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A Selective Preservation of Numbers and Geographic Information in a Severe Anomic Patient: A Consequence of Degraded Visual Knowledge Base?

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Abstract

This paper reports a single-case study of a severe anomic patient, Bobcat, who demonstrates a remarkably spared ability to produce spoken output for numerical and geographic information in the context of severe word retrieval impairments for common objects and concepts. His category-specific preservation of word retireval ability is first empirically documented. Then, using the data gathered in a series of five experiements, we argue that Bobcat's unique naming profile of spared and impaired categories results from a severely impaired visual semantic system coupled with a relatively spared verbal semantic system.

Introduction

This paper presents a single-case study of an aphasic patient, “Mr. Bobcat,” who demonstrates, in the context of a dense anomia, a remarkably well-preserved ability to retrieve certain categories of words, like numerical and geographical information. Our central goal in this paper is to empirically document his category-specific preservation of word retrieval ability and explain the nature of his unique deficits in terms of a cognitive psychological model of picture naming. We will argue that Bobcat’s severely impaired ability to name common objects and natural concepts in the face of remarkably spared ability to retrieve more artificial, "school-learned" concepts may reflect a degradation of his visual semantic knowledge base and a consequent (or additional) problem of accessing an appropriate phonological word from in the speech output lexicon.

Although producing an appropriate name for a pictured common object (e.g., “telephone” and “cup”) is seemingly an easy task for normal individuals, it often turns out to be a formidable task for many brain-damaged patients. From numerous neuropsychological studies of word retrieval deficits conducted so far, it is clear that picture naming (or “confrontation naming”) is a complex cognitive activity consisting of several subcomponent processes, and that different brain-damaged patients thus fail on this task for many different reasons (for a recent review, see Ellis, Kay, & Franklin, 1992; Goodglass, 1993). Consider, for example, the processes that might be implicated in the naming of a picture of an apple. Intuitively, the naming process probably begins with an adequate visual analysis of the depicted object. Based on the visual features of the object, a successful visual identification must be achieved. Then the speaker must find an appropriate verbal label for that object before the correct answer ("apple") is finally produced. Problems in any of these component processes could lead to a naming failure.

Recent cognitive psychological and cognitive neuropsychological models of naming processes (especially, confrontation naming processes) are generally consistent with this intuitive analysis. One such model developed by Ellis and his colleagues (Ellis et al., 1992; Ellis & Young, 1988) is presented in Figure 1. Although different models may differ considerably in their details (particularly with respect to the interactivity among different subcomponents), the sequence of subcomponent processes postulated in the Ellis et al. (1992) model is widely (if not universally) accepted (e.g., Lesser, 1989; Levelt, 1989).[1]

According to this model of confrontation naming, the process must begin with visual analysis, which perhaps involves the encoding of visual features and their configurations. The model assumes that visual encodings of familiar objects are stored in long-term memory in the form of what Ellis and Young (1988) call "object recognition units" (Seymour, 1979), whose job is a visual identification of the object. A successful visual analysis of the object is considered to lead to activation of the appropriate object recognition unit. According to the model, at this stage, the viewer can only tell whether or not the object depicted in the picture is familiar; neither semantic information of the object nor the verbal label of the object is yet available.

The next stage of the naming process involves the activation of appropriate semantic representations of the visually identified object. This is the stage in which various information about the object (e.g., its functions, uses, and sensory characteristics) becomes available. Simply recognizing the object is not sufficient for lexical access. Rather, the activated semantic representations of the object must in turn activate the correct phonological word form of the object in the mental lexicon (or "speech output lexicon"). According to the model, the phonological word form available in the speech output lexicon is a specified sequence of phonemes. The final stage of successful confrontation naming is the motor programming and actual articulation of the retrieved correct word form. On the assumption that each of these separate subcomponents of the naming process and/or the connections between two adjacent subcomponents can be selectively damaged, this model (or a set of other similar models) has been successful in accounting for various naming disorders reported in the literature (Ellis et al., 1992; Ellis & Young, 1988; Lesser, 1989).

In this paper, we will use the Ellis et al. model to specify the nature of naming problems exhibited by our densely anomic patient, Bobcat. Bobcat's case is particularly intriguing because of his striking loss of the ability to name common objects and concepts (e.g., animals, vegetables, tools, etc.) in comparison to his preserved ability to name numbers and geographic information (e.g., cities, states, countries, etc.). For example, he cannot name such common objects as "watch" and "arm" in a confrontation naming task, whereas he has no difficulty naming any state the experimenter points to on a map of the United States (including multi-syllabic names such as "Pennsylvania" and "Oklahoma") or reading aloud large numbers such as 1,978 and 23,028. In this paper, we first establish the category-specific sparing of Bobcat's word retrieval capability in a specifically designed naming task. We will then provide evidence for the view that Bobcat's unique profile of word finding difficulties may reflect an impairment in the semantic memory component, more specifically, the part of the semantic memory system that represents the visual knowledge associated with an object that has been visually identified.

Although it is still highly controversial, the notion of a multiple semantic memory system that postulates visual semantic memory (or visual knowledge) is not new (e.g., Allport, 1985; Warrington & Shallice, 1984). A series of case studies of patients who demonstrate some sort of category-specificity in naming performance has motivated this multiple semantics hypothesis. For example, one class of category-specific deficits that have been particularly influential in developing the notion of multiple semantics concerns the dissociation between living things (e.g., animals, plans, fruits and vegetables) and nonliving things or artifacts (e.g., household objects, vehicles, buildings) (see Saffran & Schwartz, 1994, for a recent review). For instance, the cases reported by Warrington and Shallice (1984), J.B.R. and S.B.Y., demonstrated much more severe degradation of knowledge of living things than nonliving things, both showing poorer naming (both picture naming and naming to verbal definitions) and definition ability for living things.[1] There are also reports of patients who show the opposite tendency, showing relatively preserved knowledge of living things coupled with more severely degraded knowledge of nonliving things and artifacts(e.g., Hillis & Caramazza, 1991; Sacchett & Humphreys, 1992; Warrington & McCarthy, 1983, 1987).

According to Warrington and Shallice (1984), this dissociation does not necessarily mean that the semantic memory system in the brain is organized along taxonomic lines (see also Allport, 1985; Farah & McClelland, 1991). Rather, they suggested that semantic memory is essentially modality-specific. According to this proposal, nonliving things are largely defined by their functional use (e.g., a piano is used for playing music) rather than by their sensory characteristics (e.g., black and white, heavy), whereas living things are more dependent on sensory (particularly visual) features (e.g., an elephant has a long trunk) than their functional significance (e.g., an elephant can carry people). They argued that the underlying distinction between living and nonliving things may thus be between those concepts defined primarily by their sensory properties (i.e., living things) and those concepts defined primarily by their functional use (i.e., nonliving things).

Farah and McClellend's (1991) norming study provides some supporting evidence for this distinction. In that study, the researchers gave undergraduate participants a list of dictionary definitions of living things and nonliving things and asked them to underline visual and functional features in each definition, using different colors. The main finding of the study was that the definitions of living things are more heavily dependent on visual features than functional features (an average of 2.68 visual vs. 0.35 functional descriptors per definition; the ratio = 7.7 to 1), whereas the definitions of nonliving things are dependent relatively equally on both types of features (an average of 1.57 visual vs. 1.11 functional descriptors per definition; the ratio = 1.4 to 1). This differential distribution of visual and functional descriptors is consistent with the view that the semantic knowledge of living things and nonliving things depend differentially on visual and functional knowledge.[2] Based on this notion, Farah and McClelland (1991) successfully simulated , in a connectionist network model, the pattern of the dissociation between the knowledge of living and nonliving things that has been reported in the literature.

Bobcat's profile of naming ability is different from those patients who demonstrate a dissociation between living versus nonliving things in that his confrontation naming performance for living and nonliving things are both severely impaired. Despite this severe naming impairments for common objects, his ability to retrieve and produce spoken output for more fact-based, "school-learned" concepts is remarkably well preserved.

