-

tures to unnamed objects were always inappropriate. Usually, she could not help producing an incorrect name to which she gave an appropriate mime; this line of investigation was not pursued.

The patient was reexamined with the AAT (Aachen Aphasia Test) at 6 months and 1.5 years postonset. There were no significant differences between test results. In particular, naming remained constant at a percentile of 40 whereas percentiles on other subtests (Token Test, repetition, reading and writing, and auditory and reading comprehension) were above 70.

APPERCEPTION

Object/Non-Object Decision

HG was able to make object/non-object decisions. In an adaptation of the Kroll and Potter (1984) task, HG was asked to categorize 148 line drawings as meaningful or meaningless objects. She correctly classified 143 (97%). The patient was also able to make correct categorizations in the object decision task of Humphreys, Riddoch and Quinlan (1988). She was given two versions of their task. In the first version, non-objects were constructed by replacing a feature of an object with one from a different category. In the second version, parts were exchanged from objects of the same category. HG successfully categorized 24/27 (89%) items in both versions. The performance of control subjects in Humphreys et al. (1988) ranged from 93 to 98% for version one and 79 to 92% for version two. HG also correctly classified 160 pictures taken from the Peabody Picture Vocabulary Test as either people or animals.

Object Superiority Effect

A peculiar characteristic of logogens and pictogens is that they allow superior retention of parts of the word or object (Reicher, 1969, McClelland, 1976; Homa, Haver, & Schwartz, 1976). For example, there is better recall for the eye feature when presented in a face rather than a jumbled face (Homa et al., 1976). These superiority effects have been demonstrated without the need for brief exposure durations (Davidoff & Donnelly, 1990) and in unselected unilateral brain damaged patients without recognition disorders (Davidoff & Landis, 1990). It can be argued (Davidoff & Landis, 1990) that normal object recognition is always accompanied by an object superiority effect.

HG was presented with a line drawing of a normal chair or with its parts exchanged (i.e., the seat was below the legs) for 2 sec and then immediately afterward with a forced choice from two normal or scrambled chairs as appropriate. For the forced choice, there was only one part that differed between the two alternatives (for further details see

Davidoff and Donnelly, 1990). After some practice, HG was given a block of 24 trials which was repeated five further times on the same day. Half of each block were normal chairs and half scrambled chairs in a random order. Stimuli were projected onto a wall and timing was controlled automatically. The alternatives were exposed for 5 sec in which time HG never failed to respond. HG made 47/72 correct responses for normal chairs and 51/72 correct responses for scrambled chairs. Clearly HG does not show an object superiority effect. Her feature by feature matching strategy can be observed by breaking down her results according to the part that varied in the forced choice. HG scored 46/48 for the legs, 32/48 for the seat and 20/48 for the back. Two-tailed Fisher exact tests gave $p < .001$ for the leg vs. seat comparison and $p < .03$ for the seat vs. back comparison.

Object Matching: Foreshortened Views and Minimal Features

On each trial, three black-and-white photographs of inanimate objects were presented to the patient and she was asked to decide which two were of the same object. One of the photographs showed a typical view which had to be matched to an atypical view (Warrington & Taylor, 1973). For one series of pictures, the atypical view was achieved by foreshortening the object; for the other series, the atypical view showed predominantly a critical (minimal) feature. The third (distractor) item was visually similar to the atypical target picture but of a different object (Humphreys & Riddoch, 1984).

Each series contained 18 items. The patient was given half the trials of the foreshortened matches, then the trials with minimal feature matches in a block, and finally the remaining foreshortened matches. On each trial, the three pictures were placed along the midline of the patient's visual field to avoid responses being contaminated by neglect due to the hemianopia. The position of the distractor item was decided at random.

HG made only 4/18 errors on the foreshortened matches and 3/18 errors on the minimal feature matches (see Table 3). Her performance was roughly one standard deviation below the mean score obtained with a group of younger left CVA patients (Humphreys, personal communication).

