Priming English past tense verbs: Rules or statistics? ☆

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Abstract

A key question in language processing concerns the rule-like nature of many aspects of grammar. Much research on this topic has focused on English past tense morphology, which comprises a regular, rule-like pattern (e.g., *bake-baked*) and a set of irregular forms that defy a rule-based description (e.g., *take-took*). Previous studies have used past tense priming to support the theory that the two forms are processed using different cognitive mechanisms. In the present study we investigated this distinction more closely, focusing specifically on whether the regular/irregular distinction is categorical or graded. Priming for regular and irregular forms was compared, as well as for forms that are irregular but display a partial regularity (suffixed irregular verbs, e.g., *sleep-slept*). Participants performed a lexical decision task with either a masked visual (Experiment 1) or an auditory prime (Experiment 2). We also manipulated prime-target ISI (0 vs. 500 ms), given previous studies indicating this factor might also influence the magnitude and quality of effects. We observed priming effects for both regular and irregular verbs, however the degree of priming of both was influenced by prime modality and processing time. When the prime was masked and presented for 66 ms regulars and suffixed irregulars patterned together, and were different from vowel change irregular forms. As the processing time increased (using longer ISI or cross-modal presentation), all morphologically related words showed facilitation. The results suggest that priming arises as a convergence of orthographic, phonological and semantic overlap that is especially strong for morphologically related words.
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Human language is characterized by a grammar of highly regular patterns that apply in a rule-like fashion.

One of the key issues in cognitive science has been to understand the cognitive basis of these patterns. The theoretical debate has centered on the distinction between traditional views of mental computation, which characterize language as a mental grammar containing a set of symbolic rules (Pinker, 1991, 1997), and a distributed systems approach that operates subsymbolically and eschews rules in favor of statistics (Rumelhart & McClelland, 1986; Seidenberg, 1997).

The English past tense has been a focus of this debate because it involves both a rule-like pattern (e.g., *kicked*, *bugged*, *tested*) and a set of irregular forms that defy this

rule (e.g., *took*, *slept*, *went*). Most English past tenses are generated by adding the affix *-ed* to the verb stem. (This affix is pronounced /d/, /t/, or /Id/ depending on the phonological form of the stem). The pattern is rule-like, in that it applies in a predictable way to most verbs in English. However, exceptions to this pattern also exist: Depending on one's dialect, there are somewhere between 120 and 180 irregular verbs that form their past tenses in more idiosyncratic ways. These involve a stem vowel change (*sing-sang*), the change or addition of a final consonant (*build-built*), some combination of the two (*teach/taught*), no change at all (*hit-hit*), or even total suppletion (*go-went*). Because the degree of predictability for these changes is smaller it seems unlikely that irregular past tenses are created through rules applied to their stems (though see Halle & Mohanan, 1985, for a different view).

Accounts of morphological representation

A central question has been whether descriptive linguistic differences such as this reflect genuine differences in mental representations. One approach to the issue claims that they do. This ''dual mechanism'' account, best articulated by Pinker and colleagues, posits two distinct mechanisms for processing past tense inflections (Pinker, 1991, 1997; Pinker & Ullman, 2002; Prasada & Pinker, 1993). The first, a rule-based system, blindly adds the suffix *-ed* to regularly inflected verbs. This process is seen as automatic and obligatory, and is thus not influenced by non-grammatical characteristics of a stem such as phonology or frequency. (In comprehension, a similar procedure is used to strip the suffix from the stem.) Irregular verbs, by contrast, are relegated to an associative memory system that encodes their past tense forms as wholes. One consequence of this account is that regular verbs only have a lexical entry for the stem, and their past tense forms are derived by the affixation rule. Irregular past tenses, on the other hand, are learned and stored in a pattern-association network separately from their stems. This dual mechanism theory makes a categorical distinction between rule-generated regular past tense verbs and exceptions, and therefore predicts that these two forms will show strong dissociations in processing.

A number of other accounts of the regular/irregular difference exist, some of which make less categorical claims. Marslen-Wilson and Tyler (1998) suggest that regulars differ from irregulars not because they are formed by rule, but because they require a process of phonological assembly (or disassembly, in comprehension). Irregulars, which generally lack any obvious morpho-phonological structure, are accessed through a separate full-form route, like monomorphemic words. Thus, irregular past tenses have a close semantic rela-

tionship with their stems, but do not share one lexical representation. (Regular past tenses are strongly semantically related to their stems as well, by virtue of sharing a single lexical entry.) These representational differences can account for dissociations between the regular past tense on the one hand, and irregular past tense verbs on the other. Unlike the dual-mechanism account, this approach also notes that both regular and irregular past tenses have a morphological relationship with their stems, allowing for similarities across the two verb classes.

Other researchers also adopt the assumption of an explicit morphological relationship in the lexicon, without necessarily positing shared lexical representations for morphologically related words. In a series of priming studies, Fowler, Napps, and Feldman (1985) found no difference in the extent to which regular or irregular inflected and derived forms prime their stems. In most cases, in fact, these primes were as effective as identity priming by the stem itself. The authors conclude that morphemes, whether stems or affixes, are shared across separate words, but morphologically complex words do not share a lexical entry with their stems.

Schreuder and Baayen (1995) described a parallel dual-route model in which lexical access is attempted in parallel on the basis of the full form of a complex word and also on the basis of its constituents. On this account the lexicon contains access representations both for full forms of multi-morphemic words, and for their constituent morphemes, and recognizing a word involves decomposing it into its constituent parts. The meaning of complex words is computed from the meaning of these parts (Baayen, Dijkstra, & Schreuder, 1997; Baayen & Schreuder, 1999). The whole-word route, which matches the entire word to the stored orthographic representation, competes for access with a decomposition route, and the choice of winner depends on the frequency, predictability and transparency of the words. For more frequent words the whole-word route will allow access before the decomposition route. Note that this approach does not necessarily posit a categorical distinction between regular and irregular forms, since it allows the possibility that even regular and productive morphologically complex words might have lexical representations (Baayen et al., 1997).

Connectionist approaches offer yet another interpretation. On this view both regular and irregular verbs are processed within single integrated system (e.g., Plunkett & Marchman, 1993; Rumelhart & McClelland, 1986). Morphemes are not explicitly represented, and there is no symbolic rule specifying how the past tense should be formed. Instead, the representation of the past tense emerges through statistical regularities in the semantic and phonological relationships among words (Gonnerman, Seidenberg, & Andersen, 2007; Joanisse & Seidenberg, 1999; Seidenberg & Gonnerman, 2000).