For the purpose of discussing Bobcat's deficits, we will assume another semantic memory distinction proposed earlier in the literature, namely, the separation between visual and verbal semantic systems. Although the visual versus verbal distinction itself is not necessary to explain the dissociation between living versus nonliving things, several investigators (e.g., Ellis & Young, 1988; Shallice, 1988) this dimension to account for other patterns of naming deficits reported in the literature as well (e.g., optic aphasia).

We will argue that this verbal and semantic distinction provides a useful basis to account for Bobcat's unique pattern of sparing and impairment in word retrieval. In particular, we will claim that the knowledge of fact-based, "school-learned" concepts are represented more strongly in the verbal semantic system than the visual semantic system. Note that, according to Farah and McClelland's (1991) norming study described above, the knowledge of both living and nonliving things still depends strongly on visual attributes (2.68 and 1.57 visual descriptors per definition, respectively). Our argument is that certain categories of knowledge, such as numbers and geographic information, are far less dependent on visual features and attributes than knowledge of living things and nonliving things. Such knowledge is instead more dependent on verbal associations and verbal knowledge, given the way it is typically acquired (i.e., via verbal instructions at school). Based on this idea, we will attribute Bobcat's unique naming profile across different categories to a severely impaired visual semantic system, but a relatively (if not completely) spared verbal semantic system.

Patient Description

Bobcat, a 70-year-old right-handed male, was approximately 4 years post-onset of a single, unilateral left hemisphere cerebral vascular accident at the time of testing. In addition to his aphasia, he had right hemiparesis, but there was no evidence of visual field deficits. An Ivy-league college graduate with a degree in civil engineering, Bobcat worked as a high-level administrator for a state highway department until his retirement at age 65.

Lesion Information

Unenhanced computerized axial tomography images (see Figure 2) showed an infarction involving the left inferior frontal, anterior temporal, and inferior parietal lobes, including the frontal and parietal opercula, insula, putamen and internal capsule. This extensive lesion indicates a stroke in the distribution of the left middle cerebral artery, which is typically associated in a dextral patient with severe aphasia and right hemiparesis.

Language and General Cognitive Abilities

Bobcat came to the attention of the first author when he came to the University Clinic for a speech-language evaluation. He presented with a dense anomia (Boston Diagnostic Aphasia Examination composite score for the three naming subtests placed him at the 43rd percentile for aphasic patients), but there was a striking preservation of access to certain categories of words (e.g, letters, numbers, spatial directions, and geographical terms).

His confrontation naming performance was assessed in more detail with the Boston Naming Test (BNT, Goodglass & Kaplan, 1983) on which he spontaneously named only two (cactus and volcano) of the 60 items . He named one additional item (tree) when given a semantic stimulus cue and four more items (bed, canoe, globe, and igloo) when given phonetic cues. These BNT results suggest that word frequency had little or no effect on his naming performance. Many of his errors in the naming test were perseverative, and several others were circumlocutory attempts using words from his preserved semantic categories (e.g., rhinoceros = "*2000 pounds*"; tripod = "*three sides*"; protractor = "*90 degrees*"). He also produced some unrelated words, but there were only a few instances of semantic paraphasia and neologisms that were phonetically similar to the target.

Bobcat's spoken output, as shown in the speech samples below, was difficult to describe in terms of a classic fluent-nonfluent dichotomy. On the one hand, he produced very few verbs and many short disjointed phrases with limited syntactic form, as is often seen in nonfluent aphasic patients. On the other hand, his speech was easily produced with good melodic line, like patients with fluent aphasia. Several utterances were greater than seven words in length (e.g., "*I got a stroke with the right hand,*" and "*Twelve days later I had a stroke.*"). Articles, prepositions, and adverbs were richly supplied, although paraphasia were frequent (e.g., "I" for "he"). Like many other anomic patients he seldom used subject pronouns, and his phrases were unanchored and consequently conveyed little information unless the listener knew what he was trying to talk about. Because of these mixed speech characteristics, Bobcat was classified as *Borderline Fluent* on the Aphasia Diagnostic Profiles (ADP) (Helm-Estabrooks, 1992).

The following are two samples of Bobcat's spontaneous speech output:

Question: "Tell me exactly what happened to you."

*"Okay, uh, uh, June 6, I got a stroke with the right hand. Um, um, ten days earlier in Ann Arbor. A wedding, a wedding. Uh, forty years old, forty years old, six foot one (*referring to his son, whose wedding he attended). *I think, May 25th. I got married, on a Saturday? Twelve days later I had a stroke. But, okay. Okay."*

Question: "Do you remember President Kennedy? What can you tell me about him?"

"Okay. Dead nineteen sixty-three. November twenty-six.

But before, um. around 1917 born. Uh, so um forty-three years. 1917 born to 1960, so 43 or 40 not 44, but I think so, 43 years old. John F. Kennedy, yup. Assassinated in uh, one o'clock in the afternoon in Dallas. Um, two strokes and uh, quarter or a half an hour afterwards, dead. Assassinated. Uh, 1946 in Massachusetts, uh, his first term. Uh, so, yea, fort-14 years later, uh to the president. Fourteen years. Uh, 1946, 1948, 1950, 1952, 1954, and I don't know thereafter, or six to the president, or no. the senate in 1960, January 20, the president."

Note that, consistent with his number-related circumlocutions in confrontation naming, his spontaneous speech is also abundant in numerical information. Functionally, he had a great deal of difficulty communicating in everyday situations. He made no use of drawing or gesture (other than pointing and head nods) to augment his spoken output, even though it had been a main focus of therapeutic efforts.

Bobcat's overall auditory comprehension on standardized testing was generally poor (16th percentile for aphasic norms), as measured by the ADP. His best comprehension performance was observed on relatively simple tasks, such as the Following Commands (60%

correct) and Comprehension of Single Words (70% correct) subtests. However, he correctly answered only 2 of 10 yes-no question pairs on the more complex Understanding Stories subtest.

His repetition ability was relatively well preserved in relation to his severe naming problems. He easily repeated one, two, and three word phrases on the ADP, including the phonetically challenging items (e.g., happy hippopotamus and a terrible tornado). Successful repetitions were rapid and confidently articulated. With the exception of the item involving numbers (i.e., three hundred and twenty-one dollars), however, he had difficulty when stimuli exceeded six words (or seven syllables) in length. His repetition errors on these items consisted of word omissions, additions, and paraphrasing. His oral reading was also relatively well preserved at the level of single words. Bobcat obtained a raw score of 24/30 (75th percentile for aphasic norms) on the Oral Word Reading subtest of the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1983).

These language performances placed Bobcat at the 32nd percentile for aphasic norms for overall aphasia severity on the ADP (see Table 1 for a complete profile of Bobcat's performance).

Bobcat's nonverbal cognitive abilities in several areas were generally well-preserved. For example, he exhibited superior analytic intelligence, as indicated by a raw score of 29 (90th percentile for 70-year-old normal individuals) on the Raven Coloured Progressive Matrices (Raven, Court, & Raven, 1977). He also obtained an age-scaled score of 15 (timed) on the Arithmetic and 13 (untimed) on the Block Design subtests of the Wechsler Adult

Intelligence Scale-Revised (WAIS-R) (Wechsler, 1981), placing his performances nearly two standard deviations above the normal mean. He also demonstrated relatively preserved ability to copy simple drawings using his nondominant hand. In marked contrast to these high performances, certain visuospatial tasks that may rely heavily on stored visual knowledge for success were poorly performed, as we will describe later.

Experiment 1: Category Naming

As the language profile outlined above indicates, Bobcat appears to have a unique category-specific pattern of word retrieval problems: his ability to produce numbers and geographic information appears relatively intact, whereas his ability to name ordinary common objects is severely compromised. In Experiment 1, we administered a specifically designed naming test to Bobcat, as well as several other aphasic patients, to confirm the pattern of category-specific sparing that was suggested by our clinical observations of his language performance.

We selected six specific categories for this naming task. Categories were selected to include some (Household Objects, Body Parts, & Colors) that had been found to be relatively easy categories for most aphasic individuals (Goodglass, Wingfield, Hyde, & Theurkauf, 1986) but were expected to present difficulty for Bobcat. Three additional categories were selected (Numbers, U.S. States, and U.S. Geographic Regions) because his standardized testing and spontaneous speech suggested that naming for these categories would be preserved.

