

distributed N400-type effect [7]. This evidence, that the irregular-stem mapping in the intact system is no more semantic than the regular-stem mapping, leads us to interpret the co-occurrence of semantic deficits and of disrupted access to irregular past tense forms as accidental rather than causal in nature. This interpretation is supported by the report of an anomic patient with a deficit for the irregular past tense but no semantic deficit [8].

The second problematic aspect of M&P's model is that it seeks to explain poor performance with the regular past tense purely in terms of general phonological processing deficits, and rejects the possibility of a deficit specific to morphological or morpho-phonological factors. This generates clear predictions, which we have falsified in two recent studies. Our experiments use a speeded same-different judgment task, where participants are asked to detect differences between the past tense and stem of regular (*played/play*) and irregular (*taught/teach*) past-tense verbs, matched pseudo-regular and irregular word pairs (*trade/tray; port/peach*), and matched sets of non-words. In one study [5], patients with documented difficulties with regular inflection performed consistently worse on the regular past-tense pairs than on the phonologically matched pseudo-regular and non-word pairs. Furthermore, performance on the task did not correlate with the patients' phonological processing difficulties, which ranged from very mild to severe. Preliminary results from a second study, using fMRI to examine activation patterns in the intact brain for the same experimental contrasts, showed differential activation for regular pairs in brain areas that overlap with regions

that are damaged in the patients, and where purely phonological factors can again be excluded.

In summary, although we remain agnostic as to the types of mental computation implicated by these results, we do not believe that connectionist models of the type proposed by M&P represent a promising direction, either for resolving the past-tense dispute, or for capturing the specific functional and neural architecture of the human language system.

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## Differentiation and integration in human language

Reply to Marslen-Wilson and Tyler

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The work of Marslen-Wilson and Tyler contributes importantly to our understanding of the neural basis of language processing. The arguments given in their letter [1], however, do not refute our view [2–5] that both regular and irregular verbs are processed in the same integrated system, and that performance on regular verbs is more affected by a disruption of phonological processes whereas performance on irregulars is more affected by a disruption in the use of semantics to constrain phonology.

Marslen-Wilson and Tyler (MW&T) argue against our suggestion that the relatively poor performance of Broca's aphasics with the regular past tense arises from the general phonological impairment that such patients exhibit. To be

clear about our position: we hold that Broca's aphasia comprises a deficit in phonology as well as a deficit in the representation of syntactic and morphological information and/or the relevant underlying semantic distinctions that syntax and morphology convey, with relative sparing of concrete object semantics [5]. The syntactic/morphological deficit explains the finding that Broca's aphasics are impaired in the inflection of both regular and irregular verbs [5–7]. The deficit in phonology accounts for the apparent *relative* disadvantage for regular verbs compared with irregulars, and depends on the generally greater articulatory complexity and perceptual subtlety of regular past-tense forms [8,9]. MW&T dispute our account on the basis of a recent study [10] in which Broca's patients were significantly slower to detect a difference between

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morphologically contrasting verb-stem/regular past-tense pairs (*press/pressed*) relative to control word pairs matched for phonological similarity (*chest/chess*)<sup>1</sup>. This outcome could be explained by the patients' deficit in representing morphology, without requiring a special mechanism for parsing regular inflections. A deficit in representing the distinction conveyed by the past-tense inflection would render *press* and *pressed* semantically indistinguishable, possibly delaying the response of 'different' in such cases.

MW&T also consider three findings that they see as incompatible with our proposal that semantic information is important for inflection of irregular verbs. First is their finding from a priming study with normal individuals, that both regular and irregular stem-past pairs (e.g. *bake/baked*, *take/took*) yield long-lasting priming, whereas priming for semantically related word pairs (e.g. *cello/violin*) is short-lived [11]. Second is their finding of a common pattern of ERPs for both regular and irregular pairs that again contrasts with the pattern for semantically related pairs [12]. As above, these differences between stem-past pairs on the one hand and semantically related concrete noun pairs on the other are consistent with the view that the brain mechanisms for processing syntax and morphology (damaged in Broca's aphasia) are distinct from those representing concrete object semantics. Third, MW&T argue that a patient with selective impairment of the irregular past tense but apparently intact comprehension [13] is evidence against our proposal. This patient, however, exhibited a frequency-sensitive anomia, which indicates a deficit in using semantic information to activate phonological representations, just as our account requires. Within the Joanisse and Seidenberg model [3] discussed in our article [4], a lesion that affected the outgoing connections from semantics would produce the required reduction in semantic influences on phonology,

with semantics itself remaining intact. In short, all of these findings are consistent with our account.

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<sup>1</sup> In a very similar study with a larger number of matched pairs, but measuring accuracy only [5], we observed equally poor performance with both types of pairs. This difference in outcome clearly requires further investigation.

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