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Why No Mere Mortal Has Ever Flown Out to Center Field

JOHN J. KIM
STEVEN PINKER
Massachusetts Institute of Technology

ALAN PRINCE
Brandeis University

SANDEEP PRASADA
Massachusetts Institute of Technology

The English past tense system has recently been used to argue that formal grammatical categories (such as root, rule, and lexical item) may not be necessary to explain the acquisition and knowledge of language. Rumelhart and McClelland (1986) devised a connectionist model relying solely on phonological information; it is often suggested that any deficiencies of such a model can be remedied by supplying it with semantic information. These proposals are incorrect: Grammatical categories and abstract morphological structure are indispensable and cannot be replaced with semantics while preserving the patterns of psychological generalization in the system. Linguists have noted that irregular past tense mappings (e.g., *fly/flew; stick/stuck*) apply only when a verb's root is marked in the lexicon as having an irregular past. Because nouns are never so marked, verbs with noun roots—*denominal verbs*—are regular even if they are phonologically identical to irregular verbs, hence: *flied out/*flew out to center field; high-sticked/*high-stuck the goalie.* Experiment 1 shows that adult subjects are highly sensitive to this principle when rating regular and irregular past tense forms of novel versions of irregular sounding verbs: New verbs formed from nouns were judged as better with a regular past tense (e.g., *line-drived* was the preferred past of "to hit a line drive"); new verbs formed from verbs were judged as better with an irregular past tense (e.g., *line-drove* was the preferred past of "to drive along a line").

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Correspondence and requests for reprints should be sent to John J. Kim, E10-108, MIT, Cambridge, MA 02139.

Experiment 2 replicated the results with noncollege-educated adults, showing that the effect is not due to prescriptive language training. Experiment 3 tested an alternative to the formal grammatical account proposed by Lakoff (1987): When a verb has two meanings, one with an irregular past and one with a regular past, the irregular will belong to the meaning that is more central. Using regression techniques and ratings data, we disconfirm this prediction: In the data from Experiment 1, judgments of regular and irregular forms of a new verb are shown to be affected by whether the verb is derived from a noun or a verb, but not by whether its new sense is near the center or the periphery of the sense of the word it was derived from. Experiments 4 and 5 explain the few apparent counterexamples by gathering independent evidence for a short-circuiting process: When a denominal verb appears to have an irregular past tense form, it is because speakers sometimes interpret such verbs as having been derived directly from a related irregular verb root, bypassing the relevant noun. The experiments serve as a straightforward demonstration that representations of formal grammatical categories and structures are powerful determinants of linguistic behavior, and are not reducible to semantics, phonology, or prescriptive training.

At the very heart of grammar are formal categories like *noun, verb,* and *adjective.* To most linguists it is virtually unthinkable that a theory of the psychology of language could do without mental representations of them: They define regularities in the syntax and morphology of virtually any sentence that a speaker utters. Yet, perhaps because of the very ubiquity of grammatical categories and the complexity of the linguistic structures they govern, clear and simple arguments for their psychological reality are not easy to find in the literature, and many philosophers, psychologists, and computer scientists remain skeptical. In this article we focus on a simple domain (one of many that could be chosen) in which it can be shown conclusively that grammatical categories and morphological structure play a subtle but powerful role in linguistic behavior. The domain has special relevance because it has recently figured in attempts to show that connectionist models (networks of densely interconnected simple neuronlike units) make traditional grammatical categories and structures obsolete.

In English, there are two types of verbs, those that have a regular suffixed past tense form, such as *walk/walked, jump/jumped,* and *open/opened* and those belonging to one of several lexically restricted classes, which use other modes of past tense formation, such as *blow/blew, sing/sang, eat/ate,* and *break/broke.* A familiar simple account of the knowledge of the past tense of English verbs is that a regular rule generates the past tense form of regular past tense verbs, and irregular past tense forms are simply memorized by rote.