Aphasic Control Participants

Six individuals with aphasia served as controls. They represented a range of naming abilities, aphasia types, and severity levels, as assessed by the ADP. Table 1 provides a summary of each participant's aphasia profile. While a control sample of six individuals cannot be considered truly representative of the aphasic population, we tested them on this naming task in order to rule out the possibility that Bobcat's unique pattern of preservation and impairment was simply a reflection of the overall pattern of difficulty exhibited by other aphasic individuals.

Materials and Procedures

The stimuli consisted of 58 pictures divided into six categories: Numbers, U.S. States, U.S. Geographic Regions, Household Objects, Body Parts, and Colors. Each category included 10 items, except for the U.S. Geographic Regions category for which only eight items were possible. Appendix A lists all the target words used in this naming task.

The pictures for Household Objects and Body Parts were reproductions of black and white line drawings from the Snodgrass and Vanderwart (1980) set. Numbers were represented by sets of black dots arranged in an orderly fashion, varying from 0 to 9. The U.S. States and U.S. Geographic Regions were represented by highlighting the appropriate portion of an unlabeled, black-and-white line drawing of the United States with state boundaries showing. Colors were shown in 1 1/4 inch square patches. All pictures were individually mounted on 5 x 8" cards.

Stimulus cards were presented to Bobcat and aphasic control participants one at a time, with the instruction, "Tell me the name of this." The presentation of stimuli was blocked by category, but items within each category were randomly ordered. All responses were orthographically transcribed, and credit was given for recognizable productions of the target words. In order to assure the stability of Bobcat's performance on this task, he was tested twice with approximately one month between sessions.

Because the selected categories for this particular naming task were quite heterogeneous, we found it impossible to precisely control for some of the variables that have been known to affect aphasic patients' naming performance (e.g., imageability, number of syllables, etc.). The categories in this task varied considerably along those variables, as was the case in an earlier study of category-specific naming impairments (Goodglass et al., 1986). We will report, however, the results of some posthoc analyses to explore whether Bobcat's naming performance might be explained by one or more of those variables for which we were not able to systematically control.

Results and Discussion

Across all the aphasic control participants, the mean percentage of items named correctly was 65%, with a range of 47% (U.S. Geographic Regions) to 93% (Numbers). As Table 2 shows, Bobcat's pattern of naming performance for the six categories was as we had predicted: he was able to name all the items in the Numbers, U.S. States, and U.S. Geographic Regions categories, but he named only 2 or 3 items in the Household Objects, Body Parts, and Colors categories. Bobcat's mean performance across all the six categories was stable over time with 62% (first administration) and 65% (second administration). The predicted pattern of naming performance also was quite stable across time, yielding an almost identical performance profile for both sessions.

Although the six control participants differed greatly in their overall levels of naming performance, none of them showed the pattern of naming performance similar to Bobcat's. Figure 3 graphically illustrates the uniqueness of Bobcat's performance profile. The graph plots the performance profile of each aphasic individual across the six categories without an influence of overall severity differences in his or her naming ability. To eliminate the effects of overall performance levels, we converted the naming accuracy for the six categories into a set of z-scores for each individual. For example, Bobcat's scores for the first testing session (i.e., 100%, 100%, 100%, 20%, 20%, and 30% , for the six categories) were converted into the $\underline{z}$ scores of 0.91, 0.91, 0.91, -0.99, -0.99, and -0.75, respectively. As Figure 3 shows, Bobcat was clearly the only patient who demonstrated the dissociation that we had predicted on the basis of his conversational speech and standardized clinical testing. Consistent with the report by Goodglass et al. (1986), the Numbers category was easy and relatively well-preserved for all participants, but performance in the remaining five categories varied considerably across participants. Although this type of idiosyncratic naming profiles is not necessarily uncommon (Goodglass et al., 1986), the source of such micro-level category-specificity is not clear and is probably multifaceted. The important point, however, is that none of the control patients showed the same naming profile as Bobcat, which strongly suggests that Bobcat's category-specific pattern of sparing and impairment was not a mere reflection of differences in the general difficulty of the items used in the six categories.

A series of statistical analysis further support this conclusion. A two-tailed, independent $\underline{z}$ test for differences between proportions (Glass & Stanley, 1970) showed that Bobcat performed significantly better than the control patients as a group for the U.S. States

(100% vs. 43%) and U.S. Geographic Regions (100% vs. 38%) categories (both ps $< .05$), whereas he performed significantly worse than the control group for the Household Objects (20% vs. 83%), Body Parts (20% vs. 68%), and Colors (30% vs. 68%) categories (all ps $<$ .05). Bobcat's performance did not differ significantly from the control group for the Numbers category (100% vs. 92%, $p > .05$), presumably because of the ceiling effect.[3]

Note that this analysis based on an independent z test does not take into account his naming performance for a particular category in relation to his overall level of performance in this task. The same pattern of results holds, however, even when we explicitly take it into consideration in an additional Chi-square analysis, using the same procedure used by Goodglass et al. (1986). This analysis specifically tests whether or not Bobcat's performance for a particular category relative to his performance across all the other categories is in proportion to the same relative comparison (i.e., the performance on the same specific category vs. all the other categories) for the control aphasic patients as a group. The results of this analysis were essentially identical to those of the independent z test we reported in the previous paragraph. Bobcat's performance was disproportionately better than the control group as a whole for the U.S. States and U.S. Geographic Regions categories, but was disproportionately worse than the control group for the Household Objects, Body Parts, and Colors categories, all ps $< .05$. These results are clearly incompatible with the view that the systematic pattern of spared and impaired naming performance Bobcat demonstrated simply reflect the overall difficulty levels of the items used in the six categories. Hence, it requires a cognitive account of the nature of his category-specific deficit.

As we mentioned earlier, when selecting the stimuli for this category naming task, it was not possible to control variables that have been shown to impact the naming performance of individuals with aphasia in general (e.g., frequency, imageability, concreteness, etc.). We should emphasize that this fact does not undermine our demonstration of Bobcat's category-specific preservation of naming ability for numerical and geographic information, primarily because our analysis reported so far has established that his pattern is considerably different from that of other aphasic individuals and rules out any idiosyncratic effects due to the specific items used in the study. Our posthoc analysis of category differences in the variables that have been known to affect aphasic patients' naming performance, however, provides interesting insights as to the nature of the functional deficits that underlie Bobcat's category-specific naming and word retrieval problems.

For this analysis, we focused on five of the six categories (Numbers, U.S. Geographic Regions, Household Objects, Body Parts, and Colors), which contained a sufficient number of items for which we were able to obtain the normed ratings for relevant dimensions such as imageability, concreteness, and familiarity (Toglia & Battig, 1978). We also included the number of syllables in this posthoc analysis. Table 3 provides a summary of the results from this posthoc analysis of between-category differences. The results from a one-way analysis of variance (ANOVA) indicated that, while the familiarity ratings did not differ from category to category, $F(4, 31) < 1$, there was a statistically significant difference in imageability, $F(4, 31) = 30.50$, $p < .01$, concreteness, $F(4, 31) = 50.46$, $p < .01$, and the number of syllables per word, $F(7, 70) = 11.70$, $p < .01$.

The results of Tukey's Honestly Significant Difference (HSD) test (with the significance level set at .05) indicated that the number of syllables per word was significantly greater in the category of U.S. States than in all other categories. It is usually the case that aphasic patients have more difficulty producing long words than short words (in terms of the number of syllables). However, Bobcat's naming ability was disproportionately better, rather than worse, for this difficult category, indicating that the number of syllables per word does not seem to be the underlying feature that accounts for his naming difficulty.

Interestingly, the results of the Tukey-HSD test also showed that the words in the Number and the U.S. Geographic Regions categories had significantly lower imageability and concreteness ratings than the words in the categories of Household Objects, Body Parts, and Colors. Note that this statistical contrast coincides with the distinction between the categories of words Bobcat was able to name and those he was not able to. Previous models and theories of mental representation (e.g., Pavio, 1986) have postulated that the representation of highly concrete and imageable concepts are likely to be dependent on visual knowledge. Although not conclusive, the result of this posthoc analysis suggests that Bobcat's category-specific pattern of sparing and impairment might have arisen, at least in part, from a degradation of his visual knowledge. More specifically, an underlying disorder of visual knowledge might have negatively impacted Bobcat's ability to name items that were associated with a strong visually-based knowledge, but did not impact his ability to name items that were not strongly associated with visually-based knowledge. The next five experiments were designed in an effort to explore this hypothesis.

