Commentary

Hemispheric asymmetries in visual word-form processing: Progress, conflict, and evaluating theories

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Abstract

The ubiquitous left-hemisphere advantage in visual word processing can be accounted for in different ways. Competing theories have been tested recently using cAsE-aLtErNaTiNg words to investigate boundary conditions for the typical effect. We briefly summarize this research and examine the disagreements and commonalities across the theoretical perspectives. This work may provide a good example why a multi-level, multi-method, and multi-paradigm approach holds the greatest promise for rapid theoretical progress.

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A ubiquitous finding in neuropsychology is the left-hemisphere (LH) advantage in processing visual word forms. The question of whether it reflects a LH-lateralized lexicon or dissociable neural subsystems of visual-form processing is fundamentally important. If visual word processing is performed in qualitatively different ways in parallel subsystems, rather than in a single lexical system, a greater understanding of the subsystems and their properties may be crucial for explaining the flexibility and complexity of visual word processing. Different effects may be observed depending on which subsystem is responsible for performance.

Deason and Marsolek (2005; hereafter D & M) used the subsystems theory to predict critical boundary conditions for the LH advantage. This theory posits that an abstract-category visual subsystem operates more effectively than a specific-exemplar visual-form subsystem in the LH, and vice versa in the right hemisphere (RH). An abstract subsystem recognizes the visual-form category of a word (e.g., the visual-form category for band/BAND), whereas a specific subsystem recognizes the visual-form exemplar of a word (e.g., the exemplar “band” which is different from “BAND”). Both subsystems can recognize word forms, but the typical LH advantage occurs because the nature of most word processing tasks—what word is this?, or is it a word?, not which exemplar is it?—typically advantages an abstract subsystem in the LH (see Burgund & Marsolek, 1997). D&M theorized that an important boundary condition may exist, such that the LH advantage may be eliminated when words take the shape of unfamiliar wholes (i.e., their holistic configurations are unlikely to have been viewed before), as occurs with cAsE-aLtErNaTiNg words. This is because a specific subsystem processes novel visual wholes effectively (Marsolek, Schacter, & Nicholas, 1996), helping that subsystem to overcome the typical advantage held by an abstract subsystem.

Indeed, it is important to emphasize that evidence for an abstract subsystem operating effectively in the LH and a specific subsystem operating effectively in the RH should not be found in all experimental conditions. According to the subsystems theory, both stimulus and task demands predictably affect the relative contributions of these subsystems to performance (for examples see Burgund & Marsolek, 1997; Marsolek, 1999; Marsolek & Burgund, 2003; Marsolek & Hudson, 1999).
reported evidence supporting this prediction in two experiments; the LH advantage in word processing (found for lowercase and for UPPERCASE words) was eliminated or numerically reversed when novel visual wholes were used as stimuli.

Ellis, Anzorge, and Lavidor (this issue; hereafter EAL) disagreed with the interpretation of D&M’s results, and they reported new experiments to test the main question. It is notable that D&M had to present cAsE-aLTerNaTiNg words for long exposure times in order to equate word identification performance for them compared with lowercase/UPPERCASE words. Thus, EAL examined whether a LH advantage for lowercase words and its elimination for cAsE-aLTerNaTiNg words would be observed when lowercase words are presented for the same, relatively long exposures used for cAsE-aLTerNaTiNg words (144 ms) in D&M. In line with D&M’s theory, EAL’s results (Experiment 1B) replicated D&M’s. It is worthwhile to note points of agreement between EAL and D&M. Not only was a common pattern of results observed across experiments, but EAL also suggest that their loss of a LH advantage when lowercase words were presented very briefly in Experiment 1A may be due to the hemispheric differences in visual processing (involving high versus low visual-spatial frequency information; Christman, 1989; Sergent & Hellige, 1986) that we have cited for the same reasons (Marsolek, 1999; Marsolek & Burgund, 1997, 2003; Marsolek & Hudson, 1999). However, it also is important to consider the disagreements between EAL and D&M to assess progress in this area.