The familiar account fails, however, to capture the fact that irregular past tense verbs tend to pattern with other phonologically similar verbs (Bybee & Moder, 1983; Bybee & Slobin, 1982). Examples include the class where the stem has an *i* followed by a velar nasal consonant, such as *sing/sang,*

ring/rang, spring/sprang, drink/drank, shrink/shrank, stink/stank, and the closely related class *string/strung, sting/stung, swing/swung, sling/slung, wring/wrung,* and so on. Within the rote-memory account, these similarities are purely incidental, a historical residue of the Old English strong verb classes.

However, clusters of irregular past tense verbs are not completely unproductive, which suggests that their phonological structure plays a role in the mental processes governing their use. Historical evidence for this semiproductivity is the fact that a number of verbs, namely *catch/caught, cost/cost, fling/flung, kneel/knelt, quit/quit, sling/slung, stick/stuck,* and *string/strung* have been assimilated into irregular past tense clusters within the past several hundred years under the influence of similar existing clusters of irregular verbs (Jesperson, 1942/1961). Furthermore, many dialects of English show that the subregularities must have been at least somewhat productive at some time. For example, *thunk* is a common past tense form for *think,* which presumably is due to the partial productivity of the *sting/stung* cluster. Children, of course, occasionally use forms like *brang* for *brought, bote* for *bit,* and *truck* for *tricked.* Finally, Bybee and Moder (1983) showed that when experimental subjects are asked to produce the past tense form of a novel verb (e.g., *to spling*), the likelihood of an irregular past tense response (e.g., *splung*) increases with the phonological similarity of the novel verb to the phonological prototype of an irregular past tense cluster.

Rumelhart and McClelland's (1986) connectionist model of the acquisition of the past tense of English verbs was able to represent the similarity among irregular past tense clusters of verbs and to capture the semiproductivity of those clusters. The parallel distributed processing architecture of the model, in conjunction with the phonological representations that the model used, allowed it to find similarities among the instances of the irregular past tense verbs it was trained on, and to generalize to new forms based on their similarity to the forms in the training set. The model, often characterized as an alternative to symbol-processing or rule-based accounts of the acquisition and knowledge of language, made no reference to formal linguistic notions such as "verb root," "rule," and "lexical item."

In the model, a base form was represented by a pattern of activation within a vector of nodes each of which, when turned on, represented a phonological property that the stem possessed (e.g., stop consonant at the beginning, high vowel between two voiced segments). The network had an output vector with a similar structure, which represented the computed past tense form of the verb. Thus, the model performed the stem-to-past mapping based solely on the basis of phonological information. Every input node was connected to every output node by a connection with a modifiable weight. Presented with a series of stem–past pairs, a learning mechanism strengthened connections between phonological properties of the stem and

those of its past tense form. This allowed the network to reproduce the pairs in the training set and to generalize to new forms on the basis of their phonological similarity to the pairs in the training set. The model treated regular and irregular past tense formation as a unified phenomenon, encoding them in a single network. The fact that regular past tense formation seems to have the status of a linguistic rule simply reflects the predominance of regular past tense verbs in English, which causes strong connections to be set up between many stem features and the features in the *-ed* set of endings.

According to Rumelhart and McClelland (1986), their model implies that children may not have mental representations of rules or lexical items. Moreover, they note that the basis for their model's successful performance is its sensitivity to details of the phonological representation of the stem:

> We have, we believe, provided a distinct alternative to the view that children learn the rules of English past-tense formation in any explicit sense. We have shown that a reasonable account of the acquisition of past tense can be provided without recourse to the notion of a "rule" as anything more than a *description* of the language.... The child need not figure out what the rules are, nor even that there are rules. The child need not decide whether a verb is regular or irregular. There is no question as to whether the inflected form should be stored directly in the lexicon or derived from more general principles. There isn't even a question (as far as generating the past-tense form is concerned) as to whether a verb form is one encountered many times or one that is being generated for the first time. A uniform procedure is applied for producing the past-tense form in every case. *The base form is supplied as input to the past-tense network and the resulting pattern of activation is interpreted as a phonological representation of the past form of that verb. This is the procedure whether the verb is regular or irregular, familiar or novel.* (p. 267, emphasis added)

Indeed, the fact that weighted combinations of phonological features largely suffice to discriminate regular verbs from irregular verbs, and different kinds of irregular verbs from each other, is a surprising and interesting discovery of their modeling effort. In sum, the model's exclusive dependence on phonological information is the basis both for the more radical claims about the psychological unreality of formal linguistic constructs, and for its most interesting contributions to our understanding of morphological phenomena.

