

Optic Aphasia and the Right Hemisphere: A Replication and Extension

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Optic aphasia is a rare, visual modality-specific naming disorder. We describe a patient who developed this disorder subsequent to a left occipital lobe infarction. Like another case that we described previously, this patient performed normally on a variety of tasks assessing the recognition of objects he could not name. Additionally, although he never read aloud a single word, his performance on lexical decision and word comprehension tasks was far better than chance. We suggest that his performance was mediated by a right hemisphere semantic system.

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Optic aphasia is a rare, visual modality-specific naming disorder first described by Freund in 1889. In an argument presaging Dejerine's now familiar account of pure alexia (1892), Freund attributed the syndrome to a disconnection between the right hemisphere (to which the visual information was restricted by virtue of a right homonymous hemianopia) and left hemisphere language areas. In a clinical setting, the disorder is differentiated from visual object agnosia by the fact that optic aphasics demonstrate evidence of object recognition by gesture or sorting tasks; additionally, these patients demonstrate no evidence of impaired object recognition in everyday situations. Similarly, the disorder is differentiated from anomic aphasia by the fact that the deficit is modality-specific; optic aphasics name from palpation or description more reliably than from vision.

Optic aphasia is an unusual syndrome and well-described cases are rare (Lhermitte & Beauvois, 1973; Ratcliff & Newcombe, 1982; Larrabee, Levin, Huff, Kay, & Guinto, 1985; Riddoch & Humphreys, 1987). At

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least in part because of the paucity of well-documented patients, the nature of the processing deficit underlying optic aphasia remains controversial. Riddoch and Humphreys (1987), for example, investigated a case of optic aphasia which they attributed to an impairment in access to a complete semantic specification for visually presented stimuli. Lhermitte and Beauvois (1973; see also Beauvois, 1982) accounted for optic aphasia (and presumably other modality-specific naming impairments) in terms of dissociations between modality-specific semantic stores; thus, on their analysis, this disorder reflects a disconnection between putative visual and verbal semantics. Indeed, Bauer and Rubens (1985) argue that the syndrome of optic aphasia as defined above does not exist; they argue that the symptoms are attributable to a mild form of visual object agnosia.

We recently reported a patient with optic aphasia (1989b) who performed normally on a variety of tasks assessing access to semantic information appropriate to visually presented stimuli; the patient also performed well on tests of comprehension of words of high imageability which he could not name. On the basis of these data, we proposed that the patient's object recognition and reading comprehension were mediated by a semantic system supported by the right hemisphere.

We report data from another patient with optic aphasia which serve to support and extend our previous analysis. This patient performed normally on a variety of tests of object recognition, suggesting that his deficits were not attributable to a mild form of visual object agnosia. Additionally, although unable to explicitly identify a single written word, he performed far better than chance on a series of lexical decision and semantic categorization tasks; he was unable, however, to access phonologic information for visually presented words. These data are consistent with the hypothesis that optic aphasia reflects a dissociation between a right hemisphere lexical-semantic system and left hemisphere structures mediating language production.

PATIENT DESCRIPTION

The patient (EM) was a 67-year-old right-handed retired insurance adjuster with a college education who noted the sudden onset of right-sided weakness, loss of vision on the right, and word-finding problems. His past medical history was significant for hypertension as well as two myocardial infarctions. The clinical diagnosis of stroke was confirmed by a CAT scan performed 1 week after the onset of symptoms which demonstrated an infarction involving the left occipital lobe and posterior, inferior temporal lobe (see Figs. 1 and 2).

Neurological examination 5 weeks after the stroke revealed a dense right homonymous hemianopia. A mild right pyramidal clumsiness as well as a minimal right reflex preponderance were noted. Sensation to pin and light touch was slightly impaired over the right face and body.



FIG. 1. A low ventricular image demonstrating an extensive infarction of the left occipital lobe including portions of the forceps major.

