The visual categories for letters and words reside outside any informationally encapsululated perceptual system

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Abstract

According to Pylysyn, the early visual system is able to categorize perceptual inputs into shape classes based on visual similarity criteria, and it is suggested that written words may be categorized within early vision. This speculation is contradicted by the fact that visually unrelated exemplars of a given letter (e.g., a/A) or word (e.g., read/READ) map onto common visual categories.

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Pylyshyn, as Fodor before him, is uncommitted about the exact boundaries of the cognitively impenetrable early vision system, but argues that this system computes as much as possible given its inputs and the visual knowledge internal to the system. These computations would include the derivation of a three-dimensional representation of visible surfaces (the 2.5-D sketch of David Marr), and the determination of perceptual categories on the basis of visual similarity, which in the case of objects, might be coextensive with basic-level categories. Pylyshyn also raises the possibility that printed words may map onto perceptual categories within early vision, again based on the visual similarity of word exemplars (sect. 7.2).

In this commentary, I want to summarize evidence that the perceptual categories for words are not structured on the basis of geometrical similarity, and therefore, must lie outside early vision. These findings contradict the claim that visual word identification is mediated by a modular system (e.g., Polk & Farah, 1997; Seidenberg, 1987), and further, highlight the complexity of identifying to boundaries of early vision. Indeed, to the extent that perceptual word categories are non-encapsulated, it raises questions as to whether other perceptual categories, such as basic level object categories, reside in an encapsulated system.

The difficulty in arguing that perceptual categories for words -- so-called orthographic codes -- are encapsulated within an early visual system is that different exemplars of a given letter or word are often unrelated in their visual form, and nevertheless, they map onto the appropriate perceptual category. For example, the visual patterns <u>A/a</u> or <u>READ/read</u> map to the same abstract letter and word codes, respectively.

Clearly, perceptual categories that map together these forms cannot be learned in an encapsulated system that only has access to “bottom-up” visual input.

Evidence for the existence of abstract orthographic codes comes from a variety of sources. Coltheart (1981), for example, describes a conduction aphasic patient who could not name individual letters or name pseudowords (e.g., nega), but who nevertheless was able to match upper/lower pseudowords that were perceptually dissimilar (e.g., NEGA/nega) without difficulty. Given that these items are (a) meaningless, (b) perceptually dissimilar in upper/lower case, and (c) unpronounceable by the patient, Coltheart concluded that the patient must have accessed abstract orthographic codes in order to perform the task, what he called "abstract letter identities". Consistent with this conclusion, McClelland (1976) reported that the word superiority effect (WSE) is equally large for words presented in case uniform and mixed conditions; for example the words FADE and fAdE were both better identified than the matched pseudowords GADE and gAdE in a task in which participants were required to identify briefly presented targets. Given that mixed-case words are unfamiliar visual patterns, these results suggest that the WSE is mediated by word representations coded in an abstract fashion. In addition, Bowers (1996) found long-term priming to be equally robust for words repeated in the same and different case, even though the different-case words were perceptually dissimilar at study and test (e.g., READ/read). This cross-case priming was attributed to orthographic knowledge, since the priming was dramatically reduced following a study/test modality shift in which words were studied auditorily and tested visually. Bowers and Michita (1998) extended this finding, observing robust priming between the Hiragana and Kanji scripts of Japanese, and this priming was again modality specific.

These and other findings strongly support the conclusion that orthographic knowledge is organized into abstract perceptual categories that cannot be learned on the basis of the visual properties of the input. Accordingly, it is necessary to assume that a non-visual "teacher" acts on the orthographic system in order to organize the perceptual representations of words. One possible account of this teacher is outlined in Bowers and Michita (1998). Briefly, it is argued that there are bi-directional connections between orthographic knowledge on the one hand, and phonological and lexical-semantic codes on the other, and these phonological and lexical-semantic codes act together as an external teacher to construct abstract orthographic codes.

To see how phonology may act as a teacher and penetrate into the visual system, consider the two arbitrarily related visual letters (e.g., a/A), as depicted in Figure 1. In this figure, the different visual patterns map onto the same phonological representation, and because of bi-directional connections between orthography and phonology, both orthographic patterns are consistently co-activated within the orthographic system, via feedback. It is this co-activation that makes it possible to learn arbitrary perceptual mappings. More specifically, the learning process might proceed as follows. When the child learns that visual pattern “A” maps to sound /ei/, bi-directional connections develop such that the presentation of “A” leads to the activation of /ei/, and conversely, the presentation of the sound /ei/ activates the orthographic pattern “A”. Similarly, when the child learns that the visual pattern “a” maps onto /ei/, bi-directional connections develop. As a result, when one of the visual patterns is presented, for example “A”, it activates /ei/, which in turn activates “A” and “a”, given the learned feedback connections. This co-activation, when combined with associative learning principles, provides a simple mechanism for acquiring abstract orthographic representations. That is, a learning rule would associate representations that are consistently co-activated within the orthographic system, which would include such items as upper- and lower case letters.

On this view, then, the perceptual categories for individual letters and words are structured in accordance with background knowledge. Various findings such as the word superiority and phoneme restoration effects have been described as compatible with the view that the relevant perceptual systems are encapsulated, because the top-down influences may occur within the module. However, as the above evidence indicate, the perceptual representations of words that might support these effects are located outside the putative early visual system. It remains to be seen whether other categories, such as structural descriptions of objects are completely determined on the basis of visual information, or whether non-visual sources of evidence constrain this knowledge as well.

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Figure Caption

Figure 1. The visual patterns A and a each map onto the phonological code /ei/, which results in the coactivation of A and a each time one of the patterns is presented, via feedback. Associative learning principles within the orthographic system act to map together these coactive patterns to produce an abstract letter code.

Figure 3