According to the information-processing model of confrontation naming we described earlier, one source of naming difficulty maybe at the level of visual analysis and object recognition. Experiments 2, 3, and 4 were designed to rule out the possibility that Bobcat's difficulty with confrontation naming was due to an impairment at this level. Given that Bobcat's relatively spared repetition and oral single-word reading ability reported earlier, the underlying impairment also is unlikely to be at the level of the speech output lexicon. We thus propose that his impairment is likely to reside in semantic memory, particularly visual semantic knowledge. Experiments 5 and 6 tested this possibility, tapping his visual semantic knowledge.

Experiment 2: Test of Visual Agnosia

When testing for visual agnosia it is desirable to separate apperceptive and associative disorders (Lissauer, 1889). Patients with apperceptive visual agnosia are unable to recognize visual stimuli because of entry-level perceptual deficits. Consequently, patients with apperceptive visual agnosia are not only unable to identify visually presented items, but they are also unable to draw or match to sample. In contrast, patients with associative agnosia are believed to have a disorder that impacts higher levels of visual processing, but does not interfere with early perceptual processes. Thus, while these patients are able to draw and match to sample, they are unable to recognize visually (Rubens, 1979).

Bobcat's good performance on the Block Design subtest of the WAIS-R (Wechsler, 1981), to be discussed later in this paper, and his fair performance when copying line drqwings mentioned earlier, suggest that his inability to name pictured concepts was not due to apperceptive agnosia. Experiment 2 was, therefore, designed to rule out the possibility that a higher level visual processing disorder (e.g., associative agnosia) contributed to his naming disorder. More specifically, we tested Bobcat and the six aphasic control participants on a three-alternative forced-choice task of higher-level visual analysis, which required participants to judge which of the three pictured objects “do not belong.” This visual matching paradigm is a common way to test visual agnosia non-verbally, although researchers have used different materials such as line drawings and photographs (e.g., Humphreys & Riddoch, 1984; Warrington, 1982).

Materials and Procedures

Twelve sets of black and white pictures were selected from the Corell Gallery set (1994). Two pictures in each set were different visual representations of the same concept, while the third picture in each set shared visual characteristics with one of the other pictures in the set, but was unrelated in concept. For example, one set consisted of two different representations of snakes (one coiled around a tree branch and the other stretched out) and a coiled garden hose (see Figure 4). Each set of pictures was reproduced and placed on a 5 x 8" card. The stimulus cards were randomly ordered and presented with the instruction, "Which one is different? Which one doesn't belong?" Thus, participants could base their response on either the common concept represented by two of the three drawings, or the common visual characteristics of two of the three drawings (interpreted as evidence of associative visual agnosia).

Results and Discussion

As we predicted, Bobcat’s performance on this task was satisfactory; he correctly answered 10 out of the 12 trials. Although his performance was not perfect, his performance (83%) was significantly better than chance (33%), $p. < .05$, according to a binomial distribution test (the performance of 67% correct or better is considered statistically above chance). As Table 4 indicates, all the other aphasic control participants ($\underline{X}$ = 93%; Range = 82-100%) also performed significantly better than chance.

While Bobcat's score may not be as high as we would have liked to completely rule out the visual agnosia interpretation, we suspect that he erred on at least one of the two items he missed for reasons other than a difficulty in recognizing the objects depicted in the pictures. For example, on one test item, he was shown three pictures (an old fashion typewriter, a touch-tone telephone and a modern electric typewriter) and asked to point to the one that was different. He responded by pointing to the old fashioned typewriter and commenting, "Nineteen thirty or forty." It appeared that he was selecting the "different" picture on the basis of the era in which it was manufactured. Although this anecdotal evidence is not conclusive, Bobcat's above-chance performance provides evidence consistent with the conclusion that his object recognition ability was relatively intact. Bobcat's poor naming performance for common objects in Experiment 1 (at least the categories of Household Objects and Body Parts), hence, cannot be accounted for entirely in terms of an impairment in the visual object recognition process.

Experiment 3: Color Identification

We further tested Bobcat's visual analysis capability by administering a two-alternative, forced-choice color identification task, similar to the one used by Sheridan and Humphreys (1993). We conducted this study because Bobcat's naming performance for the Color category in Experiment 1 was poor (30% correct). According to our view, it was mainly due to his problems in successfully activating the appropriate phonological form of the target color from visual semantic knowledge. Another simpler explanation, however, is that Bobcat has impaired visual perception of colors. This experiment was designed to rule out this possibility.

Materials and Procedures

Eleven sets of two colored squares were individually presented on 3 x 5" cards with the instruction, "Which one is ______." Participants responded by pointing to one of the colored-squares. Responses were recorded as correct or incorrect.

Results and Discussion

As Table 4 indicates, this task presented no difficulty for any aphasic participant (including Bobcat), with all participants scoring 100%. A binomial distribution test indicates that all participants' performance was statistically above chance ($\underline{p} < .05$).

Experiment 4: Spoken Word - Picture Matching Test

While the results of Experiments 2 and 3 suggest that Bobcat's visual analysis and general object recognition skills are relatively intact, there remained the possibility that his failure on the category naming test may have resulted because he did not recognize and/or know the specific stimulus items used. Therefore, we administered a test of spoken word -to-picture matching to rule out this possibility.

Materials and Procedures

The 58 pictures used in Experiment 1 were reduced in size and reproduced onto three 9" X 14" sheets, each containing 19, 19, and 20 pictures, respectively. The pictures from the six categories were randomized so each sheet contained items from all categories.

Each sheet was presented one at a time to Bobcat and he was asked, "Show me the _____."

Results and Discussion

Bobcat performed remarkably well on this task in light of his overall poor auditory comprehension.[4] He identified the items in the Numbers, U.S. Geographic Regions, U.S. States, and Household Objects, with 100% accuracy, and missed only one item in each of the remaining two categories (e.g., Body Parts and Colors).

The data from Experiments 2, 3 and 4 are consistent with the view that Bobcat's visual analysis and general object recognition capability is relatively intact. The results thus rule out the hypothesis that his poor confrontation naming performance in the Boston Naming Test and in some of the categories used in the Experiment 1 task (i.e., Household Objects, Body Parts, and Colors) is associated with the visual analysis and object recognition stages of the picture naming process in the Ellis et al. (1992) model.

As we argued elsewhere, Bobcat's relatively well-preserved repetition and oral word reading abilities indicates that his speech output lexicon itself also seems to be intact. The remaining sources of his naming problems according to the Ellis et al. model, then, concern primarily the semantic memory system (and the connection between the semantic system and the speech output lexicon). Our hypothesis is that Bobcat has degraded visual semantic knowledge, which in turn makes it difficult for him to successfully activate the appropriate phonological forms. Experiments 5 and 6 were designed to explore this hypothesis by showing that Bobcat's visual knowledge is indeed impaired.

Experiment 5: Test of Visual Knowledge - Color Verification

Previous investigations of visual knowledge have utilized several procedures that heavily depended on the participant's relatively intact language comprehension or production abilities. One such common procedure is the one that requires participants to make a true-false judgment of orally presented statements regarding the physical attributes of common objects. Unfortunately, however, it was not possible to test Bobcat's visual knowledge with this technique because of his relatively severe comprehension difficulties beyond the level of single words and simple phrases. Therefore, we designed two tasks (Experiments 4 and 5) that were not heavily dependent upon language comprehension or expression. More specifically, the two tasks we developed, based on the nonverbal tasks used by Sheridan and Humphreys (1993), featured pictorial stimuli, had straightforward requirements that could be understood without elaborate spoken instructions, and allowed participants to indicate their responses via pointing, thus eliminated the need for verbal output. Experiment 5 specifically tested Bobcat's knowledge of typical colors of common objects in a four-alternative, forced-choice task.