EAL claimed that an important concern with D&M’s theory is that the features-based processing hypothesized to occur in an abstract subsystem should enable it to process cAsE-aLTerNaTiNg words as effectively as lowercase/UPPERCASE words, and hence should lead to a LH advantage for cAsE-aLTerNaTiNg words. EAL write, “Mixed case words contain the same abstract visual features that the abstract-category subsystems use to recognize words in familiar formats. Hence it could be argued that identifying words in mixed case should be easier for the abstract-category subsystems than for the specific-exemplar subsystems.” This is a misunderstanding of D&M’s theory. EAL have it right that cAsE-aLTerNaTiNg words contain the same features that an abstract-category subsystem uses to recognize familiar-format words, but it is incorrect to assume that the extraction of those features is as easy for cAsE-aLTerNaTiNg words as it is for familiar-format words (an assumption that has never been made by proponents of the dissociable subsystems theory). Indeed, we would cite evidence against this assumption. For example, a large literature on contextual cuing effects (e.g., Chun & Jiang, 1998, 1999; Jiang, Song, & Rigas, 2005) indicates that extracting a target shape within configurations of non-target shapes is incidentally learned to be faster after the configurations have been familiarized than before they have been familiarized, a visual learning effect that is not accompanied by explicit memory for the repeated configurations. Our view is that such evidence from outside the typical domain of word processing is crucial for efficient theoretical progress.

The results from EAL’s first experiments are consistent with D&M’s theory, but the results from EAL’s Experiment 2 are not, thus it is perhaps most important to highlight a serious methodological question raised in the latter. EAL correctly reviewed that under many conditions the subsystems theory leads to the predictions that case-specific repetition priming (greater priming from DEAR to DEAR than from dear to DEAR) should be observed when test stimuli are presented directly to the RH and no case-specific priming (no greater priming from DEAR to DEAR than from dear to DEAR) should be observed when test stimuli are presented directly to the LH (for evidence see Burgund & Marsolek, 1997; Marsolek, Kosslyn, & Squire, 1992; Marsolek, Squire, Kosslyn, & Lulenski, 1994; Marsolek, 2004). To test these predictions in a new way, EAL used a (short-term) masked priming procedure (following Bowers & Turner, 2005), in which a “prime” word appears briefly (60 ms) in the same location as a subsequently presented target word (100 ms). The “prime” and target word could be the same word in the same case-alternating version (e.g., DeAr followed by DeAr) or the same word in cross-case versions (e.g., DeAr followed by dEaR). No greater identification of target words occurred in the same-case condition than in the cross-case condition when stimuli were directly to the RH, in contrast with the subsystems prediction. However, a prohibitive concern is that, in the same-case condition, there are no discernibly different prime and test stimuli—a single word was presented for 160 ms. This means that the target stimuli were presented for 160 ms in the same-case condition but for only 100 ms in the cross-case condition, which is crucial because EAL’s first experiment indicates that RH processes are relatively advantaged by brief test presentations and relatively disadvantaged by long test presentations. Thus, the reason why same-case and cross-case performance in Experiment 2 was equivalent following RH presentations may be that the briefer presentations of targets in the cross-case condition benefited RH processing and the longer presentations of targets in the same-case condition hurt RH processing, to points at which no difference was observed between the two conditions following RH presentations. Perhaps more important, another concern is that case-specific masked priming has been observed by one of the EAL authors when primes were presented centrally and targets were presented laterally (Lavidor, 2002), yet no case-specific priming was observed in EAL’s Experiment 2 when the stimuli were presented in the same location. This provides evidence that whether primes and targets are presented in the same location greatly affects the patterns of results in masked priming experiments. Until future research clarifies this (potentially very interesting) inconsistency, it is difficult to know how the
masked priming paradigm can be used to address case-specific priming.

