Graded Semantic and Phonological Similarity Effects in Processing Morphologically Complex Words

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Morphology has been a controversial area within both linguistics and psycholinguistics. Linguists disagree as to whether morphology constitutes a component of grammar independent of syntax and phonology (Anderson, 1992; Aronoff, 1994; Lieber, 1992); psycholinguists disagree about whether complex words are processed: (1) as single "gestalt" forms (e.g., Butterworth, 1983); (2) according to their stems, with affixes added via rules of word formation (e.g., Taft, 1988); or (3) by hybrid systems that store some types of words (irregulars or semantically opaque forms) as gestalts and other types (regulars and semantically transparent forms) as separate stems and affixes (e.g., Marslen-Wilson, Tyler, Waksler, & Older, 1994; Prasada & Pinker, 1993).

Classically, complex words are thought to be formed and processed by rules that combine stored morphemic units, such that adding the agentive suffix *–er* to the verb stem *teach* forms *teacher*. A number of researchers have begun to question these assumptions about the need for morphological rules and the nature of the units involved in representation and processing (Gonnerman, 1999; Rueckl, Mikolinski, Raveh, Miner, & Mars, 1997). On the alternative view, lexical knowledge is distributed across simple, neuron-like processing units that encode information about the sound and meanings of words, and morphology simply emerges from the correlations between these codes. In this paper we present results from a series of four cross-modal lexical decision experiments that examine the roles of semantic and phonological relatedness, as well as morphological type, and provide support for this currently emerging view of the mental lexicon.

In all four experiments, the procedure was as follows: subjects heard auditory primes and were required to make lexical decisions to visual targets, presented immediately after the offset of the prime. Stimuli were developed using semantic similarity judgments previously obtained from ratings studies with separate groups of subjects.

Experiments 1 and 2 both address the question: Can graded semantic relatedness predict priming effects when phonological relatedness is held constant? In Experiment 1, prime-target pairs were phonologically transparent “suffixed” forms and their stems that varied in their semantic relatedness, from highly related (e.g., *baker-bake*), to moderately related (e.g., *backer-back*), to unrelated (e.g., *corner-corn*). An additional semantically unrelated condition included pairs whose primes, unlike *corner*, did not end in suffix-like phonological segments (e.g., *spinach-spin*). A final condition included pairs that were only semantically related (e.g., *idea-notion*).

Results from Experiment 1 for suffixed words and stems showed that semantically unrelated words do not prime, whether there is a suffix-like segment (e.g., *corner-corn*) or not (e.g., *spinach-spin*). Moreover, the findings in the other conditions clearly demonstrate that words related in meaning do prime, and that the degree of relatedness affects the magnitude of the priming effects; moderately related words (e.g., *backer-back*) prime half as much (19 vs. 40 ms) as highly related words (e.g., *teacher-teach).* Finally, in the absence of phonological similarity, there is a

reduced, yet significant, priming effect for highly semantically related words (i.e., 13 ms for *idea-notion* pairs).

Results from Experiment 2 demonstrate a strikingly similar pattern for prefixed words and stems: highly related pairs (e.g., *preheat-heat*) prime twice as much (42 vs. 20 ms) as moderately related pairs (e.g., *midstream-stream*), and unrelated pairs show no priming effects (e.g., *rehearse-hearse*). These results are inconsistent with theories proposing different processing mechanisms for prefixed and suffixed words (e.g., Colé, Beauvillain, & Segui, 1989; Marslen-Wilson et al., 1994) and suggest instead that semantic similarity is more crucial to lexical processing than the order of affix and stem.

Experiment 3 tested the claim that morphological type effects processing such that pairs of suffixed words inhibit one another (Marslen-Wilson et al., 1994). Our results do not support this claim and suggest instead that overlap in meaning and sound is more important than morphological type; pairs of suffixed words show significant priming when highly related (34 ms for *saintly-sainthood*), and marginal effects when less related (14 ms for *observation-observant*).

Experiment 4 tested whether degree of phonological relatedness determines priming effects for highly semantically related words. Results indicate that pairs exhibiting only a consonant change (e.g., *deletion-delete*: 65 ms) show greater priming than those with a vowel change (e.g., *criminal-crime*: 48 ms), which in turn prime more than pairs that contain both vowel and consonant changes (*introduction-introduce*: 35 ms).

The results presented in this paper demonstrate that both semantic and phonological similarity are continuous dimensions and that this grading is reflected in processing: priming magnitudes vary systematically along the full continuum of relatedness. Furthermore, the effects we have shown generalize across morphological types, holding for suffixed-stem, prefixed-stem, and suffixed-suffixed pairs. These results are awkward for hybrid theories of morphological processing, as it would be difficult to delimit the set of items to be decomposed from those to be treated as wholes, whether the items are divided according to their semantic transparency or their morphological type.

By our theory, morphology is an interlevel representation that mediates mappings between semantics and phonology and that emerges in the service of language acquisition and processing. Morphology reflects structure present in the world: language input contains patterns that are picked up on by language learners to the extent that they are useful in solving the primary tasks of competent speakers, that is comprehending and producing speech. Thus, although we assume these same principles operate across all languages, the system that emerges may differ depending on the reliability of phonological similarity as a cue to meaning, as well as other factors, such as the type and token frequencies of related complex forms and the nature of the orthographic system.

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