

Cognitive Neuroscience and the English Past Tense: Comments on the Paper by Ullman et al.*

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We will devote our commentary to two topics from Ullman et al.'s study: (1) the linguistic assumptions that underlie the Ullman et al. investigation, and (2) the implications of the study for linguistic theory. The paper is a detailed study of the English past tense in aphasia, and is couched in the context of the larger debate between connectionist and non-connectionist models of human linguistic competence. From the perspective of linguistic theory, the attention devoted to arguing against connectionist models is regrettable, however necessary it may be in the larger context of cognitive neuroscience. Research in connectionist frameworks in the past has revealed nothing new about the nature of the human language faculty, and the current research program is based more on vague and unsatisfying promissory notes than on results that have consequences for our understanding of language (McClelland and Seidenberg (2000)). The results of the Ullman et al. study indicate yet again that there are fundamental problems with the connectionist research program, about which we have nothing further to say.

The study is an important and positive contribution to the study of language and cognition because it applies linguistic categories seriously to neuroscientific questions. Ultimately, however, the study of language and cognition will have to acknowledge complexities that are not recognized in extant discussions of the English past tense, complexities which have been articulated in linguistic theories for many decades.

The background assumptions that characterize Ullman et al.'s study are divided into two components: first, the theory of what is in the Lexicon; and, second, the theory of what it means for complex words to be created 'by rule'. The theory of the Lexicon adopted at the outset is essentially that of Jackendoff (1997). The authors assume that chunks of linguistic structure of various sizes are memorized in the Lexicon to the extent that there is idiosyncratic information associated with these chunks. The authors' own example - storing the idiom *kick the bucket* as a chunk - leads one to wonder whether the past tense of *kick the bucket* could possibly be produced by the "regular" past tense rule. If *kick the bucket* is a lexical unit, either it has a memorized, suppletive allomorph *kicked the bucket* for the past tense, or one would expect the regular rule to yield *kick the bucketed*. These are the only possibilities allowed on the assumption that the past tense is either derived by rule or memorized; the former option completely misses the transparent relationship between *kick the bucket* and *kicked the bucket*, while the latter is simply incorrect. The correct past tense for *kick the bucket* can be derived via the regular past tense "rule" under the assumption that *kick the bucket*

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is stored “in the lexicon” if it is acknowledged that stored information can be information about complex syntactic structures rather than simply about unanalyzed wholes. But allowing stored information to be information about complex structures undermines Ullman et al.’s simple dichotomy between what is stored and what is derived via rule. Once the stored is allowed to have internal syntactic complexity, syntactic “rules” are relevant to predictions both about completely regular and about partially irregular constructions. Thinking through assumptions about the interaction between stored information and grammatical processes is crucial for understanding the subjects’ behavior in the experiments of Ullman et al., but the authors present little in the way of clarification here.

The assumptions concerning the grammatical processes responsible for forming inflected words are even less clear; it is evident only that they are ‘rule based’ for Regular verbs. The appeal to rules is reminiscent of the theory of Anderson (1992), but no assumptions about the details of this computation are provided. Anderson, however, explicitly advocates rule-based mechanisms for both Regular and Irregular forms. A crucial issue for any theory of this sort is how tense features – which are properties of an independent element or position in the syntax – get associated with verbs prior to being “spelled-out” via morphological rule. Anderson’s theory makes it difficult to account for blocking effects, such as *went* blocking *goed*, while at the same time allowing for stem modifications, as in *shelv-es* from *shelf*, or suppletion cooccurring with regular inflection, as in *tul-t̄* (Perfect Tense Latin verb, with Present form *fer-ō* ‘bear, carry’) - see Halle and Marantz (1993). The notion that Nonfluent aphasics with syntactic combinatoric deficits should have trouble with the regular past tense flies in the face of Anderson’s A-Morphous approach, in which neither Regular nor Irregular affixes are pieces that are combined in any syntax-like way. So clearly Ullman et al. are not adopting Anderson’s theory. But what theory is it, then, in which inflectional features are features of stems rather than of independent morphemes, yet in which affixes are ‘pieces’ that combine in some syntax-like manner?