Materials and Procedures

Black and white drawings of 12 animals and 12 fruits and vegetables were selected from the Corell Gallery set (1994). Each was easily recognizable and associated with a single, prototypical color (e.g., cherry - red). Drawings were reproduced and individually placed on 5 x 8 inch cards. Four colored squares (one correct and three foils) appeared directly below the drawing on each card. Stimuli were blocked by category, but items within each category were presented in random order with the instruction, "What color is this in real life?" The participant's color response was recorded.

Results and Discussion

This task turned out to be moderately difficult for aphasic patients, yielding an average performance of 72% correct for the Animals category and 89% correct for the Fruits and Vegetables category (see Table 5 for a summary). According to a binomial distribution test (the cutoff point at the $p = .05$ level was 58% correct), however, all the aphasic controls performed significantly above chance for the Fruits and Vegetables category (Range: 67-100%; all $ps < .05$) and all but one patient did so for the Animals category (Range: 50-100%; all $ps < .05$, except for Patient E.H. who responded correctly to only 50% of the trials).

In striking contrast, Bobcat performed poorly on this task, answering correctly on only 25% of the tokens in the Animals category and 8% in the Fruits & Vegetables category. His performance was statistically indistinguishable from chance-level (25%) for both categories ($p > .10$), according to a binomial distribution test. His performance on this task was far worse than the aphasic controls, even though his performance was at least comparable to theirs on tests of high-level visual analysis (Experiments 2 and 3).

In particular, Experiment 3 demonstrated that Bobcat's ability to comprehend a color word and select a matching color was relatively spared. Given this result, his poor performance in this color verification task suggests that his visual knowledge might be seriously compromised. It is consistent with the view that his poor naming ability of common objects (including colors) might have to do with his difficulty in activating appropriate phonological word-forms from visual semantic knowledge.

Experiment 6: Test of Visual Knowledge - Size Judgement

Experiment 6 further examined Bobcat's visual knowledge impairments by tapping a another dimension that appeared to hinge critically on visual knowledge: the knowledge of object sizes. Based on the Sheridan and Humphreys (1993) study, we created a two-alternative, forced-choice size judgment task.

Materials and Procedures

Thirty pairs of pictures were selected from the Snodgrass and Vanderwart (1980) set such that there were ten pictures in each of three categories (Animals, Household Objects, and Fruits & Vegetables). Pairs were selected so that they shared the same spatial orientation (for example, a kangaroo was paired with a penguin because both were longer in the vertical dimension than the horizonal), and basic geometric shape (for example, carrot was paired with asparagus because they are both somewhat cylindrical in shape). In order to assure that successful performance on this task relied on the use of visual knowledge, we tried to avoid any stimulus pairs in which size differences are so apparent (e.g., ant vs. elephant) that the mediation of visual knowledge might not be necessary. We instead tried to make sure that the target objects in each were relatively similar in size (e.g., asparagus vs. carrot).

Pictures were reproduced, colored, and enlarged so that each pair was approximately the same size. Pairs were blocked by category, but pairs within each category were presented in random order with the instruction, "Show me which one is bigger in real life." The participant's choice was recorded.

Results and Discussion

As Table 6 indicates, the aphasic control participants performed this task well for all three categories, with an average of 94% correct for the Animals category, 83% for the Fruits and Vegetables category, and 87% for the Household Objects category. A binomial distribution test (the cutoff value at the $\underline{p} = .05$ level was 80% correct) indicates that all control participants performed significantly above chance for all three categories (all $\underline{p}$s < .05), except for the performance of one control participant E.H., who failed to perform at above-chance level for the Fruits & Vegetables category (70%), but performed above chance for the remaining two categories.

Consistent with the findings from Experiment 5, however, Bobcat's performance on this size judgment task was again very poor. His performance did not differ from chance-level for any of the three categories tested in this task, all $\underline{p}$s > .10 (Animals, 60%; Fruits & Vegetables, 60%; Household Objects, 50%). Bobcat's poor performance on this task and the color verification task point strongly to a deficit in visual knowledge.

In addition to the data from Experiments 5 and 6, the pattern of performance that Bobcat showed on two visuospatial subtests of the WAIS-R (Wechsler, 1981), namely the Block Design and Object Assembly tests, corroborates with this conclusion. He had great difficulty putting together puzzles of common objects in the Object Assembly subtest, where his age-scaled score of 4 was two standard deviations below the normal mean. Consistent with the assessment of a visual knowledge deficit, he appeared to show no recognition of the target object (except for the mannikin) when shown the puzzle pieces. His performance also did not improve when the experimenter explicitly told him the name of the target object. Even when he did assemble pieces correctly, his performance appeared to be guided by the continuity of the lines in the drawings, rather than the knowledge of what the target object was and what it looked like. In marked contrast, performance on the Block Design subtest (which requires that the examine replicate pictured geometric patterns through the manipulation of colored blocks) indicated above average-to-superior skills, with a score of 11 on the timed version and 13 on the untimed version of this test (1 and 2 standard deviations above the normal mean, respectively).

Lezak (1983) has suggested that patients who do well on the Block Design subtest of the WAIS-R and the Raven's Coloured Progressive Matrices, but have difficulty with the Object Assembly subtest of the WAIS-R may be unable to "conceptualize, or at least identify, the finished product in order to assemble it mentally or actually" (p. 286). Thus, while visual analysis and visuo-motor constructional abilities must remain intact in order for adequate performance on Block Design and the Raven Matrices, failure on the Object Assembly subtest may be tied to a deficit in stored visual knowledge and/or the ability to access visual knowledge, further supporting the view that Bobcat's visual knowledge is severely impaired.

General Discussion

We have presented a patient who demonstrates a selective preservation of naming for certain categories of concepts (i.e., numbers and geographic information) in the context of a dense anomia. As Experiment 1 showed, Bobcat's naming performance was excellent for the categories of Numbers, U.S. Geographic Regions, and U.S. States, whereas his performance was quite poor in the categories of Household Objects, Body Parts, and Colors. His naming profile is quite distinctive in the sense that it cannot be explained in terms of the differences in the general difficulty of the six categories of words used in this study. None of the six control aphasic patients showed a profile qualitatively similar to Bobcat's. Rather, the control individuals generally exhibited the opposite hierarchy of naming difficulty for the six categories. That is, the three categories Bobcat failed to name successfully were the easiest for the six controls, and the two categories (i.e., U.S. States and U.S. Geographic Regions) that were easiest for Bobcat were the most difficult for the control individuals.

This category-specific naming deficit does not occur at the level of basic visual analysis or visual object identification. As Experiments 2 and 3 demonstrated, Bobcat's problems are not similar to those of patients with visual agnosia. His ability to perform well on a spoken word-picture matching test (Experiment 4) for the same items he cannot name, also shows that his visual object recognition ability is spared, unlike that of associative visual agnosic patients. Nor does Bobcat's category-specific naming deficit does seem to be due to impairments in his speech output lexicon, since his speech repetition and oral single word reading performance are well preserved.

By eliminating those possible loci of the naming problems, the Ellis et al. (1992) model we presented earlier (see Figure 1) points to a problem at the stage of semantic memory. More specifically, our hypothesis was that Bobcat's category-specific naming problems reflects a degraded visual knowledge base in the context of a relatively (if not perfectly) spared verbal semantic knowledge. The data from Experiments 5 and 6 clearly demonstrate that Bobcat's visual knowledge base is clearly degraded. He was not able to reliably judge the correct color of a target object depicted in black-and-white drawing (Experiment 5), even though he can correctly match a spoken word to its appropriate pictorial representation. Similarly, he was not able to tell reliably which of the two objects or animals was actually larger in size (Experiment 6). His impaired performance in the Object Assembly task from WAIS-R (particularly the fact that his performance was not facilitated even if he was told what the object depicted in the puzzle was) also provides converging evidence for Bobcat's visual knowledge impairments.

How can the notion of a degraded visual knowledge base account for the category-specific pattern of performance that Bobcat demonstrated in this study?