In this article, we will address neither Rumelhart and McClelland's (1986) model in general (see Lachter & Bever, 1988; Pinker & Prince, 1988; Prince & Pinker, 1988 for such detailed critiques), nor the issue of connectionism versus rule-based architectures. We focus only on whether the input to linguistic mappings, in this case the mapping from English verb stems to their past tense forms, requires information about formal grammatical structure, including grammatical categories such as lexical item, form class, and past tense rule, or whether it can be represented solely in terms of phonological

information. We show that past tense formation makes crucial use of formal constructs such as verb root, rule, and lexical item. We also show that a semantic alternative to the formal category account is empirically untenable. The demonstrations do not constitute evidence against connectionism, but they do constitute evidence against any model, connectionist or otherwise, that lacks representational devices dedicated to grammatical distinctions.

THE NEED FOR FORMAL LINGUISTIC REPRESENTATIONS

Though the semiproductivity of irregular past tense clusters may seem like justification for making phonological representations the sole determinant of the past form of a verb, this move has disastrous empirical consequences.

Lexical Item as the Locus of Idiosyncrasy

Given the fact that some pairs of verbs have homophonous stem forms but different past tense forms, it is clear that phonological properties cannot be the sole determinant of the past tense form of a verb.

(1)	a.	Jimmie *rang* the bell.	ring/rang
		Jimmie *wrung* the washcloth dry.	wring/wrung
	b.	Preston *lay* on his bed.	lie/lay
		Preston *lied* to me again.	lie/lied
	c.	Kim *hung* a painting on the wall.	hang/hung
		The executioner *hanged* the criminal.	hang/hanged
	d.	That shirt never *fit* Fran.	fit/fit
		The tailor *fitted* Fran with a shirt.	fit/fitted

Somehow these homophonous verbs must be given nonidentical representations when they are input to whatever process derives the past tense form. The linguistic notion of "distinct lexical entries" is the standard way of expressing this distinctness: The verbs in each pair of sentences are not represented as the *same item;* they have separate entries in the mental lexicon, each of which can have (or not have) an irregular past tense form linked to it.

Because the pairs in (1) need only be distinguished by some representational difference, one might think that lexical entries, conceived of as abstract indices or addresses, are not strictly necessary. In each case the different verbs have different meanings that must be represented somewhere. Because this difference in meaning has to be represented in any case, perhaps it could be used as part of the input to the past tense system, providing the representational difference that the system needs to distinguish homophonous verbs with different past tense forms. Adding a set of semantic features to the input vector is the obvious augmentation of the Rumelhart and McClelland model, and has been suggested by MacWhinney and Leinbach (1990). How-

ever, adding semantic features to a distributed representation has additional consequences. As Hinton, McClelland, and Rumelhart (1986) pointed out in their tutorial, "one of the most interesting properties of distributed representations [is that] they automatically give rise to generalizations" (p. 82). In fact, "any subset of the microfeatures can be considered to define a type. . . .This allows an item to be an instance of many different types simultaneously" (p. 84). Thus, the addition of semantic features would not only distinguish homophonous verbs, but at the same time would define semantic subtypes of verbs (those that share some of the distinguishing semantic features) that would be expected to show similar behavior in past tense formation, just as overlap in phonological features defines clusters of verbs with similar past tense forms.

