Not All Triads Are Created Equal: Further Support for the Importance of Visual and Semantic Proximity in Object Identification

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Identification deficits were investigated in ELM, a temporal lobe stroke patient with category-specific deficits. We replicated previous work done on FS, a patient with category-specific deficits as a result of herpes viral encephalitis. ELM was tested using novel, computer-generated shapes that were paired with artifact labels. We paired semantically close or disparate labels to shapes and ELM attempted to learn these pairings. Overall, ELM’s shape–label confusions were most detrimentally affected when we used labels that referred to objects that were visually and semantically close. However, as with FS, ELM had as many errors when shapes were paired with the labels “donut,” “tire,” and “washer” as he did when they were paired with visually and semantically close artifact labels. Two explanations are put forth to account for the anomalous performance by both patients on the triad of donut–tire–washer. © 2002 Elsevier Science (USA)

INTRODUCTION

The observed dissociation in object identification in patients with category-specific visual agnosia (CSVA) is a frequently discussed phenomenon in neuropsychology. Most patients with CSVA present with a selective impairment in the ability to correctly identify living objects (e.g., lion and tiger) yet are able to correctly identify nonliving objects (e.g., windmill and cannon). One theory that attempts to account for this dissociation is that proposed by Humphreys, Riddoch, and Quinlan (1988) and more recently by Forde, Francis, Riddoch, Rumia, and Humphreys (1997). Central to this theory is the proposition that identification deficits in brain-damaged patients exist where object sets consist of members which are both visually and semantically similar. For example, wild felines such as lion, tiger, and leopard cause naming problems because they share many visual (i.e., they have fur, four legs, large teeth, etc.) and semantic (i.e., carnivorous hunters, etc.) features. Consequently, identification deficits arise due to a difficulty in activating a particular representation amongst many structurally and semantically similar exemplars.

Further support for the importance of visual and semantic proximity in category-specific visual agnosia comes from a series of studies by Dixon and colleagues (Dixon, Bub, & Arquín, 1997; Dixon, Bub, Chernkow, & Arquín, 1999) in which CSVA patients were tested. In these studies, computer generated shapes were created with well-defined, underlying shape dimensions such as curvature, thickness, and tapering. By varying these combinations of dimensions, shape sets were generated...
in which members were either visually close (i.e., had numerous overlapping values) or were visually distinct (i.e., had no overlapping values) (Dixon et al., 1999).

In a typical experiment using this ELM Paradigm, the patient receives short groups of learning trials followed by short groups of test trials. This pattern of interleaved learning-then-test trials continues until a certain performance level is reached and/or a certain number of trials have been completed. On learning trials, shapes are presented one at a time along with a verbal label. On test trials the shape is presented by itself, and the patient is asked to provide the appropriate label that was previously paired with that particular shape. Previous research revealed that for visually similar shape sets with multiple overlapping values, patients generally perform much better on trials where shapes were paired with semantically disparate labels (e.g., “helicopter,” “photocopier”) than semantically similar labels (e.g., “robin,” “crow”). By manipulating the visual proximity of the blobs and the semantic proximity of the labels, one can independently assess the role of object form and object meaning in object identification. Using this paradigm Dixon and his colleagues (Dixon et al. 1997, 1999) showed that objects that were both visually similar AND semantically similar posed preferential object identification deficits with CSVA patients.

In previous research (Schweizer, Dixon, Westwood, & Piskopos, in press), FS, a patient with category-specific deficits as a result of herpes viral encephalitis, was tested using the ELM paradigm. The triad that paired shapes to visually and semantically disparate artifact labels (“bell,” “eraser,” and “cane”) led to significantly fewer errors than the triad that was visually and semantically close (“banjo,” “violin,” and “guitar”). This result was consistent with previous research done by Dixon and colleagues. A third triad was included by Schweizer et al. (in press), containing visually close but semantically disparate artifact labels (“donut,” “tire,” and “washer”). It was hypothesized that these items should have led to an error rate that fell between those of the two previously mentioned triad types. Instead, this triad led to many errors as the visually and semantically close set, a finding that may suggest that the visual similarities of the objects referenced by the labels may be of greater importance than the semantic differences between those objects.

The current experiment is an attempt to more fully explore the influence of the visual and semantic overlap among objects in CSVA. More specifically, previous work by Dixon et al. (1997) revealed that the identification errors made by ELM were driven primarily by the interplay between visual and semantic proximity. It follows from this finding that ELM’s highest error rates should be in relation to labels referring to artifacts close in visual and semantic proximity (i.e., guitar, violin, banjo). To more fully test this theory and to rule out any possible anomalous findings with the single triad of donut–tire–washer, two further visually close and semantically disparate triads were employed in the present study (snorkel–cane–crowbar and spike–straw–pencil). If visual similarity is primarily responsible for the identification errors with only a minimal influence of semantics, then all three visually close and semantically disparate triads should produce relatively the same error rates as the visually and semantically close set of guitar–violin–banjo.

METHODS

**Participant**

ELM is a 72-year-old man who was admitted to hospital for heart failure in 1982. He was readmitted in 1985 and was found to have bilateral lesions deep in the mesio-
temporal lobes. Previous testing of this patient revealed category-specific visual recognition impairments (see Arguin, Bub, & Dudek, 1996, for complete patient profile).