As Ullman et al.’s comments on linguistic theory are directed at the analysis of inflection in Distributed Morphology (DM; Halle and Marantz (1993)), we now turn to the elements of this analysis. In the DM treatment of English inflection, every type of past tense has the same abstract structure: Verb-[past], with a Verb and an affix position containing the feature [past] for past tense. In all cases, this Verb-[past] structure is present as the result of a computation in the syntactic component of the grammar.¹ In the case of Regular Verbs, the [past] feature is supplied, or *spelled-out*, with the phonological signal *-ed*, the default instantiation of [past]. The process by which abstract features like [past] are provided with phonological material is called *Vocabulary Insertion*. In the case of Irregular verbs, the choice of affix, either $-\emptyset$ or *-t*, is determined by the identity of the verb. That is, the affixes $-\emptyset$ and *-t*, for e.g. *hit* ~ *hit- \emptyset* and *bend* ~ *ben-t*, are each specified for a list of the verbs on which they will appear. The insertion of the particular affixes *-ed*, *-t*, $-\emptyset$ follows the Pāṇinian principle, such that affixes with more specific conditions on insertion take precedence over less-specified affixes. Thus if the $-\emptyset$ or *-t* affixes, which require specific lists for insertion, appear, the default past tense *-ed* will be blocked.

From one point of view, the morphologist’s job is over when the list of stems to which restricted affixes apply have been identified. If these stems do not belong to a conjugational class, i.e., if this list is not relevant for the choice of other affixes, then the list is morphologically uninteresting. However, to say that the list is arbitrary is not to say that it does not have a structure that is important for both language acquisition and language use.² Apparently, these lists are organized at least

¹The status of Tense as a syntactic component separate from the Verb in English stems from Chomsky (1957).

²For discussion of the former issue, and clarification of a number of questions concerning the acquisition of such lists,

according to similarity in phonological structure, accounting for the ability of people to generalize the irregular endings to novel stems that bear phonological resemblances to clusters of existing stems on the list. Moreover, activating a stem in the mental dictionary should activate all the lists that this stem is on, to a degree related to the frequency of combination of the stem and the relevant affix. Thus generalization of the Irregulars in “wug” test situations and frequency effects for Irregulars should be accounted for in much the way that Ullman and Pinker suggest.³

The selection of the correct allomorph of the past tense feature, *-ed*, *-t*, or \emptyset , the essential step in the process described above, is not all that is involved in deriving the behavior of this inflection in English. In addition, a number of phonological rules, called *Readjustment Rules*, apply to effect phonological changes on verb stems when they appear with [past] suffixes. Thus, for instance, the rime of *sing* is converted by a phonological ablaut process which operates in the context of the zero past tense to produce *sang* (cf. Halle and Mohanan 1985 for discussion of this and related phonological rules). Because lists must be appealed to, the computation resulting in the inflected forms of these verbs requires information that is simply not required for Regular verbs. Crucially, however, information concerning the fact that \emptyset appears with e.g. *sing*, and that a particular phonological rule applies to *sing* when it appears with [past], can be stored without the entire form of *sang* having to be represented as unanalyzable. Specifically, one simply has to specify that there is a \emptyset -realization of [past] that appears with a specific list of verbs, and that *sing* is on this list. A similar representation is found for past-tense *-t*, as in *buy* \sim *bough-t*, again with Readjustment Rules applying to the stem. This is a *dual system* view, in the sense that the correct derivation of Irregular forms requires two distinct components: both computation (generation of V-[past]) and memory (consultation of a list).

This listing determines the behavior of Irregular verbs with respect to additional psycholinguistic tests alluded to above, and requires further elaboration. In particular, we hold that the existence of frequency effects with Irregular forms (see Ullman (1999) for a recent detailed study) does not require rote memorization of these forms as unanalyzed wholes. A standard observation is that Regular and Irregular verbs show processing differences with respect to stem-frequency as opposed to past tense frequency. Stem frequency, rather than past tense frequency, affects the processing of Regular past tense forms. But past tense frequency does affect the processing of Irregular past tense forms. Ullman, Pinker and others use these facts to argue that the Regulars are not memorized, while the Irregulars are. However, all that is required to explain these facts is the notion that people tally occurrences of constructions only when the constructions involve memorized connections between the elements.⁴ Thus exposure to *walk-ed* only ups the tally for *walk* and *-ed* separately, because the relationship between *walk* and *-ed* involves no listing. Exposure to *gave- \emptyset* , on the other hand, ups the tally for *give*, for \emptyset , and *gave+ \emptyset* , since the zero past tense ending has *give* on its list, and the combination of *give* and past tense is an instantiation of the relation encoded by having *give* on the list. This account would predict frequency effects for expressions like *kick the bucket* that are crucially tied to the appearance of these elements in this expression – without requiring that *kick the bucket* be treated as an unanalyzable whole. Clearly, when Ullman et al. explore the consequences

see Yang (2000).