Face Matching

HG had difficulty matching different views of the same face. She performed at the severely impaired level (32/54) on the Benton Test. HG's ability to make identical face matches was preserved. She made only one mistake on the first six items from the Benton Facial Recognition Test (Benton, Van Allen, Hamsher & Levin, 1975).

NAMING

Object Naming from Line Drawings

Exp. 1. Effects of familiarity, complexity, and structural similarity. The Snodgrass and Vanderwart (1980) line drawings (excepting 9 items regarded as culturally inappropriate) were enlarged ($\times 3 = \text{approx. } 1.5'' \times 1.5''$) and mounted on plain white cards. They were presented individually for naming in two conditions; these were oral naming and written naming. The oral naming and written naming tasks were counterbalanced and performed in two sessions separated by 1 week. Oral responses were tape recorded; written responses were given by the patient on individual cards that were then removed. Naming was poor. HG gave 127/251 immediately correct responses and a further 21 self-corrections. When asked to write her responses, 162/251 were immediately correct with a further 4 self-corrections. The McNemar test for the significance of changes gave oral naming to be more impaired than written naming ($\chi^2 (1) = 11.7, p < .001$). However, if self-corrected responses are considered, the difference escapes significance ($\chi^2 (1) = 3.4, p < .1$).

Errors (before self-correction) were independently assessed by three judges into one of four categories, viz., visual, semantic, visual + semantic, and other. Spelling errors were ignored for the analysis of written responses. The very few items for which there were disagreements were placed in the "other" category. Of the "other" errors, for oral naming, only 5 were responses produced to any of the 10 preceding items. Thus, perseveration can be discounted as a major source of errors. There were no perseverations in written naming. "Other" errors were not circumlocutions. It was felt that they reflected idiosyncratic attention and confabulation to parts of the items. By inspection of Table 1 it can be seen that purely semantic errors are rare.

The oral naming responses were analyzed with respect to scores of familiarity and visual complexity provided for the Snodgrass and Vanderwart pictures. An analysis of familiarity (four categories) showed no relationship to correct responses with ($\chi^2 (3) = 2.2, p < .5$) or without ($\chi^2 (3) = 4.5, p < .2$) self-corrected responses (see Table 2).

TABLE 1
Errors in Oral and Written Naming to Line Drawings (Exp. 1)

	Error type			
	Visual	Semantic	Visual + semantic	Other
Oral naming	24	5	51	44
Written naming	11	4	29	45

TABLE 2
Correct Naming Responses According to the Ratings for (Visual) Familiarity
and Visual Complexity for the Stimuli of Exp. 1

	Snodgrass and Vanderwart ratings			
	Low 1-2	2-3	3-4	High 4-5
Familiarity	11/26	32/71	48/80	36/74
Complexity	22/38	46/93	45/82	14/38

Humphreys et al. have argued that impoverished name output can result from the difficulty in sorting out visually similar items within broad object categories (e.g., animals, musical instruments). They make a distinction between categories in which items have, in general, consistent structural similarity from categories in which items are structurally distinct. The 219 items that were easily categorizable into a structurally distinct or structurally similar category were analyzed. 38/77 structurally similar items and 73/142 structurally distinct items were named correctly. Thus, the variable was unimportant ($\chi^2 < 1$) to HG's naming.

Exp. 2. The effect of object color. The effect of object color on naming was examined by a comparison of the patient's responses to realistically colored and achromatic versions of the Snodgrass and Vanderwart figures (Davidoff & Ostergaard, 1988). Two versions of 79 objects were presented in two blocks. Each block contained one version of each object with 40 (39) in color. HG named correctly 55 of the colored and 54 of the achromatic versions. Clearly, there was no reliable effect of object color naming on naming performance.

Object Naming from Photographs

Exp. 3. The effect of type of view. The 54 photographs (3 versions of each object) used in the object matching task (described above) were also presented for naming. The order of the photographs was such as to have three blocks in which each object was represented once and each type of view was present equally often. HG showed better naming from the typical view (see Table 3) which approached reliability in a comparison to the other two conditions ($\chi^2(2) = 4.8, p < .1$).