EAL’s Experiment 2 notwithstanding, which theoretical approach should be taken to account for the consistent results in D&M and EAL? Given that both theories can account for these results (in different ways), a good move is to appeal to evidence from additional paradigms and procedures. We applaud EAL for making this kind of move by explaining how their results can account for word length effects as well. For lowercase and UPPERCASE words, word lengths (numbers of letters) affect processing following RH presentations to a greater degree than following LH presentations (Bub & Lewine, 1988; Ellis, 2004; Ellis, Young, & Anderson, 1988; Lavider, Ellis, Shillcock, & Bland, 2001). However, for cAsE-aLtErNaTiNg words (and nonwords), comparable word length effects are found following LH and RH presentations (Bub & Lewine, 1988; Ellis et al., 1988; Lavider & Ellis, 2001; Lavider, Ellis, & Pansky, 2002; Young & Ellis, 1985), thus EAL hypothesize that a LH lexicon is engaged only when familiar-format words are presented directly to the LH (novel format words and words presented to the RH are processed without the benefit of top-down lexical processes).

An alternative account for word length effects can be offered from the subsystems theory (Marsolek, 2004), although future research is needed to provide empirical tests. With familiar-format words, greater word length effects following direct RH presentations than following direct LH presentations may reflect the difference in amount of visual information stored in whole-based representations (in a specific subsystem) versus features-based representations (in an abstract subsystem). The whole-based representation of a word form (useful for recognizing the exemplar) necessarily contains more information than the features-based representation of that form (useful for recognizing the category of the form). The longer the word, the more time-consuming the match to stored representations, for both specific and abstract subsystems, but that effect should be greater in a subsystem that has representations containing relatively more information than in a subsystem that has representations containing relatively less information (the more the represented information, the more time-consuming the match to that information). Note that this explanation applies to standard words. When nonwords are presented to be identified, they do not match very well the preexisting representations in both abstract and specific subsystems, and apparently different processing compared with the processing that normally occurs in either abstract or specific subsystems (perhaps letter-by-letter processing) takes place to cause the length effects. When cAsE-aLtErNaTiNg words are presented, both abstract and specific subsystems should have a high degree of difficulty in matching the input stimuli to stored representations, given the novelty of the input forms. The increased difficulty should be exacerbated by longer words, especially in the abstract subsystem (in the specific subsystem, the more effective processing of novel whole forms should counteract the impairment), causing word length effects in an abstract subsystem to be comparable with those in a specific subsystem.2

It is not surprising to find that different cognitive theories can account for a common set of behavioral results in different ways. In fact, Anderson (1978) provides an excellent discussion of this kind of situation and an argument that behavioral evidence alone may be insufficient for ultimately arbitrating between the relevant cognitive theories. Our perspective is like EAL’s in that we value appeals to evidence from additional paradigms, but we go further. For explanatory adequacy of a theory of visual form processing (see Marsolek, 2003), mutual constraints on theory from multiple levels of analysis, multiple methods, and multiple kinds of visual-form stimuli likely are needed for greatest theoretical progress. Any one of these kinds of constraints has its limitations or weaknesses, but converging evidence from different levels, methods, and stimuli can help to overcome such limitations and weaknesses. For example, evidence from object processing also is used to constrain the subsystems theory (e.g., Burgund & Marsolek, 2000), in part because neuropsychological evidence (Farah, 1991) and neuroimaging evidence (Price & Devlin, 2003) indicates that common visual processing in the brain underlies normal visual word and object identification. Also, evidence from interhemispheric transfer (Marsolek, Nicholas, & Andresen, 2002), neuroimaging (e.g., Koutstaal et al., 2001), brain-damaged patients (e.g., Vaidya, Gabrieli, Verfaellie, Fleischman, & Askari, 1998), and neuromodulatory effects (Burgund, Marsolek, & Luciana, 2003) are used to support the subsystems theory. These multiple and varied constraints may click together to derive an additional “emergent” constraint if an integrated “whole” is greater than the sum of its “parts,” essentially helping to explain why the visual system appears to work in that way and not in other potential ways. This is the approach we recommend when faced with multiple cognitive theories offering plausible but different accounts of visual word processing.

References

2 Another possibility for word length effects with familiar-format words is less interesting, in that the main pattern of results could reflect statistical pressures. Word processing is almost always more efficient following LH presentations than following RH presentations, so statistical pressures from the ceiling/floor could be responsible for attenuating word length effects (that would otherwise be strong without the floor/ceiling) when words are presented directly to the LH. Less such attenuation should occur when words are presented directly to the RH.