Language assessment revealed that EM's speech was fluent except for occasional word-finding pauses. A full range of syntactic structures was employed; paraphasic errors were infrequent. The patient was grossly impaired in naming objects or pictures but was able to name many objects by palpation. Formal language assessment with the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1972) demonstrated that EM was unable to reliably name pictures, colors, letters, or words. He performed well on tests of oral spelling and naming spelled words. The

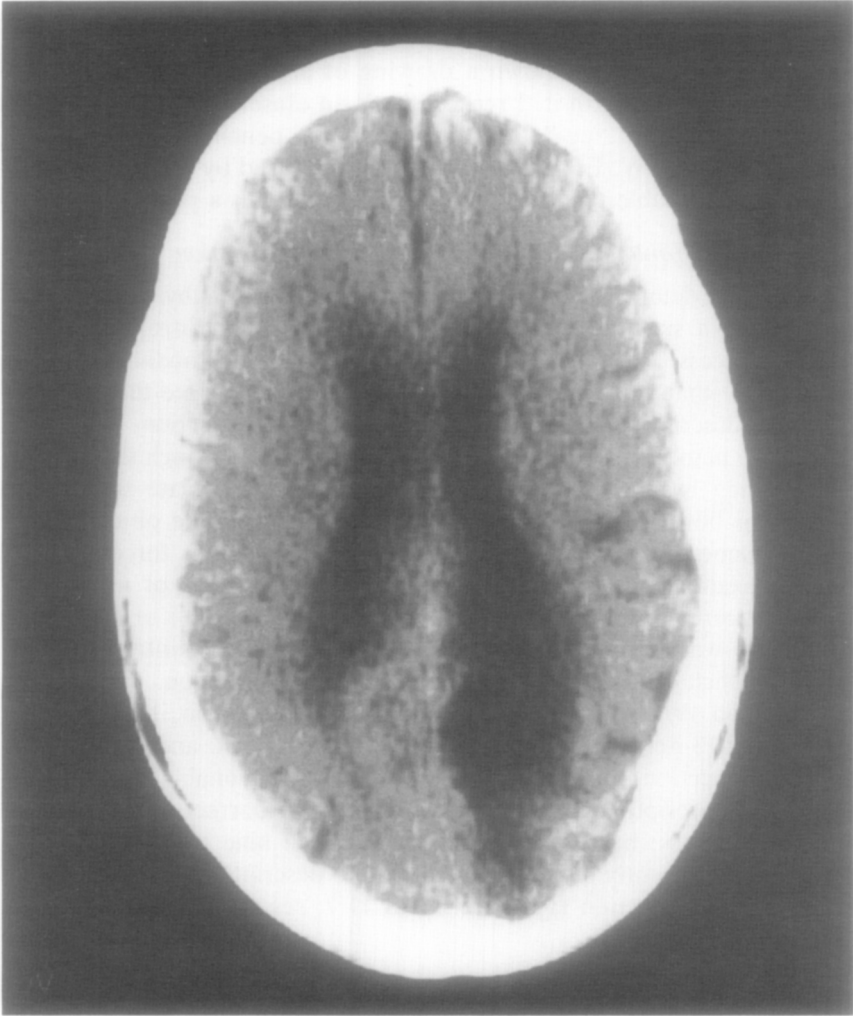


FIG. 2. A mid-ventricular image demonstrating the left occipital infarction.

following series of investigations was undertaken to assess his processing of visually presented objects and words.

NAMING

Boston Naming Test

The first 40 line drawings from the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1982) were presented to EM free-field for an unlimited period. He correctly named only three of the drawings. Semantic cues did not improve performance. He named an additional six items with

phonemic cues. For all 31 trials on which EM was unable to name the drawing even with cues, he provided some semantic information about the pictured item. When shown a drawing of a PENCIL, for example, he responded, "write with it, I reckon that's an eraser back there"; given the phonological cue "pe-", he said "it's not a pencil, not a pen." In response to the SAW, EM said, "an instrument, used by people who use saws"; he was unable to name the drawing even with a phonemic cue.