But this consequence turns out to be false. The past tense form of a verb does not directly depend in any way on recurring semantic distinctions. For example, consider the verbs *slap, hit,* and *strike.* They are similar in meaning, but they have different past tense forms: *Slap* has the regular past tense form *slapped, hit* has the no-change irregular past tense form *hit,* and *strike* has the irregular past tense form *struck.* Thus, similarity of meaning does not imply similarity of form. Conversely, phonological clusters of irregular past tense verbs are not semantically cohesive: Similarity of form does not imply similarity of meaning, either. Consider the *sting/stung* class of irregular past tense verbs: *sting, sing, drink, shrink, swing, sling, spring, stink, ring.* There is no set of semantic features that seems to distinguish these verbs from those that take different past tense forms, nor is there a set of semantic features that partitions this set of verbs into those that have a past tense form that changes the vowel to an *a* and those that change the vowel to an *u.* Semantic features would not help in learning these distinctions; they would just get in the way.

The independence of semantics and past tense form has other striking consequences: If several forms are sensed as being built out of the same verb morpheme, they will all have the same irregular past, no matter how semantically dissimilar. Verbs like *take, put, give, make, have, come, go,* and *set,* sometimes called "light verbs," have many meanings, especially when combined with prefixes such as *be-, for-, under-,* and *over-* and particles such as *up, out, in, off,* and *away.* However, they resist regular forms across all such incarnations, no matter how tenuous the semantic thread that might be said to hold them together (e.g., *took/*taked a walk, took a bath, undertook, took off, took in; came/*comed up, came around, became, overcame*).

None of this implies that it is impossible to use semantic information as a way of distinguishing homophonous verbs with different past tense forms. For example, one could add a set of units to the input bank upon which each verb that needed to be distinguished was given an orthogonal activation vector. Of course, in that case the units would simply be a code for the standard notion of "distinct lexical item"; in no sense would they be *semantic.* Alter-

natively, the system could somehow be constructed so that any difference in the semantic representation would be treated as indicative of a potential difference in morphology, and would feed into distinct bits of hardware representing unique phonological mappings for each of the combinations of values of the semantic features. But these distinct mappings, contingent on the mere *existence* of a semantic difference, independent of the actual patterns of semantic features across verbs, would also be implementations of the notion of pure distinctness of wordhood that is captured by the construct of lexical entries. As such, they run counter to the automatic construction of generalization-supporting subclasses that Hinton et al. (1986) considered to be one of the virtues of connectionist models employing distributed representations.

Regular Past Tense Formation as a Rule

The regular past tense form is not just one of several kinds of annotations to a verb's entry; it has a special status as a *default* rule that applies automatically whenever it is not explicitly blocked by a competing irregular. This asymmetry is shown by a phenomenon discussed by Mencken (1936), Kiparsky (1982a, 1982b, 1983), and Pinker and Prince (1988): Denominal verbs (those analyzed by speakers as having been derived from, or as being built around, a noun) have regular past tense forms, even if homophonous with, or ultimately derived from, an irregular verb. Examples are shown in (2); (a) and (b) are due to Paul Kiparsky; (c)–(j) are from Pinker and Prince (1988); (k) was provided by Lila Gleitman (personal communication, October, 1989).

(2)	a.	He *flied out* to center field.	*flew
	b.	He *grandstanded* to the crowd.	*grandstood
	c.	He *spitted* the pig.	*spat
	d.	He *braked* the car suddenly.	*broke
	e.	He *ringed* the city with artillery.	*rang
	f.	Martina *2-setted* Chris.	*2-set
	g.	He *sleighed* down the hill.	*slew
	h.	He *de-flea'd* his dog.	*de-fled
	i.	He *righted* the boat.	*rote
	j.	He *high-sticked* the goalie.	*high-stuck
	k.	The doctor *casted* his arm.	*cast
	l.	Vera *costed* the equipment requests in the grant proposal for us.	*cost

m.	Chris Chelios of the Canadiens had *cheap-shotted* him. (*Boston Globe,* 4/26/90)	*cheap-shot
n.	I *big-ringed* it the rest of the way (i.e., used the big chain ring while bicycling; from a bicycle magazine).	*big-rang
o.	In each of the past two seasons, Cleveland State guard William Stanley has sported a self-styled, one-of-a-kind hairdo. In 1987–88 it was a half-foot-high flattop. Last season he went to a bilevel box cut. This season, as a senior, Stanley has *outdo'ed* himself. (*Sports Illustrated,* 12/6/89)	*out-done