³Although there are additional complexities that arise when these facts are studied in detail; see, for instance, Schreuder and Baayen (1997) and Baayen et al. (1997).

⁴Baayen et al. (to appear) suggest that additional factors, including morpheme content, may lead speakers to tally constructions involving completely regular affixes, i.e., affixes without lists. This leads to “surface frequency effects” even for completely regular constructions.

of adopting the Jackendovian notion that phrases are stored in the Lexicon, they too will come to the conclusion that frequency effects with Irregular past tense forms must involve the frequency of a complex construction in which there is something memorized about the relation between the elements, rather than the frequency of a single, simple form.

Returning to the level of linguistic theory, the DM theory outlined above is clearly at odds with the position that irregulars of any type are simply stored as wholes, an oversimplification found in many recent discussions of the topic (cf. Pinker 1999, who directs his criticism at Chomsky and Halle (1968)). Storing the past tense forms of such verbs as unanalyzable wholes is simply an unworkable option from the perspective of morphological theory. It treats the alternation between e.g. *bend* and *ben-t* as indistinguishable from outright suppletion of the type found with *go* ~ *wen-t*, or *be* ~ *was*. If *sang* is simply memorized as the past tense of *sing*, the fact that it is related to *sing* by a simple phonological rule changing the vowel is completely accidental; that is, the past tense of *sing* could very well be *porcupine*, as the present and past tense forms would be distinct entities. Outright stem suppletion of the *go* ~ *wen-t* type is vanishingly rare cross-linguistically, and a theory that equates non-default affixation with suppletion is therefore untenable.⁵

The aphasia data that Ullman et al. present speak clearly to the differences in linguistic and psycholinguistic theories that we have presented. The specific implications that Ullman et al. draw concerning morphological theory are based on their demonstration that Non-Fluent Aphasics (NFAs) treat Regular and Irregular past-tenses differently. They conclude that this finding is incompatible with the DM analysis outlined above. The reasoning is as follows:

Some theories of morphology posit that irregulars as well as regulars undergo affixation, either with phonologically overt morphemes, for irregulars as well as regulars (e.g. *keep* → *kep-t*, or with “zero-morphemes”, for many irregulars (e.g. *hit* → *hit-∅*; *dig* → *dug-∅*) (Halle & Marantz 1993). On this view, if affixation were impaired in agrammatic non-fluent aphasia, it should affect irregulars as well as regulars. In particular, it should result in the omission not only of the regular affix, but also of irregular affixes.(ms. p. 42)

Without specific assumptions about the nature of the linguistic deficit that characterizes the NFA population, Ullman et al.’s findings do not necessarily speak to any particular morphological theory directly. The reason for this is that both groups of aphasics in their study show different behavior for two types of verbs that will be distinguished from each other on any linguistic analysis. The assumptions that underlie the interpretation of the data in the quote above are that (1) the Regular past tense requires computation, while the Irregular does not; and (2) the anatomical locus of computation is in anterior cortical regions, while lexical memory is located in temporal (or temporal/parietal) regions. Their argument is thus that NFAs, with anterior lesions, cannot compute Regular past tense forms, but can recall Irregulars from memory; and that this interpretation is incompatible with a theory that holds that all past tense forms are derived via computation.

⁵It might be objected that suppletion is simply very costly from an acquisition perspective, and therefore disfavored in natural language. This position, however, is difficult to interpret in the absence of a theory of how this cost is to be calculated. Pinker emphasizes the phonological relation between the stems that have irregular past tense forms, not the phonological relation between the stems and their past tenses. We believe he assumes some sort of analogy, e.g. *sing:sang::ring:rang*. However, such analogical extension could work as well for suppletion. So, for instance, *be:was::pee:whas(/hwəz/)*.