Naming to Confrontation, by Description, and by Palpation

In order to determine if the naming deficit exhibited by EM was attributable to a specifically linguistic impairment (e.g., disruption of or failure to access output lexical phonology) or a visual modality-specific impairment—that is, optic aphasia—EM was asked to name the same 28 objects by description, by palpation, and by visual inspection. When attempting to name by inspection he was not permitted to touch the object; when naming by palpation he was permitted to manipulate the object with one or both hands but was not permitted to view the object. If he failed to name the object to description, EM was given a forced choice task; for example, after failing to name the item "made of metal and used to eat cereal or soup," he was asked if it was a "spatula or a spoon." The testing was performed in three sessions using a counter-balanced design in which each item was tested only once per session.

EM named 19/28 (68%) objects from their description, 17/25 (68%) by palpation (3 items were not tested in this condition), and 6/28 (21%) by visual inspection. On those trials on which he was unable to name the object from description, EM was asked to pick the correct response from one of two words; he responded correctly on all nine trials. Thus, EM performed significantly better when naming to description or by palpation than to visual inspection ($\chi^2 = 12.2$ and 11.7 , respectively, $p < .01$ for both).

Letter Naming

EM was asked to name uppercase and lowercase letters. He failed to name any letters; all errors involved the substitution of different letter names. There was no consistent visual similarity between the target and the named letter.

Discussion

These data support two conclusions. First, the fact that EM exhibited some degree of impairment on all naming tasks suggests that he suffered from a mild degree of anomia, presumably as a manifestation of a primary language disorder. Second, and most significantly in this context, he exhibited a significant effect of the modality in which the stimulus was presented; he named objects better to description or by palpation, a

discrepancy not typical of an aphasic anomia. This visual modality-specific naming disorder is the defining feature of the syndrome of optic aphasia.

OBJECT RECOGNITION

EM's ability to recognize the objects which he could not name when visually presented was assessed by the following tasks.

Gesture Production

EM was asked to name and produce the gesture appropriate to 20 visually presented objects. He named only 3 of the objects but produced well-formed, readily identified, specific gestures for all of the items.

Lexical Comprehension Test

EM was asked to match an auditorily presented single word to one of four pictures. In the Across-Category condition, the pictured items were drawn from different semantic categories; for example, the response sheet for one trial included pictures of an ostrich, pear, crowbar, and seamstress. In the Within-Category condition the four pictures were drawn from the same semantic category (e.g., fruit or tools). There were 16 trials in each task. EM responded correctly on all trials.

Functional Similarity Test

In this test, which was modeled after the functional similarity test of Warrington and Taylor (1978), the patient was shown three pictures and asked to point to the two objects which were similar in function or "served the same purpose." As the stimuli were selected so that the functionally similar objects were visually dissimilar and the foil was judged to be more visually similar to one of the semantically related objects than was the other semantically related object, good performance on this task is not readily explained by the hypothesis that the subject categorized objects on the basis of basic visual features common to most members of a semantic category.

Stimuli for the task included 32 sets of three color photographs. Two of the three objects were related in terms of function but were dissimilar in appearance while the foil was visually similar to one of the functionally related objects. Examples of the objects pictured in a trial include a zipper, a button, and a coin. The stimulus sheets were presented across a desk with no time limit.

EM was correct on 31 of 32 trials (97%). Normal controls 60 and older scored from 27 to 31 correct with a mean of 30. Thus, the patient performed normally on this task; in fact, he made fewer errors than most age-matched controls.

Cross-Case Letter Matching

EM was asked to match an uppercase letter to one of two lowercase letters. The three letters were printed on a 3 × 5-in card and presented across the table. He responded quickly and correctly on all 10 trials.