In all of these examples, the verbs, though homophonous with irregular past tense verbs, are regular; all are transparently based on nouns or adjectives. Informally, one can account for this contingency by saying that irregularity is a property listed in the lexical entries of *roots* of words, not the words themselves. A verb derived from a noun has a noun root. Nouns cannot be listed in the mental lexicon as having an irregular past tense form because it makes no sense for a noun to have a past tense form at all. Therefore, denominal verbs cannot be listed as irregular, and the regular rule applies by default. For example, the verb *to high-stick* is derived from the noun *stick,* which cannot have a past tense. Note that a change of category is a sufficient condition for regularization: It holds across noun and adjective roots, and across the heterogeneous semantic roles that the noun referent plays in the event denoted by the verb.[1]

However, this informal account is not precise enough to account for why verbs with a circuitous derivation from verb roots (e.g., V→N→V), such as *to fly out,* based on the noun *fly* (as in *pop fly, fly ball*), which in turn was derived from the verb root *to fly,* have a regular past tense: in some sense, they do have irregular roots.[2] A more precise version comes from Williams (1981).[3]

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[1] Of course, a change of category is not a *necessary* condition for regularization; the examples in (1) show that distinct lexical regular and irregular entries for the same morpheme within the verb category are sometimes possible. As Dan Slobin (personal communication, May 16, 1990) pointed out to us, occasionally differences in register (formal vs. informal), dialect (British vs. American), or meaning can segregate one usage of a verb from another in a distinct lexical entry, which may then admit of a different past tense form, as in *She weaved/*wove through traffic* and *She knelt/?kneeled to pray; She ?knelt/kneeled to tie her shoe;* see the Appendix to Pinker and Prince (1988) for other examples, and Ullman and Pinker (1990) for discussion. Note that these examples are haphazard in terms of which verbs will split into different past tense forms and which of the two senses will be linked to the regular form. In contrast, the regularization-through-derivation effect is completely predictable, and, we will show, probably exceptionless.

[2] It also does not account for regularizations of certain complex nouns, as when *low-life* gets pluralized as *low-lifes,* not **low-lives* (cf. also *still lifes, hotfoots, walkmans*), even though such nouns have roots that are also nouns.

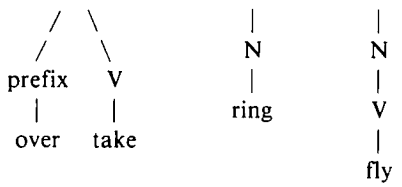
[3] For alternative accounts, see Kiparsky (1982a, 1982b, 1983) and Gordon (1986, 1989).

1. Derived words have a constituent structure (which can be shown as a tree structure), reflecting their derivation from more basic morphemes.
2. A constituent at any level of a tree inherits all the grammatical features of one of its subconstituents if and only if the subconstituent is in *head* position. In English, the head is ordinarily the rightmost constituent at a given level of decomposition.
3. Irregularity is a feature of morphemes, like grammatical category, gender, and so on.

Therefore, a verb that is derived from a noun cannot have inherited all the features of its root, because if it had, the feature "noun" would have been among them and it could not be a verb. Therefore, verbs derived from nouns cannot have heads; they are headless or *exocentric*. As a result, there is no way in such structures for features to pass up from a constituent morpheme to the whole. Therefore, there is no way for the whole verb to inherit the "irregular" feature from one of its parts, even if the part was marked as irregular. Therefore, irregularity cannot be associated with denominal verbs and the past tense of such verbs are formed by the application of the default regular rule.