HG's abnormal performance is confirmed from the observation that there were two items (horse and jug) which were correctly named from the foreshortened view but were, nevertheless, subsequently named incorrectly from the typical view.

Exp. 4. The effect of stereopsis. Thirty objects were photographed twice in color from slightly different viewpoints to provide vivid stereop-

TABLE 3
Matching Errors and Naming Errors for the Stimuli of Exp. 3 (Max = 18)

	Object view		
	Foreshortened view	Minimal Feature view	Typical view
Matching	4	3	
Naming	12	13	7

sis when placed in a stereoviewer. HG named the objects twice; once when the photographs were in the stereoviewer and once with the photographs placed on a table at the same viewing distance. The experiment was performed in two blocks with crosswise allocation of items across conditions. HG named 13 of the objects in the 2-D and 15 of the objects in the 3-D condition; this was not a reliable difference.

A Comparison of Naming from Different Modalities and Different Views

Exp. 5. Objects: The effect of visual versus tactile presentations. One hundred and four stimuli were selected for naming in all of four conditions at a testing session conducted six months after exp. 1. Three of the conditions used objects; the other, colored photographs of the same objects. The conditions were: (1) Objects in free view but without tactile exploration placed 1 m in front of the subject (visual naming), (2) colored photographs of these objects as viewed head-on in Condition 1 on a plain white or black background, (3) objects presented as in Condition 1 but viewed through a peephole, (4) objects with only tactile exploration. Testing took place on 3 consecutive days. The 104 objects and their photographs were divided into two equal groups to form four blocks each containing 52 stimuli. Two blocks were presented in a counterbalanced order on each day. No object was presented twice on the same day. Three hours after completion of conditions 1 and 2 on the second day, the stimuli in the peephole condition were presented arranged to closely simulate the photographs. Objects were placed on a bare white cloth and viewed monocularly through a hole in a curtain. The disparity in size between the objects meant that head movements did allow more than one view of the smaller objects. The back wall of the room was visible through the peephole which combined with other perspective cues present allowed a good estimate of object size. Tactile naming (Condition 4) was performed on the third day.

Analysis of the patient's responses with a Cochran Q test gave $Q = 41.7$, $p < .0001$. Post hoc pairwise comparisons using the McNemar test

for the significance of changes gave significant differences between most of the conditions. In order of descending performance, HG was best at tactile naming followed by visual naming, peephole naming and then photograph naming. The only comparison to escape significance was that of visual naming (condition 1) compared to the peephole (3) viewing condition. Correct scores, significance levels, and error types are given in Tables 4a and 4b.

Exp. 6. Letter naming: The effect of visual vs. tactile presentations. The patient's letter naming was examined with wooden letters 1-cm thick and with a height and width between 5 and 7 cm. Five letters of the alphabet were omitted because they would have been ambiguous with tactile presentation. The 21 remaining letters were presented separately in capital and lower case versions. They were used in the following naming tasks: visual presentation in canonical position, visual presentation at an angle of 30 deg (randomly to right or left of the canonical position), tactile presentation to the right hand. The different conditions were randomized across three blocks.

In a subsequent task, nominal matching was assessed in three tests. First, canonical versions of capital letters had to be matched to the corresponding lowercase letter from a choice of three in a visual-visual format. Second, the name was matched to canonical versions of three visually presented lowercase letters. Third, the first test was repeated in a tactile-tactile format. For these tasks, one of the distractors had visuo-tactile similarity and the other was unrelated (e.g., A:a, o, z).

It can be seen in Table 5 that naming errors substantially increased for the visually rotated compared to the canonical presentations ($\chi^2(1) = 6.9, p < .01$). There was, unlike in exp. 5, no improvement of tactile over visual naming but it is clear from the matching performance that the tactile letters were harder to recognize.