One important assumption in our account is that the naming of concrete objects and animals --- the kinds of materials that appear in typical confrontation naming tasks --- relies on sufficiently intact visual knowledge. As mentioned earlier, Farah and McClelland (1991) demonstrated that the representations of common objects (both living things and nonliving things) rely considerably on visual knowledge, even though the extent of reliance on visual knowledge might be significantly less for nonliving things than living things. Our new proposal is that the representations of more fact-based, "school-learned" concepts (such as numbers and geographic regions) might be even less dependent on visual knowledge than the representations of living things and nonliving things. Rather, those concepts appear to be more reliant on <u>verbal</u> semantic memory than <u>visual</u> semantic memory.

According to this view, Bobcat's difficulty in naming common objects and colors in Experiment 1 reflects his inability to activate an appropriate phonological word form of the target object or color from visual semantic memory.[5] We assume that those concepts are also represented in the relatively intact verbal semantic system to some extent, but the activation from the verbal semantic system might not be strong enough to guarantee the selection of an appropriate phonological word form. In contrast, consider the naming of numbers and geographic information, which we argue might be less dependent on visual knowledge and more on verbal knowledge. If this view is correct, then, he should have much less difficulty activating the appropriate phonological word form for numerical and geographic information from the relatively verbal semantic system.

It is important to emphasize at this point that we are not denying that some aspects of these fact-based categories are represented in visual knowledge, such as the spatial configuration of a written digit (e.g., 7) and the general shape and location of a U.S. state (e.g., Colorado). Our proposal is simply that, given the way we typically acquire those concepts (i.e., via verbal instructions at school), they might be more strongly represented in verbal semantic memory than visual semantic memory, possibly even more so than concepts corresponding to typical living things and nonliving things. Indeed, typical dictionary definitions of those fact-based concepts (such as numerical and geographic information) are devoid of any visual features, listing instead some relevant verbal facts such as the population and the name of the capital. In addition, such concepts as 7 or Colorado seem to have many verbal associates (e.g., days of the week, Snow White's dwarfs, etc. for 7; Rocky Mountains, the Avalanche hockey team, etc., for Colorado), but few visual associates. If we follow Farah and McClelland's (1991) view and assume that this lack of visual features in dictionary definitions may reflect the extent to which such concepts rely on visual knowledge, then, our proposal regarding the distinction between common living and nonliving things and fact-based, "school-learned" concepts is at least a plausible one and merits further investigation.

One prediction that might reasonably follow from this account of Bobcat's category specific naming deficit is that, contrary to that of many aphasic patients, Bobcat's naming performance might be relatively spared for abstract concepts when compared to concrete concepts. Recent studies of semantic memory report patients demonstrating such reverse concreteness effects, particularly among patients with so-called semantic dementia (e.g., Breedin, Saffran, & Coslett, 1994). Although this reverse concreteness effect in naming is a plausible prediction for Bobcat, we were unfortunately unable to test the prediction mainly because of Bobcat's relatively severe language comprehension problems beyond the level of simple words and phrases.[6] Future research is necessary to develop an ingenious task that can test the reverse concreteness effect hypothesis in patients like Bobcat.

In conclusion, the unique pattern of behavior exhibited by Bobcat on the series of experiments described in this paper lends support to current models of lexical access that postulate separate predominately-visual and predominately-verbal arousal of semantic information. Detailed case descriptions such as this contribute to information processing explanations of language, and this, in turn, should lead to new, theoretically based rehabilitation techniques for persons with acquired language impairments.

References

Allport, D. A. (1985). Distributed memory, modular subsystems and dysphasia. In S. K. Newman & R. Esptein (Eds.), Current perspectives in dysphasia (pp. 207-244). Edinburgh: Churchill Livingstone.

Breedin, Saffran, & Coslett (1994).

Corell Gallery for Macintosh version 1.0 (1994). Salinas, CA: Corell Corporation.

Ellis, A. W., Kay, J., & Franklin, S. (1992). Anomia: Differentiating between semantic and phonological deficits. In D. I. Margolin (Ed.), Cognitive neuropsychology in clinical practice (pp. 207-228). New York: Oxford University Press.

Ellis, A. W., & Young, A. W. (1988). Human cognitive neuropsychology. Hove, UK: Erlbaum.

Farah, M. J., & McClelland, J. L. (1991). A computational model of semantic memory impairment: Modality specificity and emergent category specificity. Journal of Experimental Psychology: General, 120, 339-357.

Glass, G. V., & Stanley, J. C. S. (1970). Statistical Methods in Education and Psychology. Englewood Cliffs, N.J.: Prentice-Hall, Inc.

Goodglass, H. (1993). Understanding Aphasia. San Diego, CA: Academic Press.

Goodglass, H., & Kaplan, E. (1983). Boston Naming Test. Philadelphia, PA: Lea & Febiger.

Goodglass, H., & Kaplan, E. (1983). The Boston Diagnostic Aphasia Examination. Philadelphia, PA: Lea & Febiger.

Goodglass, H., Wingfield, A., Hyde, M. R., & Theurkauf, J. C. (1986). Category specific dissociations in naming and recognition by aphasic patients. Cortex, 22, 87-102.

Helm-Estabrooks, N. (1992). Aphasia Diagnostic Profiles. Riverside Publishing.

Hillis, A. E., & Caramazza, A. (1991). Mechanisms for accessing lexical representations for output: evidence from a category-specific semantic deficit. Brain and Language, 40, 106-144.

Humphreys, G. W., & Riddoch, M. J. (1984). Routes to object constancy: Implications from neurological impairments of object constancy. Quarterly Journal of Experimental Psychology, 36A, 385-415.

Lesser, R. (1989). Some issues in the neuropsychological rehabilitation of anomia. In X. Seron & G. Deloche (Eds.), Cognitive approaches in neuropsychological rehabilitation (pp. 65-104). Hillsdale, NJ: Erlbaum.

Levelt, W. J. M. (1989). Speaking: From intention to articulation. Cambridge, MA: MIT Press.

Lezak, M. D. (1983). Neuropsychological Assessment. New York: Oxford University Press.

Lissauer, H. (1889). Ein Fall von Seelenblindheit nebst Beitrage zur theorie derselben. Arch. f. Psychiat. u. Nervenkr., 21, 222-270.

Martin, A., Wiggs, C. L., Ungerleider, L. G., & Haxby, J. V. (1996). Neural correlates of category-specific knowledge. Nature, 379, 649-652.

Pavio, A. (1986). Mental representations: A dual coding approach. New York: Oxford University Press.

Pietrini, V., Nertimpi, T., Vaglia, A., Revello, M. G., Pinna, V., & Ferro-Milone. F. (1988). Recovery from herpes simplex encephalitis: Selective impairment of specific semantic categories with neuroradiological correlation. Journal of Neurology, Neurosurgery, and Psychiatry, 51, 1284-1293.

Raven, J. C., Court, J. H., & Raven, J. (1977). Raven Coloured Progressive Matrices. Los Angeles, CA: Western Psychological Services.

Rubens, A. B. (1979). Agnosia. In K. M. Heilman & E. Valenstein (Eds.), Clinical Neuropsychology (pp. 233-267). New York: Oxford University Press.

Sacchett, C., & Humphreys, G. W. (1992). Calling a squirrel a squirrel but a canoe a wigwam: A category-specific deficit for artefactual objects and body parts. Cognitive Neuropsychology, 9, 73-86.

Saffran, E. M., & Schwartz, M. F. (1994). Of cabbages and things: Semantic memory from a neuropsychological perspective --- A tutorial review. In C. Umilta & M. Moscovitch (Eds.), Attention and performance XV: Conscious and nonconscious information processing (pp. 507-536). Cambridge, MA: MIT Press.

Satori, G., & Job, R. (1988). The oyster with four legs: A neuropsychological study on the interaction of visual and semantic information. Cognitive Neuropsychology, 5, 105-132.

Seymour, P. H. K. (1979). Human visual cognition. West Drayton: Collier MacMillan.

Shallice, T. (1988). From Neuropsychology to Mental Structure. New York: Cambridge University Press.

Sheridan, J., & Humphreys, G. W. (1993). A verbal-semantic category-specific recognition impairment. Cognitive Neuropsychology, 10, 143-184.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. Journal of Experimental Psychology: Human Learning and Memory, 6, 174-215.

Toglia, M. P., & Battig, W. F. (1978). Handbook of semantic word norms. Hillsdale, NJ: Erlbaum.