Discussion

The patient's normal performance on these tasks suggests that he has access to semantic information appropriate to a visually presented object. The ability to determine that visually dissimilar objects perform the same function suggests that the patient was not relying on information available at the level of a visual object representation or structural description but was accessing object-specific semantic information.

WORD RECOGNITION

The previous investigations attempted to demonstrate that the patient could recognize objects he could not name. The following tests were performed to determine if he could also process visually presented verbal stimuli in the absence of explicit identification. Because the patient never explicitly identified even a single word, tasks requiring the subject to make a choice among alternative responses were utilized.

Lexical Decision Tests

High/low frequency lexical decision test. For this task letter strings were presented for 250 mses with a microcomputer and the patient was asked to say "yes" if the stimulus was a word. A randomized list of 60 words of high frequency and 60 words of low frequency as well as 60 word-like nonwords and 60 nonwords containing unusual or illegal letter sequences served as stimuli (see Coslett & Saffran, 1989a for details).

EM responded "yes" to 55/60 high frequency and 35/60 low frequency words; he (incorrectly) responded "yes" to 12/60 high "N" and 7/60 low "N" nonwords. He reliably distinguished words from nonwords ($d' = 1.67$, $z = 28.3$). Additionally, a robust effect of frequency was observed with real words; he performed significantly better with high than with low frequency words ($\chi^2 = 17.77$, $p < .01$). No letter strings were explicitly identified nor was semantic or phonologic information relevant to a word reported on any trial.

Affixed word lexical decision test. Most accounts of the language capacity of the right hemisphere suggest that this structure primarily supports the reading of high imageability nouns; words of low imageability and those that primarily serve a syntactic role are assumed not to be adequately supported by the right hemisphere (Coslett & Saffran, 1989a). If this is true, one might expect that the right hemisphere would not support other

closed-class items such as bound morphemes (e.g., the suffixes “-ly,” “-ing,” “-est”). In accordance with this hypothesis, a lexical decision task was performed in which correctly and incorrectly suffixed words were presented. We reasoned that if the right hemisphere does not support closed-class items such as bound morphemes, the patient would be insensitive to the appropriateness of the suffix.

The test developed by Shallice and Saffran (1986) and reported by Coslett and Saffran (1989a) was administered. Stimuli for the test included 63 root morphemes between five and nine letters in length. The root morphemes included an equal number of nouns, adjectives, and verbs. Each root morpheme was presented on three occasions: unaffixed (e.g., “elephant”), appropriately suffixed (e.g., “elephants”), and inappropriately suffixed (e.g., “elephanting”). For nouns the appropriate suffix employed was -s, for adjectives appropriate suffixes included -ly, -(i)er, and -(i)est, and for verbs appropriate suffixes included -s, -ed, and -ing. The same suffixes were used to generate inappropriately suffixed words.

Stimuli also included 63 nonwords generated by changing two letters in each of the 63 root morphemes; each nonword appeared twice, once unsuffixed and once in conjunction with the suffix appropriate to the word from which it was derived.

EM was instructed to say “yes” if the stimulus was a word. The test was administered in four sessions over 2 weeks; each root morpheme appeared only once in each session.

EM responded “yes” to 52/63 unsuffixed words (83%), 55/63 correctly suffixed words (87%), 42/63 incorrectly suffixed words (67%), 6/63 (10%) suffixed nonwords, and 6/63 (10%) unsuffixed nonwords. Overall, EM performed well above chance (77% correct). Of greatest interest in this context, however, is the comparison between performance with correctly suffixed words and that with incorrectly suffixed words. EM was not completely insensitive to the appropriateness of the suffix; he said yes to inappropriately suffixed words significantly less frequently than to appropriately suffixed words ($\chi^2 = 7.57, p < .05$). He did, however, perform substantially less well than normals who accept fewer than 25% of inappropriately suffixed words.