TABLE 4a
Correct Naming Responses and Comparisons between Conditions
(Significance Levels) of Exp. 5 (max = 104)

	Conditions			
	1	2	3	4
	Objects		Objects	Objects
	visual	Photographs	peephole	tactile
	90	67	84	101
Visual		.0002	ns	.007
Photos			.01	.0001
Peephole				.0005

TABLE 4b
Errors Associated with the Experimental Conditions of Exp. 5

Conditions	Error type			
	Visual	Semantic	Visual + semantic	Other
Visual	4	2	1	7
Photos	5	4	9	19
Peephole	6	3	4	7
Tactile	1	1	1	—

Exp. 7. Color naming. Ten different patches of color (red, orange, yellow, green, blue, violet, pink, brown, white, black) were mounted on a grey card in a random spatial array. The colors were pointed to once each and naming was requested. The task was repeated on five occasions each separated by at least a day. A different order was used for color naming on each testing. HG provided only 29/50 correct color names. In contrast, when given the color name she correctly pointed to the color on 48/50 trials.

CATEGORIZATION

Object Categorization

HG's ability to categorize objects from visual information was assessed for both pictures and words. HG was asked to choose the item from a set of three line drawings (or words) which belonged to the same category (see Bub, Black, Hampson, & Kertesz, 1988). A total of 100 line drawings were taken from Snodgrass and Vanderwart (1980). The items were divided equally into animals and non-living objects. For the animal sets, HG was asked to select the bird, the dangerous animal, the foreign item, the one that lives in water, the one that was brown, and the largest. For

TABLE 5
Errors in Matching and Naming Letters (max = 21)

	Visual					
	Capital		Lower case		Tactile	
	Canonical	Rotated	Canonical	Rotated	Capital	Lower case
Naming	4	12	4	9	6	8
	Visual-visual		Verbal-visual		Tactile-tactile	
Nominal matching	1		0		6	

the non-living objects, HG was asked to identify the kitchen object, the musical instrument, the one used by children, the outdoor item, the heaviest, and the one made of metal. Thus, the investigation considered functional knowledge, associated knowledge, and knowledge of sensory properties. There were 10 decisions required per category. Testing was divided into two sessions separated by 4 hr. Sessions were balanced for type of presentation and categorization task.

In the picture version, HG chose the correct item (see Table 6) for 57/60 of the categorizations concerning animals and 51/60 of the non-living objects. HG correctly classified 59/60 animals and 58/60 non-living objects from words. The words were categorized better ($\chi^2(1) = 4.27$, $p < .05$) using the McNemar Significance of change test. Performance in every category and for both presentation modes was significantly above chance ($p < .001$).

As HG was given the names of the stimuli as words, picture naming was not tested after the categorization. However, it is clear that categorization can be achieved for items that HG cannot name. In exp. 1 (performed the previous day) HG named only 26/50 of the animal line drawings that she categorized very well (57/60).

Color Categorization

HG was asked to sort a random order of the 20 different colors used in the identical matching condition (see tests of apperception) into four piles. She performed the task slowly by placing each sample next to the color on the top of each pile and then making her decision. Apart from one error that was corrected after asking for a reallocation, her perfor-

TABLE 6
Correct Categorization Responses (max = 10) for Picture and Word Stimuli

	Picture	Word
Animals		
Bird	9	9
Dangerous	10	10
Foreign	9	10
Water	10	10
Brown	9	10
Largest	10	10
Objects		
Kitchen	9	9
Musical	9	10
Children	9	9
Outdoor	8	10
Heaviest	9	10
Metal	7	10

mance was normal. One year later, further similar categorization tasks were given to HG. She was given (a) a set of 16 desaturated colors divided into the same four color regions but with less similar examples within each category, and (b) 16 stimuli of varying brightnesses and saturations that would be divided into 4 equal groups of red, brown, green, and violet. HG was first asked to divide the stimuli into as many piles as she thought necessary to contain similar items. She was then asked to divide them into four piles. The tasks were repeated after an interval of one hour.