Warrington, E. K. (1982). Neuropsychological studies of object recognition. Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences, 298, 15-33.

Warrington, E. K., & McCarthy, R. A. (1983). Category-specific access dysphasia. Brain, 106, 859-876.

Warrington, E. K., & McCarthy, R. A. (1987). Categories of knowledge: Further fractionation and an attempted integration. Brain, 110, 1273-1290.

Warrington, E. K., & Shallice, T. (1984). Category specific semantic impairments. Brain, 107, 829-854.

Wechsler, D. (1981). WAIS-R Manual. New York: Psychological Corportation.

APPENDIX A: Experiment 1 Naming Stimuli

US States
Nevada
Oklahoma
Washington
Maine
Texas
Minnesota
California
New York
Florida

Number of Dots
Zero
One
Two
Three
Four
Five
Six
Seven
Eight
Nine

US Geographic Regions
Southeast
Southwest
Northeast
Northwest
East
West
North
South

Body Parts
Thumb
Hair
Leg
Finger
Eye
Hand
Finger
Lips
Arm
Foot

Colors
Orange
Purple
Brown
Gray
Blue
Yellow
Red
Black
Green
Pink

Household Objects
Fork
Telephone
Toaster
Pot
Iron
Book
Key
Cup
Brush
Comb

Authors Notes

This project would not have been possible were it not for Mr. Bobcat's willingness to undergo extensive testing. Our interactions were not only informative from an experimental stand point, but also were personally enjoyable because of his wonderful sense of humor and positive attitude.

Footnotes

1. Interestingly, all four cases reported by Warrington and Shallice and several other cases of selective impairments of living things recently reported by other investigators (e.g., Pietrini, Nertimpi, Vaglia, Revello, Pinna, & Ferro-Milone, 1988; Sartori & Job, 1988; Sheirdan & Humphreys, 1993) tend to have the same etiology, namely, herpes simplex encephalitis, affecting the temporal lobe bilaterally.

2. A recent brain imaging study (Martin, Wiggs, Ungerleider, & Haxby, 1996) further supports this view. This positron emission tomography (PET) study found that, although the naming of living things (animals) and nonliving things (tools) both activated common areas of the brain (i.e., the ventral temporal lobes and Broca's area), they also selectively activated different brain areas as well. The naming of pictures of animals, for example, activated the left medial occipital lobe, a region involved in early stages of visual processing. In contrast, the naming of tools selectively activated a left premotor area and an area in the left middle temporal gyrus, the areas that have been shown in previous studies to be activated by imagined hand movements and by the generation of action verbs, respectively.

3. This analysis is based upon Bobcat's performance on the first administration of the category naming test.

4. Had Bobcat performed poorly on this task we would not have been able to know if it was caused by poor auditory comprehension or poor visual recognition of the target pictures.

5. It might also be the case that the connection between his visual semantic memory and speech output lexicon is impaired in addition to the degradation of the knowledge base itself. We do not have a good means to access this possibility, however.

6. Given that it is difficult to pictorially depict an abstract concept (such as "illness" and "theory") in a manner that guarantees to induce the intended target word in many people, a reasonable alternative is to use a naming-to-definition task. Unfortunately, Bobcat's relatively low general auditory comprehension ability (16 percentile for aphasic norms on the ADP) prevented us from testing him in this regard. (Although his performance on single word reading is relatively spared when compared to his naming performance, his comprehension of written sentences and passages was also not good enough for this purpose.)

TABLE 1: Aphasia Characteristics of Bobcat and Control Subjects

Subject	Age	Sex	Time Post Onset (months)	Etiology	ADP Phrase Length (# of words)	ADP Aud. Comp. (%'ile)	ADP Lexical Retrieval (%'ile)	ADP Aphasia Type	ADP Aphasia Severity (%'ile)
Bobcat	70	M	48	Left CVA	10	16	37	Borderline Fluent	32
E. H.	83	F	55	Left CVA	15	9	25	Wernicke	19
S. K.	73	F	132	Left CVA	11	91	63	Conduction	70
D. F.	59	M	22	Left CVA	5	37	37	Mixed Nonfluent	45
P. J.	68	F	17	Left CVA	1	63	9	Broca's	35
H. Z.	61	M	100	Left CVA	7	95	50	Broca's	75
W. K.	55	F	5	Left CVA	9	25	37	Wernicke	37

TABLE 2: Category Naming Results

Test	Bobcat		Aphasic Controls	
	Test 1	Test 2	Mean	Range
Numbers	100%	100%	92%	70-100
U.S. States	100%	100%	43%	20-80%
U.S. Geographic Regions	100%	100%	38%	0-100%
Household Objects	20%	30%	83%	60-100%
Body Parts	20%	30%	68%	20-100%
Colors	30%	30%	65%	0-100%

* $p < .01$ on both z-test and Chi-square analyses

TABLE 3: Semantic Characteristics of Stimuli in Category Naming Test

Category	Semantic Variables			
	Imageability	Concreteness	Familiarity	Number of Syllables
Numbers	4.77 (.27)*	3.87 (.35)*	6.49 (.17)	1.20 (.13)
US States	na	na	na	3.00 (1.15)*
US Geographic Regions	4.53 (.49)*	3.68 (.31)*	6.34 (.18)	1.50 (.53)
Household Objects	5.79 (.35)	5.74 (.30)	6.38 (.28)	1.40 (.70)
Body Parts	5.88 (.14)	6.10 (.36)	6.47 (.18)	1.10 (.32)
Colors	5.81 (.25)	4.93 (.57)	6.33 (.19)*	1.30 (.48)

$p < .05$

TABLE 4: Visual Agnosia and Color Indentification Test Results

Test	Bobcat	Aphasic Controls	
		Mean	Range
Experiment 3: Visual Agnosia	83%*	93%	82-100%
Experiment 4: Color Identification	100%*	100%	na

* $p < .05$

TABLE 5: Visual Knowledge Test Results

Test	Bobcat	Aphasic Controls	
		Mean	Range
Color Verification: Animals (Chance = 25%)	25%	72%	50-100%
Color Verification: Fruits & Vegetables (Chance = 25%)	8%	89%	67-100%
Size Judgement: Animals (Chance = 50%)	60%	94%	90-100%
Size Judgement: Fruits & Vegetables (Chance = 50%)	60%	83%	70-100%
Size Judgement: Household Objects (Chance = 50%)	50%	87%	80-100%

Figure Caption

Figure 1. Model of Visual Confrontation naming a la Ellis et al. (1992).

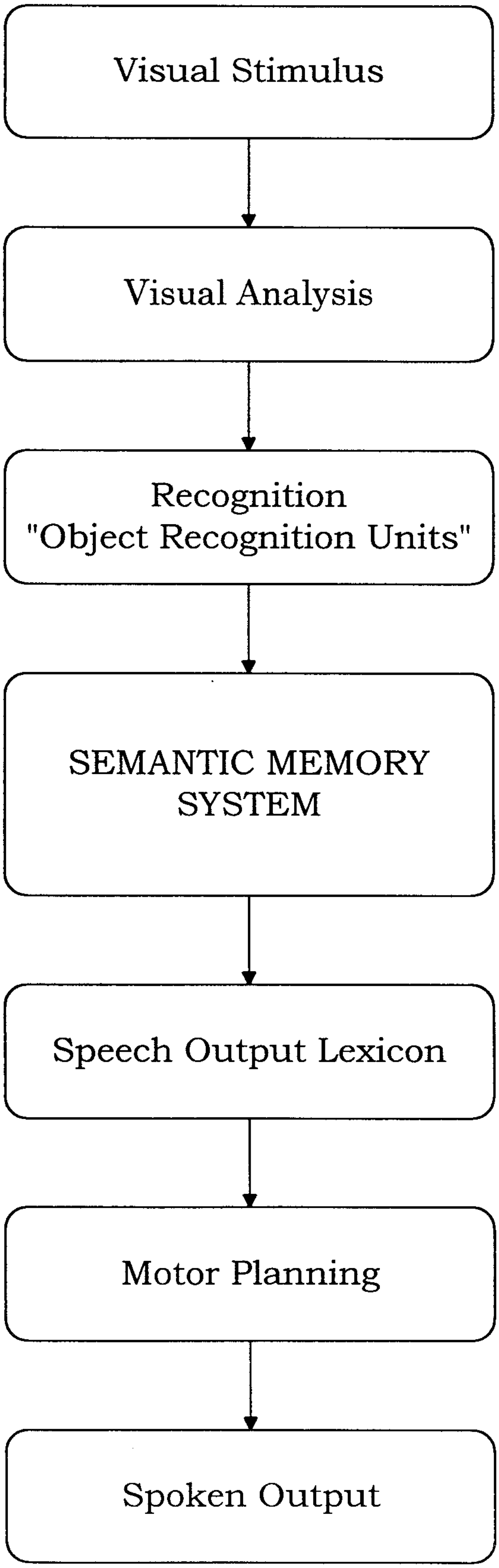

Visual Stimulus
Visual Analysis
Recognition
"Object Recognition Units"
SEMANTIC MEMORY SYSTEM
Speech Output Lexicon
Motor Planning
Spoken Output