Discussion. Thus, although unable to report a single stimulus, EM performed well above chance on two lexical decision tests. Like several previously described patients with pure alexia (Coslett & Saffran, 1989a), EM exhibited a striking effect of word frequency and accepted inappropriately suffixed words with much greater frequency than normals. This same pattern was demonstrated by our previously reported optic aphasic patient, CB (Coslett & Saffran, 1989b). These data suggest that he was able to access stored information appropriate to letter strings which he was unable to explicitly identify.

Written Word Comprehension

A series of word categorization experiments essentially identical to those described previously (Coslett & Saffran, 1989a) were performed to assess EM's ability to access semantic information relevant to words which he could not explicitly identify.

Food names. Twenty-five names of edible items (e.g., "grape"), 25 visually similar words (e.g., "graph") and 25 words matched for length and frequency (e.g., "slice"), were presented to EM for 250 msec with a microcomputer; he was instructed to indicate if the referent of the word is edible. He was also asked to name the word if he could. He responded correctly to 24/25 food names, 21/25 visually similar words, and 24/25 unrelated foils for a total of 69/75 (92%) correct.

EM failed to name any words but did offer comments for nine stimuli; examples of his responses are the following: COOKIES→ "candy, a cake"; SALAD→ "helps to add to a meal"; BACON→ "a bad thing, bad for your body"; and SANDWICH→ "not having a full meal; to have something prepared like a sandwich." After offering these comments, EM was still unable to name the word.

Animal names. A categorization task the same as that described above except that the category was animal names rather than food names was performed on two occasions. On one occasion, stimuli were presented for 250 msec whereas on the second administration, 2 weeks later, stimuli were presented for 1000 msec.

With a 250-msec exposure, EM responded correctly to 25/25 of the animal names, 23/25 of the visually similar words, and 25/25 of the unrelated words for a total of 73/75 (97%) correct. With a 1000-msec exposure he scored 24/25, 23/25, and 25/25, respectively, for a total of 72/75 (96%) correct. He failed to explicitly identify any words.

Male/female names. A series of 100 English first names, half male and half female, were presented for 250 msec; as described above, EM was instructed to indicate if the name was appropriate for a man or woman. He responded correctly on 84% of trials while failing to explicitly identify any names.

Word-to-picture matching. Evidence for word comprehension in the absence of explicit word identification was also sought with a forced-choice task requiring the matching of a rapidly presented word to one of two pictures.

The names of items pictured in the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1982) or the Peabody Picture Vocabulary Test (Dunn, 1985) were used to generate 31 pairs of words which shared the first two letters; drawings appropriate to the word pairs were copied onto a single 11 × 8.5-in. piece of paper. The 62 words were presented in random sequence with a microcomputer for 250 msec and the patient was

instructed to point to the appropriate picture. With two exceptions ("snake"/"snail" and "broom"/"brush"), pairs of word were drawn from different semantic categories. EM responded correctly on 54/62 (87%) trials.

A within-category forced-choice word-to-picture matching task was also performed in which all stimuli were animal names. Using stimuli from the Boston Naming Test (Kaplan et al., 1982) and the Peabody Picture Vocabulary Test (Dunn, 1985), 14 pairs of animal names were generated. A total of 23 different animal names were used; 7 names appeared twice, usually as part of a different pair of names (e.g., the word "snake" appeared twice, the first time paired on the response sheet with the picture of a snail and the second with the picture of a spider). EM was told that a word might appear more than once and was given no feedback regarding the accuracy of his response. He responded correctly on 28/32 trials (88%). He did not name any word correctly.

Discussion. Although unable to name a single word explicitly, EM performed well above chance on five word comprehension tasks. Interestingly, on approximately 5–10% of trials, he did offer some semantic information or association pertinent to the stimulus.

Access to Phonology

Data presented to this point suggest that EM was able to contact a catalog of stored word forms as well as at least some semantic information appropriate to briefly presented words which he could not explicitly identify. The following tasks were performed to determine if he was able to derive phonologic information for these words.