For set (a), HG spontaneously put the colors into 4 or 5 categories; for set (b) into 7 and 6 categories. When asked to put them into four piles, she reversed a green with a blue for both tests of set (a). For set (b), on the first testing she was reluctant to put the colors into less than six piles but, after stressing the instructions, managed it correctly. The second testing proceeded in a similar fashion. She named correctly 5/10 of a random assortment of these colors and obtained the same score on a replication of the color naming stimuli given the previous year.

READING AND WRITING

The patient's reading aloud and writing to dictation in the AAT were essentially normal except for occasional pauses between words in reading sentences.

HG was examined with additional material constructed with reference to a word processing model (Patterson, 1986) which assumes three routes between input and output. The first task investigated the functioning of the grapheme-phoneme conversion (GPC) route for reading and the phoneme-grapheme route for writing with a list of 80 items comparing mono- and bisyllabic concrete nouns and non-words of the same length (20 items each). A difference between word and non-word reading would show that this route is not functional. In reading aloud, the patient made 4 and 6 errors, respectively (all visual); in writing to dictation, 2 and 3 errors. Her successful performance would also be compatible with the lexical analogy model of graphemic processing (Kay & Marcel, 1981).

The second task was designed to investigate the direct lexical route. It compared HG's reading and writing of orthographically regular and irregular monomorphemic words of equal frequency using a list of 40 words (20 items each). A difference between regularly and irregularly spelled words would show an impairment in this route. In reading, she made 3 and 5 errors, respectively, all being visually related to the target; in writing, 1 and 3 errors, respectively.

With respect to the third (semantic) route, it was shown above that HG can categorize words perfectly; thus, the semantic route is, in principle, accessible for reading. A third task was designed to examine the semantic

route for writing to dictation. A list of 30 words was used with 30 allo-graphic but homophonic words dictated in a disambiguating context. Correct graphemic realization depended on a semantic-graphemic link (Seite: page of a book, Saite: string of a violin). If writing does not rely on semantics, the choice of allograph would be random. HG made two errors. Thus, all three routes were approximately normal.

To examine the patient's performance on text, she was given 5 paragraphs of 6 sentences to read aloud after which she had to answer 5 questions. Reading aloud was only at fault by frequent pauses between words. HG's answers demonstrated that she had understood the details of the story. Writing the 6 sentences of one paragraph showed only one orthographic error.

HG's written responses to the line drawings of exp. 1 were analyzed for orthographic errors. HG produced 70 long compounds and 181 short simple nouns. She made a total of 54/121 orthographic errors (29/70 for compounds, 25/181 for simple nouns). Writing compound nouns in German involves special morpheme-boundary orthographic rules so the increased number of errors would be compatible with her level of education.

DISCUSSION

HG named real objects from either visual or tactile inspection but was impaired in the naming of objects in photographs. She also had problems categorizing and naming colors but demonstrated no reading impairments except for the recognition of rotated letters.

The naming impairment of HG requires comment on two of its remarkable aspects. The first aspect is that HG's naming difficulty is considerably more pronounced to two-dimensional visual stimuli than to objects (and performance improves as more views of the object are made available). The second aspect is that her naming difficulty is accompanied by preserved reading. The first of these aspects has been noted in even a stronger form in cases where the primary concern has been the recognition disorder (Larrabee et al., 1985) or color anomia (Damasio et al., 1979). However, in these cases the pictorial stimuli used were not photographs of the identical objects. HG's discrepancy between photograph and object naming was more marked than in other studies where the objects and photographs were well matched (De Renzi et al., 1987). The second remarkable aspect (the preservation of reading) has also been noted previously. It has been observed in cases of color anomia (Gloning et al., 1968; Damasio & Damasio, 1983) and in a few exceptional cases of (associative) visual agnosia (Wilbrand, 1892; Newcombe & Ratcliffe, 1974; Albert, Reches & Silverberg, 1975; Mack & Boller, 1977). Relatively preserved reading comprehension for nouns has also been shown

to be implicitly present in a case reported as optic aphasia (Coslett & Saffran, 1989).