Figure Caption

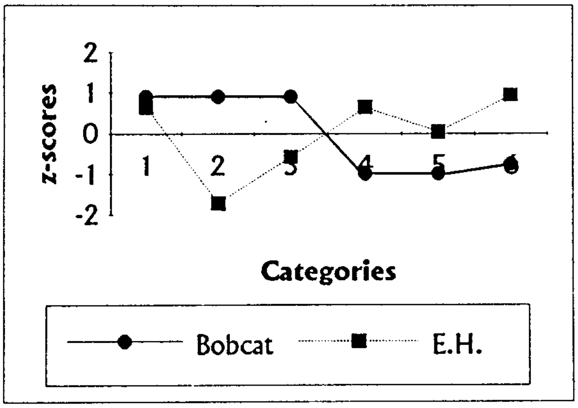
Figure 2. Bobcat's CT Scan

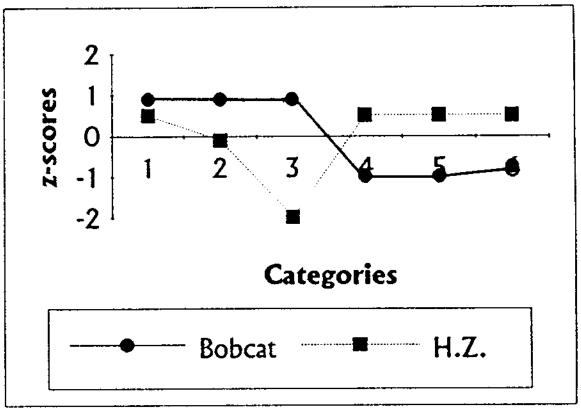
Reproductions of the CT images
were not available at the time
of submission.

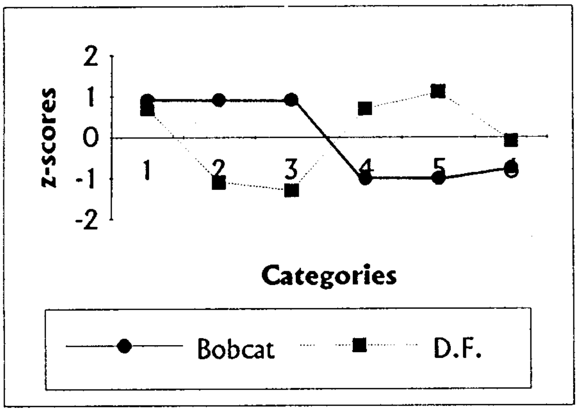
Digitized images will be submitted
following the initial review.

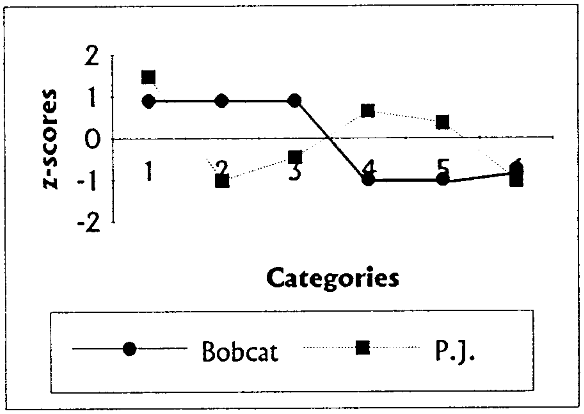
Figure Caption

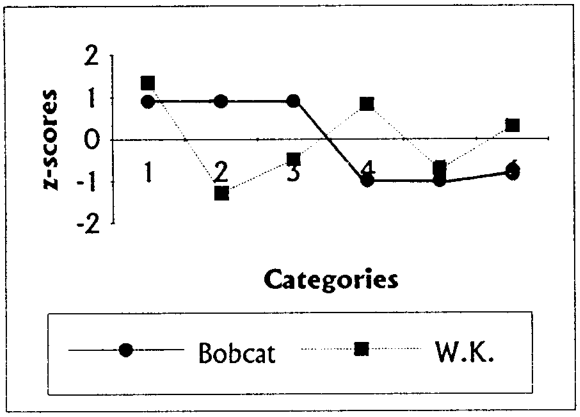
Figure 3. Experiment 1: Category Naming Results with Bobcat Plotted Against each of the Aphasic Control Participants.

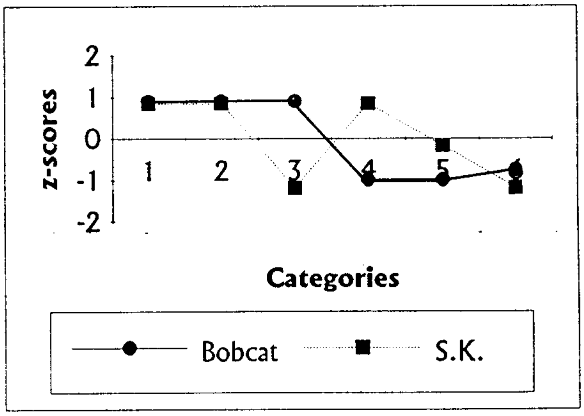








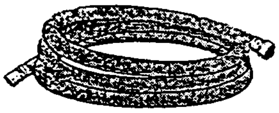
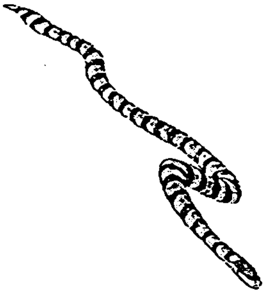
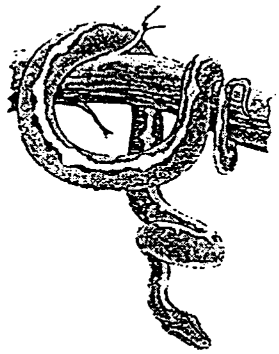




Key:
Category 1 = Numbers
Category 2 = U.S. Geographic Regions
Category 3 = U.S. States
Category 4 = Household Objects
Category 5 = Body Parts
Category 6 = Colors

Figure Caption

Figure 4. Example of Experiment 3: Visual Agnosia Test Stimulus.

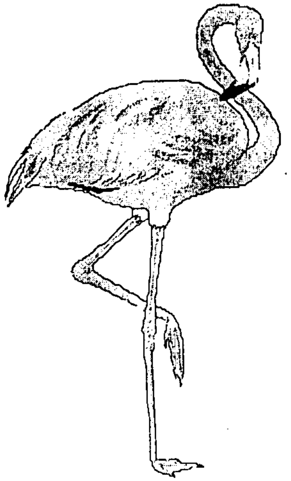




"Which one is different? Which one doesn't belong?"

Figure Caption

Figure 5. Examples of Experiment 5 & 6: Visual Knowledge Test Stimuli

Color Verification



Pink Square

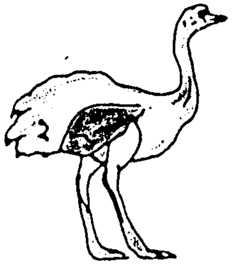
Blue Square

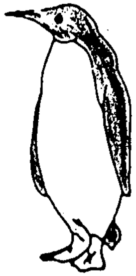
Orange Square

Yellow Square

"What color is this in real life?"

Size Verification





"Which one is bigger in real life?"

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