The first task required that EM make a rhyme judgment about two rapidly presented words. Stimuli included 64 pairs of words. Half of the pairs of word rhymed; in turn, one-half of the rhyming word pairs were visually similar (e.g., "break"/"steak") whereas the other half were visually dissimilar (e.g., "bean"/"scene"). Half of the overall corpus of 64 word pairs were visually similar; as noted above, one-half of these rhymed (that is, "break"/"steak") and half did not rhyme ("height"/"freight").

In this task, one word was presented with a microcomputer for 250 msec. Following a 1000-msec unfilled interstimulus interval, the second word was presented at the same location for 250 msec. EM was instructed to say "yes" if the two words rhymed; he was told that it was not important to identify the words but he was told to report any word which he thought he had recognized.

He responded correctly to 17/32 trials on which the words rhymed and 14/32 trials on which they did not rhyme for a total of 31/64 (48%). Thus, he performed at chance on this task.

A second analysis was performed to determine if his performance was influenced by the visual similarity of the stimuli; we reasoned that if EM

was unable to access phonology for these letter strings but responded on the basis of the visual similarity between the word pairs, he would say "yes" more frequently to words that were visually similar than to word pairs that rhymed but were visually dissimilar. EM responded "yes" to 13/16 visually similar but nonrhyming pairs compared to 6/16 pairs which rhymed but which were visually dissimilar. This difference is significant ($\chi^2 = 6.35, p < .05$).

As a control condition, the 64 word pairs were auditorily presented to EM on a different occasion; he made no errors on this task. Thus, his failure on this task cannot be attributed to an inability to understand the task or appreciate rhyme.

Because one might argue that the exclusively visual nature of the above task biased EM to respond on the basis of visual similarity, a second task was performed 1 week later. Stimuli for this task were the same as those described above. This task differed, however, in that one of the paired words was presented auditorily to the subject prior to the 250-msec visual presentation of the second word of the pair; the first word was repeated after the visual presentation and EM was asked to say "yes" if the spoken and written words rhymed.

Only 29 word pairs were presented with this paradigm; EM found the task distressing and, after stating that the task "simply can't be done," declined to complete the test. Examination of the 29 completed trials demonstrated that EM responded "yes" to 7/16 trials on which the word pairs rhymed and 6/13 trials on which the pairs did not rhyme for an overall performance of 13/29 (45%).

Additionally, he responded "yes" to 3/5 word visually similar but nonrhyming word pairs and 4/9 rhyming but visually dissimilar word pairs; the extremely small number of observations, however, makes the interpretation of these data difficult.

Discussion. EM performed at chance on two forced-choice tasks assessing implicit access to phonologic information for words which he could not identify. The fact that he performed well above chance on similar tasks assessing access to a visual word form system and a semantic store suggests that the failure to access phonologic information is not attributable to methodologic factors.

GENERAL DISCUSSION

Although EM exhibited a mild impairment on tasks assessing naming to description and by palpation, he performed substantially less well on visual confrontation naming tasks: thus, EM demonstrated a visual modality-specific anomia. EM exhibited no evidence of a visual object agnosia; there was no suggestion of an object recognition deficit in naturalistic settings and he quickly and reliably provided specific gestures appropriate to visually presented objects, most of which he was unable to name. Additionally, he performed better than most controls on a

challenging task, the "functional similarity" test, which requires that the subject access information about object function. EM, therefore, exhibits the syndrome of optic aphasia.