With reference now to the specific claims about morphological theory, the behavior of aphasics in the study does not contradict predictions made by the DM model, which in fact provides another way of viewing the behavior of NFAs, as we show below. The theory states clearly that the Regular and Irregular past tenses are distinct from one another; and this is implemented in the fact that lists must be referred to for the Irregular verbs, but not the Regulars. The predictions of the theory are thus not incompatible with the results of the aphasia study. One clear prediction that this model does in fact make is that phonological Readjustment should not occur in the absence of an overt affix for verbs with *-t*; the phonological Readjustment accompanies the past-tense affix, and will not apply if the affix is not present.⁶ This is borne out; while NFAs produce unmarked stem forms for both Regular and Irregular verbs, Ullman et al. note (p.42) that no subjects produce e.g. *kep-* for *kep-t*. Note that nothing in the Ullman et al. explanation of NFA would predict that these subjects should have any difficulty at all with the Irregular past tense forms. The DM analysis, on the other hand, predicts some level of omission of the past tense ending for the Irregulars as well as the Regulars, assuming, with Ullman et al., that NFA involves a problem with syntactic combination of pieces. On the DM story, if the NFA leave out the past tense morpheme with irregular verbs, they should produce the bare stem with these verbs, as with regular verbs. The large number of such errors by the NFA with Irregulars follows naturally under the DM story, but not under Ullman et al.'s analysis, where creating an Irregular past tense form requires no syntactic processing at all.

Turning now to a new perspective on the data Ullman et al. report, the difference between Regular and Irregular affixation found in NFAs seems to be attributable to a problem in producing the default [past] form *-ed*. Performance on verbs for which information is listed is better, although still degraded.⁷ But in cases involving a listed suffix, whether *-Ø* or *-t*, performance is better than with the default *-ed*, which requires no list. Patterns in the data support this interpretation. In both the Production and Reading tasks, NFAs produce incorrect forms in which the wrong affix is used in addition to producing unmarked stems: *-ing* in the Production task, and both *-ing* and Third Person *-s* in Reading. There are two observations to be made here. First, the fact that NFAs are producing complex forms indicates that they are using structurally complex objects, V-[past]. Second, the types of errors made support the idea that these patients have a general problem with affixes that do not involve lists. The analysis of English inflection involves exactly four affixes that do not involve lists: *-ing*, for the Present Participle; *-ed*, for Past Tense and Past Participle; *-s*, for Third-Person Singular Present; and *-Ø*, for the Present of other persons; and the errors made by NFAs in Regular verbs are of precisely these four types.⁸ Conversely, the highly marked *-en* participial suffix, which requires a restricted list, does not appear among the affixes used incorrectly for Regular verbs.⁹

Above we have criticized Ullman et al.'s discussion because of the linguistic assumptions underlying their investigation of the behavior of aphasics. But Ullman et al. are not responsible for many of these assumptions, which stem from the debate between connectionist and non-connectionist

⁶See Yang (2000) for specific proposals concerning the connection between listed verbs and the phonological processes that they are subject to.

⁷The fact that Non-Fluent Aphasics are also impaired in the production of irregular past-tense forms as compared with normals is evident in each of the experiments, but is not commented on.

⁸Although, of course, unmarked forms are indeterminate, and could represent either *-Ø* affixation or a simplified structure without [past]. We are also excluding word distortion, or word substitution errors. The problem that NFAs have with affixes without lists leads to the possibility of a Present Tense experiment for these patients; the expectation is that, since both *-s* and *-Ø* for Present have no lists, there should be increased error-rates in terms of over-application of the *-s* affix.

⁹It does appear with some Irregulars for one patient in the Production task.

models of linguistic competence presented in the opening paragraph, and in particular from the oversimplified view of linguistic theory that characterizes much of Pinker's discussion of the English past tense. Related to this is the more general point that, despite its prominence in a number of recent publications, the English past tense is in and of itself quite simple from a linguistic perspective,¹⁰ and its implications for the study of language and the brain are therefore quite limited. Ullman et al.'s study is important because it takes linguistic categorizations seriously and applies them rigorously in the domain of cognitive neuroscience; investigations of this type will only become more significant as the additional complexities of the type that we have presented are taken into account.

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¹⁰Cf. the discussion in Halle (2000).