This can be illustrated by the examples in (3). The structure in (3a) corresponds to the verb *overtake* which has an irregular root, *take,* residing in head position, from which it passes on both the categorial feature "verb" and the irregularity feature. In (3b), corresponding to *ringing the city,* shows how a verb derived from a noun is headless: The topmost node dominates a node of a different category, which would be impossible if that node were its head. Example (3c) shows that this is true even for circuitous derivations. The step in the derivation that derives the verb (*to fly out*) from the noun (*fly ball*) yields an exocentric structure, even though the noun itself was ultimately derived from the verb *to fly*. In fact, the step in the derivation that derives the noun (*fly ball*) from the root verb (*fly*) also yields an exocentric structure. Therefore, the derived verb has no head and, consequently, has no pathway for the irregularity of its root to percolate up to the top node representing the word as a whole.

(3) a.



b.

c.

AN ALTERNATIVE, SEMANTIC ACCOUNT

Lakoff (1987) suggested that models lacking representations for grammatical categories, connectionist models in particular, could handle past tense forms

such as *flied out* if semantic information were encoded. His explanation is different, however, from the one discussed earlier in which the irregular/regular distinction would be contingent on sets of semantic features. Lakoff wrote:

> [Pinker and Prince (1988)] cite the well-known fact that certain polysemous lexical items have different past tense forms for different senses of the verb. For example, *fly* in its central sense, takes the past tense *flew,* but takes *flied* in its extended baseball sense. . . . There is a general constraint on such cases: It is always the central senses that have irregular past tenses.

Lakoff's proposal needs to be examined with some care; as formulated, it is too weak to be useful. The proposal offers only a one-way implication between centrality and irregularity: Given a polysemous verb which has irregularity *somewhere* among its cluster of senses, Lakoff predicted that the irregularity will necessarily infect the central senses. Nothing is predicted about the extended senses. "It is always the central senses that have irregular past tenses"; crucially, it is not the transparently incorrect "always and only the central senses." Lakoff's constraint permits a polysemous verb to have an irregular central sense and regular extended senses; or indeed, to have any mixture of regular and irregular extended senses. What he ruled out is a polysemous verb with a regular central sense and irregular extended senses. In particular, Lakoff's constraint permits a polysemous verb to have an irregular past in *all* of its senses. But we are exactly trying to understand cases where the "extended senses" must be regular.

Lakoff's constraint can be rephrased in this way: Regular central senses imply regular extended senses; or by contraposition, irregular extended senses imply regular central senses. From this, it is clear that one is not licensed to draw any conclusions about the behavior of the extended senses when the central sense is irregular, or, even more pointedly, when the central sense belongs to a noun and is thus outside the verbal system of regularity/irregularity. Whether one accepts Lakoff's conception that *to fly out* is derived directly from *to fly* or whether one more plausibly relates it to the noun *fly (ball),* there is no entailment from his constraint about the grammaticality of "flied out" versus "flew out." The constraint must be strengthened if it is to have sufficient predictive power to compete with the grammatical theory. Yet, one cannot go all the way to the biconditional "always and only," because, as previously noted, hugely polysemous verbs can be irregular in all senses (e.g., *take, set, give*). No one wishes to claim that "only the central senses of a verb may be irregular." We, therefore, propose, as a worthy opponent to the grammatical theory, a gradient version of the semantic hypothesis:

(4) *The Semantic Centrality Hypothesis:* For an extended sense of an irregular verb, the tendency to regularize varies with the degree of sense extension;

> the more extended the sense, the higher the probability that the verb will take regular inflection.

Under this hypothesis, the notion "extended sense" has some predictive capacity, even if only probabilistically; it can be investigated empirically. This theory can indeed provide an account for why all denominal verbs have a regular past tense, if denominal verbs are always construed as having complex, extended meanings based on the meaning of a noun. So it is possible to argue that both the formal grammatical theory and the semantic centrality theory make the same predictions with respect to denominal verbs, insofar as denominal verbs are extended in meaning.