We have previously suggested that optic aphasia may reflect the capacities of the right hemisphere lexical-semantic system. We believe that this hypothesis can also account for the data from EM. On this hypothesis infarction of the left hemisphere optic radiations or visual cortex prevents visual information from directly accessing the left hemisphere. Additionally, damage to left hemisphere structures such as the forceps major prevents the transfer of visual information from the intact right hemisphere to the left hemisphere language mechanisms (Damasio & Damasio, 1983; Henderson, Friedman, Teng, & Weiner, 1985). The right hemisphere is assumed to support early visual processing culminating in the activation of the appropriate structural description or stored object-specific representation (or, for words, visual word form). Last, activation of a structural description is assumed to provide access to semantic information supported by the right hemisphere. Naming of visually presented stimuli is typically impaired because of the disconnection between the right hemisphere and the left hemisphere language mechanisms critical for speech production.

The hypothesis sketched above is consistent with EM's performance on tasks assessing object recognition; although he failed to name most visually presented objects, he performed normally on a variety of tasks assessing access to semantic information appropriate to those objects. It should be noted in this context, that EM's explicit denial that he could even "see" stimuli to which he responded appropriately is reminiscent of the behavior of patients after corpus callosum transections (Sperry, Gazzaniga, & Bogen, 1969; Gazzaniga & Sperry, 1976); CB, the optic aphasic we reported previously (Coslett & Saffran, 1989b), responded in a similar manner. It is perhaps not surprising, then, that the explanation outlined above is similar to that offered by a number of investigators studying split-brain patients.

The proposal that optic aphasia reflects the limitations of the right hemisphere lexical-semantic processing is also consistent with EM's performance on verbal tasks. Although controversial, a number of lines of evidence including investigations of patients with "deep" (Coltheart, 1980, 1983) and "pure" alexia (Shallice & Saffran, 1986; Coslett & Saffran, 1989a) and hemispherectomy (Patterson et al., 1989) are consistent with the hypothesis that the right hemisphere is at least, to a limited extent, literate. More specifically, it has been proposed that the right hemisphere lexicon consists primarily of major lexical items of high imageability (Coltheart, 1983); recent evidence from normals suggests that the right hemisphere may not support morphologically complex (e.g., suffixed) words (Todorovic, 1988). As noted above, investigations of split-brain patients as well as patients with pure alexia suggest that the right hemisphere has a poorly developed capacity for speech production; these studies have

also suggested that the right hemisphere does not support the phonologic information utilized for tasks such as rhyme judgment (Zaidel & Peters, 1981). Finally, certain investigators have proposed that semantic errors reflect right hemisphere involvement in reading (Coltheart, 1980; Saffran, Bogyo, Schwartz, & Marin, 1980).

EM's performance was consistent with the right hemisphere reading hypothesis as outlined above in virtually every respect. Although he performed well above chance on a variety of lexical decision tasks, he failed to reject inappropriately suffixed words (e.g., "elephanting"), suggesting that he did not adequately access procedures involving affixation. As indicated by his chance performance on rhyme judgment tasks with visually presented words and his inability to name written words which he comprehended, EM was unable to access phonologic information appropriate to visually presented words. Last, it should be noted that although EM did not produce semantic errors the significance of this observation is unclear as he failed to offer an explicit, single word response to *any* letter string; EM's explicit statements (e.g., "helps to make up a meal" in response to the word SALAD) were quite reminiscent of semantic errors in that they demonstrated a clear semantic relationship to the target. It is also worthy of note that these responses were not simply circumlocutions as he often failed to recognize the correct response even when he produced it himself or it was mentioned by the investigator.

Finally, we contend that the alternative account of optic aphasia which attributes the syndrome to an impairment in access to semantic information (e.g., Riddoch & Humphreys, 1987) offers a less compelling account of the disorder for at least two reasons. First, EM's excellent performance on tests of object recognition such as gesture production and functional similarity suggests that he did, in fact, access a semantic entry for these objects. Second, unlike the right hemisphere hypothesis, this account does not predict the patient's reading performance; it is not clear, for example, how this proposal accounts for the dissociations on lexical decision tests between nouns and functors and high and low imageability words or EM's ability to correctly categorize words for which he is apparently unable to retrieve or produce phonologic information.

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