**Stimuli**

**Shapes.** Shape triads were generated by combining different values of curvature, thickness, and tapering. Blobs A, B, and C were all equally tapered. Blobs B and C were equally curved (1/3 the curvature of Blob A); Blobs A and B were equally thick (30 mm) and were both twice the width of Blob C (15 mm along the horizontal axis) (see Fig. 1).

**Verbal Label Frequencies and Familiarity (freq, fam)**

The triad of shapes shown in Fig. 1 was associated with four sets of labels. Visually close and semantically disparate artifact labels included: set 1: “donut”(0,0), “tire”(22,546), and “wahser”(2,0); set 2: “snorkel”(0,0), “crowbar”(0,0), and “cane”(12,442); and set 3: “spike”(2,471), “straw”(15,508), and “pencil”(34,598). Visually and semantically close artifact labels included: “banjo”(2,0), “guitar”(19,550), and “violin”(11,468).

**PROCEDURE**

**ELM Paradigm**

Shapes were presented in the center of a computer screen one at a time accompanied by a digitized recording of their preassigned verbal label. Six learning trials were presented allowing each blob-label pairing to appear twice. After completing the learning trials, ELM was presented with six test trials consisting of the unlabeled blob appearing in the center of the computer screen. ELM was required to provide the appropriate label that was previously paired to that particular blob on learning trials. This procedure (six learning then six test trials) was repeated until 144 learning and 144 test trials were completed in each of the four shape-label conditions. Testing was conducted in four separate sessions.

**RESULTS**

**Shape-Label Task**

As illustrated in Fig. 2, ELM was able to correctly name 69% (99/144) of the visually close/semantically disparate donut–wahser–tire and 72% (103/144) of the visually close/semantically close (“banjo,” “guitar,” “violin”) combinations. This difference was not significant: $\chi^2(1) = 0.18$, ns. For the other two visually close/
semantically disparate sets, ELM was able to name 92% (133/144 for the snorkel–cane–crowbar combination) and 87% (125/144 for the spike–straw–pencil combination) of the objects correctly. This difference was also not significant: $\chi^2(1) = 2.13$, ns. The fact that ELM made a statistically equivalent number of errors on the donut–tire–washer triad as on the banjo–guitar–violin triad suggests that “donut,” “tire,” and “washer” may not be represented in as diffuse a psychological space as other semantically disparate categories. As expected, ELM made more errors on the visually close/semantically close combination banjo–guitar–violin than on the other two visually close/semantically disparate combinations, snorkel–cane–crowbar ($\chi^2(1) = 17.31, p < .001$) and spike–straw–pencil ($\chi^2(1) = 8.07, p < .005$). Critically, however, ELM also made significantly more errors on the visually close/semantically disparate combination donut–tire–washer than on the other visually close/semantically disparate combinations snorkel–cane–crowbar ($\chi^2(1) = 20.64, p < .001$) and spike–straw–pencil ($\chi^2(1) = 10.56, p < .001$).

**DISCUSSION**

We hypothesized that labels of objects with multiple overlapping visual and semantic features would cause the most identification problems for our patient, but that object labels that were visually close but semantically disparate would be associated with fewer identification problems. ELM’s performance was significantly poorer on the visually close and semantically close set of banjo, violin, guitar compared to the visually close and semantically disparate triads of snorkel–cane–crowbar and spike–straw–pencil. These results are consistent with our hypotheses and lend further support for the importance of the visual and semantic proximity of objects in order to fully understand category specific identification impairments. This was not, however, the case for the third visually close and semantically disparate triad. With the donut–tire–
washer triad, ELM had as many errors as with the visually and semantically close set (e.g., “violin,” “guitar,” “banjo”).

This study replicates previous findings with patient FS where we found that performance on the visually close and semantically disparate set of donut–tire–washer was as poor as with the visually and semantically close set of banjo–violin–guitar. The ELM results confirm that the visually close but semantically disparate triad of donut–tire–washer consistently leads to patterns of data similar to triads consisting of visually and semantically close items.

There are two possible explanations to account for the anomalous performance by both patients on the triad of donut–tire–washer. One reason may be that the objects in the triad of donut-tire-washer have as their most salient feature their visual attributes (i.e., round with a hole in the middle) with relatively little semantic information to help spread the objects apart in psychological space. If this were the case it would be very difficult for patients to activate a particular representation among many visually similar exemplars with not enough semantic uniqueness to assist in disambiguation. Another possible reason is that in colloquial English a spare tire is often referred to as a “donut.” This similarity in meaning would make the members not only close in visual proximity but also close in semantic proximity. This reasoning was confirmed when ELM was asked to tell us everything he knew about the word “tire.” He replied “... a small spare tire is called a donut, and you can’t go over certain speeds and you can only go on short distances on it until you find a garage and change it.” Unfortunately, FS was unavailable to provide us with his semantic representation of “tire” and as such we cannot rule out that his object identification deficits are primarily a result of visual similarity with semantic similarity being of less importance.

Overall, despite the anomalous performance with the donut–tire–washer triad, ELM’s shape–label confusions were most pronounced when we used artifact labels that were both visually and semantically close. These results support our hypothesis that the interplay between visual and semantic proximity is an important determining factor for errors in object identification in CSVA patients.

REFERENCES


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