The implications of HG's disorder are realized in the model of naming presented in Fig. 2. The flow diagram of Fig. 2 is a combination of the models of Warren and Morton (1982) and Patterson (1986) except that it also provides a separate analysis for color naming. The model is presented in its simplest form; for example, there are no divisions within semantics and there is no direct route to name output from the pictogen. However, the model could easily accommodate these changes and also provide a comparable route for tactile naming.

The inability to name pictures but not objects (exp. 5) has a strong implication for the theoretical analysis of HG's impairment. In HG's case, it would seem that pictures are not recognized because she requires different views of an object in order to access its pictogen. However, her impairment does not concern the ability to form a 3-D image of an object (exp. 5); it rather bears comparison to what Riddoch & Humphreys (1987a) call "integrative visual agnosia." HG often named an object based solely upon a part; for example, she justified her response of washing machine to telephone by pointing out the circular central dial. It is

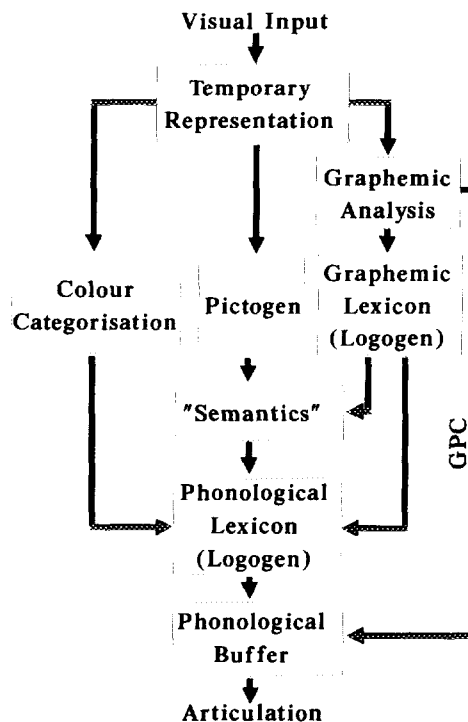


FIG. 2. Model of naming visually presented stimuli (objects, colors, written words).

surprising that more patients are not described with similar responses to 2-D stimuli. The matching procedures which effect the correspondence between the temporary representation and the pictogen are so complex (Ullmann, 1989) that there ought to be many part matches that are accepted without the extra information available from the real object. Indeed, it is the impression of Damasio et al. (1979) that the inability to name two- but not three-dimensional objects is the rule in optic aphasia. Not surprisingly, *prototypical views provide the best access to the pictogen* but even these are often insufficient to promote accurate naming (see Table 3).

Despite the obvious implication that HG's poor naming is due to a recognition disorder (i.e., at the pictogen in Fig. 2), there is evidence that she can successfully perform tasks that apparently imply access to a pictogen. For example, HG could match pictures to words and make object/non-object decisions (Riddoch & Humphreys, 1987a,b); even her matching of different views of objects is not substantially worse than one might expect from an unselected patient with left cortical damage. One might, therefore, propose (see Riddoch & Humphreys, 1987b) that her naming impairment resulted not from a recognition disorder but from a "semantic access agnosia" in which the intact "cognitive" system was inaccessible (i.e., an impaired link between the pictogen and "semantics" in Fig. 2). The distinction is not straightforward. Successful matching of words to pictures does not necessarily imply perfect object recognition. It only implies that there is successful discrimination between the distractors. Even when the distractors are visually similar, there are still marked differences between them that facilitate matching. There are similar problems for the object decision task. Riddoch and Humphreys argued that an object decision task can decide whether the structural representations required for recognition are intact. However, good performance on an object decision task does not guarantee that recognition is performed normally. Good performance on the object decision tasks could be achieved by object part recognition. When all parts can be recognized individually, there may be an overestimation of the access that has been achieved to the pictogens. For HG, at least, the conclusion of normal access ought to be tempered by her poor performance on matching different views of the same face.