It is worth noting that the semantic centrality theory is not obviously true in any absolute sense, even in the domain of simple nondenominal verbs. There are verbs that fit into the expected pattern of irregular-past-tense-forms/central-senses contrasting with regular-forms/extended-senses, for example, *to hang* and *to fit,* discussed earlier in (1). However, there do exist verbs that are irregular only in their extended senses, contrary to prediction. Consider these examples [(a) and (b) are from Pinker & Prince, 1988, p. 112]:

(5) a.	He *wetted/*wet* the washcloth.	The baby *wet/*wetted* his diapers.
b.	They *heaved/*hove* the bottle overboard.	They *hove/*heaved* to.
c.	The baby *creeped/?crept* across the floor.	The deadline *crept/?creeped* up on us.

There are, however, rather few clear examples of this type, and one could perhaps argue that the graded character of the semantic centrality theory allows even sporadic reversals of its main prediction. It is, therefore, important to distinguish the two accounts with other evidence, and it is clear how to do it: The two theories make different predictions for deverbal verbs, that is, verbs with verb roots. The formal grammatical theory predicts that, given an irregular verb root, any two senses of that verb will both have the same irregular past tense form. The semantic centrality theory predicts that the extended senses are likely to have a regular past tense form, with likelihood increasing with degree of extension of meaning. For the semantic centrality theory, any difference between denominal and deverbal verbs per se is purely incidental.

The experiments reported herein have three purposes. First, we establish that the regularization-through-derivation effect is psychologically real. Although we think it is highly unlikely, a critic could maintain that existing regularized forms were created by historical processes no longer operating, or by the reasoning of editors, formal writers, and prescriptive grammarians, resulting in regular–irregular pairs that casual speakers simply reproduce by rote. Such a criticism might even be supported by the occasional counter-examples one hears, such as *He flew out* or *The Clippers fast-broke out of*

Buffalo. But the suggestion can be refuted by showing that untutored subjects display the phenomenon in word forms they have never encountered before. Second, although existing pairs of homophonous words differing in past tense forms in English provide little support for the semantic centrality theory, they do not decisively refute it either. Consequently, we require a set of forms that independently vary according to the centrality of their meanings and their route of derivation. Third, we present evidence that certain apparent counterexamples to the grammatical category theory are, in fact, consistent with the theory, and caused by speakers' entertaining variant analyses of the items in question.

EXPERIMENT 1

The word-level phonology hypothesis (embodied in the Rumelhart-McClelland model) predicts that all verbs that are homophonous with irregular past tense verbs will have an irregular past tense form: If only phonological information is input to the past tense formation process, there is, *in principle,* no way to distinguish among phonologically identical verbs. The formal grammatical hypothesis predicts that only verbs with verbal roots in head position can have an irregular past tense form. All denominal verbs will have a regular past tense form, even if they are ultimately related to some verbal root, whereas all deverbal verbs with irregular past tense roots will have an irregular past tense form. The semantic centrality theory predicts that central senses of irregular verbs will always have irregular past tense forms, but when they are used in an extended or metaphorical sense, they are likely to have a regular past tense form. The first experiment tested these predictions.

Method

Subjects. Thirty-two native English-speaking MIT undergraduates were paid for their participation in the experiment.

Materials. Thirty-seven verbs with irregular past tense or past participle forms were selected. (The principles discussed apply to participles as well as to preterites.) Each had a homophonous noun from which a denominal verb could be formed. Each verb also could be extended to form a deverbal verb, that is, an item with an extended, noncentral meaning, but with the original verb as its head, suitable for testing the semantic centrality theory. Deverbal verbs were either metaphorical extensions of the original verb, or part of a novel compound. Thus, for each verb, a pair of items was constructed, one denominal, one deverbal. Each item had a context sentence that made the derivation of the verb clear: In the denominal contexts, the word was used

as a noun (or as an adjective); in the deverbal contexts, it was used as a verb. Each context sentence was followed by two test sentences: One used the verb in a regular past tense, the other used the verb in an irregular past tense; they were otherwise identical. The verbs in the test sentences were underlined.