Humphreys et al. (1988) might find a further, related problem, in considering HG to have a recognition disorder; there were no categories within which she had a pronounced difficulty in resolving items. Humphreys et al. have proposed that the organization of the structural descriptions is categorical. Some categories (e.g., animals, vegetables, and fruit) have members for which the structural descriptions are very similar. Items from within these categories would, therefore, be hard to distinguish from each other and should show greater deficits in tasks requiring recognition. For HG (see exp. 1), the proportion of naming errors was

not higher for categories where the items were structurally similar. The naming errors were often bizarre and appeared to be based on only part of the stimulus or its overall shape. HG was more likely to make a naming error if the stimulus was complex. Thus, irrespective of the organization between structural descriptions, HG's damaged system must require information from many views for successful access to an individual description. To maintain the alternative explanation (i.e., a semantic access account) for HG, one would have to believe that access to the "cognitive" system is only possible if the pictogen has been activated from an object but not by a picture. Such a restriction would put considerable strain on the logic of the recognition system. It is more reasonable to hold that recognition is not achieved normally.

HG's impaired recognition is also at odds with her successful categorization from visually presented material. However, there are reasons for doubting that her categorization reflected better successful access to knowledge than did her naming performance. The type of categorization tasks used in the present study for objects have similar weaknesses, with respect to distractor items, to word-picture matching tasks. Furthermore, HG could name more than half of the objects; taking that into account would give enhanced performance in, at least, a couple of the tasks.

There have been other similar demonstrations of paradoxically good access to stored knowledge in alexia (Bub et al., 1988; Warrington and James, 1988). The alexic patient of Bub et al. (1988) was able to match a word to a picture and those of Katz (1990) could perform cross-modal word matching. The explanation of how such judgments are possible from a damaged recognition system is that some knowledge can be activated without complete recognition (Warrington and James, 1988; Hillis, Rapp, Romani & Caramazza, 1990; Davidoff, 1991). Therefore, the successful categorization claimed for patients with optic aphasia (Coslett & Saffran, 1989) does not preclude damage to a recognition system. The case of Coslett & Saffran (1989) exhibited a much greater discrepancy, than did HG, between good categorization ability and poor naming. Yet, like HG, their patient did not show "semantic" errors in naming as one might have expected if damaged associated knowledge had been activated.

HG's color anomia might appear to require a different sort of explanation to that provided for her photograph anomia. However, there are circumstances where color anomia can be considered as a recognition disorder. The argument requires some elaboration on the functional and logical difference between colors, objects, and colors of objects. For example, the inability to name colors does not require an inability to name the colors of objects (Geschwind & Fusillo, 1966); nor does the inability to recall object colors require that there should be a color anomia (Farah, Levine & Calvanio, 1988). The categorization of color from the

temporary representation can be performed independently of shape (Garner, 1974; Adler, 1944; Levine, 1978) and, hence, color naming requires a functional route between the temporary (uncategorized) representation and the output lexicon which is distinct from that for object naming. A necessary intermediary stage on that route is color categorization (Rosch, 1975). Thus, the inability to categorize colors is considered equivalent to a disorder of the pictogens for objects. It follows that the term color anomia should be restricted to those impairments resulting from neural damage after successful color categorization. For objects, an impairment to the pictogens would be called a recognition disorder. Therefore, a disorder of color categorization could also be considered a recognition disorder.

It is argued that HG has the same functional disorder for colors as for pictures. Therefore, HG should exhibit a disorder of color categorization in Fig. 2. HG achieves about the same success in assigning shades of color as going together as she does in object categorization. However, like object categorization, that performance is not achieved normally. HG makes laborious multiple comparisons in order to find the minimal hue difference between a color and the alternatives. Furthermore, much of the limited categorization requested of HG is likely to be achievable from her intact opponent process (red/green, yellow/blue) mechanisms (Mullen & Kulikowski, 1990). Thus, while it is not certain that HG's impaired color naming arises entirely from imperfect color categorization, it should contribute.

The preserved reading of HG in the presence of a recognition disorder for pictures is the second striking peculiarity of HG's impairment. It emphasizes the early stage at which different visual information is segregated. However, access to the logogens must obey some of the same restraints as does access to the pictogens. For example, though demonstrating no impairments for prototypical letter recognition, HG did have difficulties recognizing rotated letters. Nevertheless, her performance certainly contradicts the suggestion of a necessary connection between the degree of photograph anomia and the degree of alexia (De Renzi et al., 1987).

HG's preserved reading discourages a simple disconnection account (Freund, 1889; Déjerine, 1892; Geschwind & Fusillo, 1966) for her naming disorders. The disconnection account finds it difficult to deal with cases in which naming loss is less than total, although there are modified accounts for limited naming disorders. For example, preserved object naming in the presence of alexia and color anomia has been attributed to a gradient of disconnection based on visual complexity (Oxbury, Oxbury & Humphrey, 1969; Damasio et al., 1979) or to spared anterior connections carrying associated tactile information (Geschwind & Fusillo, 1966). However, HG's intact reading and the variety of combined defective and

preserved naming responses in other patients (Adler, 1944; Levine, 1978) make it unlikely that preserved naming can be simply explained by a partial disconnection allowing the transfer of only visually simple information.

To maintain a disconnection account, different callosal fibers must carry visual information concerning color, words and objects. That explanation has some difficulty in accounting for HG's picture anomia unless there are specialized fibers for picture rather than object information. The disconnection hypothesis is best suited to cases where there is little or no preserved naming (Coslett & Saffran, 1989). These cases ought, if like HG, to show an accompanying mild recognition impairment. For other cases, one must rather presume that it is damage to specialized sites in the left hemisphere that causes the specific naming impairments for these different types of stimuli.

HG adds weight to the case by Farah (1990) for a left hemisphere site for the representations used for object recognition. Farah also argues that our understanding of object recognition impairments is furthered by a comparison to disorders of familiar face recognition (prosopagnosia) and alexia. HG, however, does not fit completely into the scheme proposed by Farah. She proposes that object recognition disorders arise from impairments to the recognition of individual parts (i.e., those that produce prosopagnosia) or from impairments to the combination of object parts. If the impairment for combining parts is mild, Farah claims that it results in alexia but, if severe, in an object recognition disorder. The one impairment that should not arise is an object recognition disorder without prosopagnosia or alexia. We did not carry out extensive testing of HG's familiar face recognition but in the Preliminary Neuropsychological Examination on proper name production her performance seemed normal and quite unlike her naming of objects. When HG did not know the name of a famous person she provided an adequate circumlocution. Thus, HG would appear to be the one type of patient that Farah's model does not allow. It would appear that HG's difficulty is in arriving at a description for a type of object; this applies to all classes of visual stimuli. Once she knows that the object is a face (or animal), there is no problem at reaching a more detailed description for a particular face (or animal).

HG's recognition disorder may not fit exactly with Farah's model but the left hemispheric locus of her impairment does. However, HG's recognition impairments might normally be associated with right hemisphere damage (Warrington & Taylor, 1973) because they are more pronounced for non-prototypical views. HG's recognition disorder has, therefore, implications for the assumption of right hemisphere perceptual analysis (Warrington & Taylor, 1978; Warrington & James, 1988) or a right hemisphere pictogen (Mehta, Newcombe, & Ratcliff, 1989). As all visual infor-

mation is received by HG in the right hemisphere, her performance implies that an intact right hemisphere cannot properly recognize pictures (i.e., it does not contain the entire neurological substrate of the pictogen). Evidence from split-brain research (Levy, Trevarthen & Sperry, 1972) appears to contradict that conclusion. Moreover, the data from lesion studies (Mehta, Newcombe, & Ratcliff, 1989) suggest that the function of the right hemisphere is not to perform mental rotation or other processes requiring imagery but to form an object-centered representation (pictogen). Thus, the issue concerning the neurological locus of the pictogen is clearly one that would benefit from further research.

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