Eight of the 37 items used an existing denominal verb form and a metaphorical deverbal verb form (see 6a); these served mainly to demonstrate that the subjects respect the existing English distinctions previously discussed, counterexamples notwithstanding. The rest of the items used novel denominal forms. Eight of the remaining 29 items used a novel denominal verb form and a metaphorical deverbal verb form (see 6b). The final 21 items used novel denominal and deverbal compound forms (see 6c). Items of the forms (6a), (6b), and (6c) will be referred to as Subexperiments A, B, and C, respectively. (See Appendix A for a list of the materials.)

(6) a. **Existing Denominal:**
Wade Boggs has a bad habit of hitting fly balls into center field.
In yesterday's game, he got one hit, and then flied out twice to center field.
In yesterday's game, he got one hit, and then flew out twice to center field.
Metaphorical Deverbal:
The math professor flies off the handle at the slightest things.
Last week, he flied off the handle when one student talked during class.
Last week, he flew off the handle when one student talked during class.

b. **Novel Denominal:**
When guests come, I hide the dirty dishes by putting them in boxes or in the empty sink.
Bob and Margaret were early, so I quickly boxed the plates and sinked the glasses.
Bob and Margaret were early, so I quickly boxed the plates and sank the glasses.
Metaphorical Deverbal:
When guests come, if they arrive with slides my hopes for a lively evening quickly sink.
When I saw Bob and Margaret carrying six boxes, my hopes sinked instantly.
When I saw Bob and Margaret carrying six boxes, my hopes sank instantly.

c. **Novel Denominal Compound:**
I've had so many light beers, I'm sick of them; I don't think I could possibly drink another one.
As far as beers are concerned, I'm totally lighted-out.
As far as beers are concerned, I'm totally lit-out.

Novel Deverbal Compound:
The stewardess had been trying to light up her face with a smile so much that day, she couldn't do it one more time.
As far as her smile was concerned, she was totally lighted-out.
As far as her smile was concerned, she was totally lit-out.

Design. There were two counterbalancing factors, defining four versions of the questionnaire. In each version a given verb appeared either in a denominal or a deverbal context, such that half the 37 items (± 1) were denominal and half the items were deverbal. There were two complementary sets of items, such that if a given verb morpheme appeared in its denominal form in one set, it appeared in its deverbal form in the other set. The division into sets was done so that within a set, half the verbs from each of Subexperiments A, B, and C were denominal items and half were deverbal items. Each of the two sets in turn was presented in two versions: In one, the regular past tense form of a verb and its rating scale were presented above the irregular past tense form for half of the denominal items from each of Subexperiments A, B, and C, and the irregular form was presented first for the other half; the same was true of the deverbal items. The other version had the complementary orders. Subjects were randomly given one of these four versions of the experiment such that an equal number of each of the versions of the questionnaire were distributed.

Twenty-two filler items with regular past tense verbs in a deverbal context were intermixed with the experimental items. These items were in the same format as the experimental items. For these filler items, subjects were presented either with the regular past tense form and a no-change form (e.g., *asked/ask*) or the regular form and a novel irregular past tense form phonologically similar to an existing irregular past tense form (e.g., *believed/beleft*). These were included to draw attention away from the independent variables (which, in fact, were invisible to all the subjects when queried), and to provide subjects with clear examples of good and bad regular and irregular forms, so that they would not feel compelled to exaggerate perceived small differences among the experimental items simply to distribute their ratings across the entire scale within the questionnaire.

Procedure. Each subject was asked to rate how natural sounding the regular and irregular past tense forms of a verb were in a given context on a scale from 1 to 7, where 1 meant *very unnatural sounding,* and 7 meant *very natural sounding.* The meaning of the rating scale was explained with examples, none of which provided information about the derivation effect. First, an example was given in which the irregular past tense form was clearly natural sounding and the regular past tense form was clearly unnatural sounding: *He came/*comed home to Boston.* Subjects were then instructed that of the regular/irregular past tense sentence pairs for a given item, "just

because one sentence sounds good, it doesn't necessarily mean that the other sounds bad or vice versa." This was illustrated by pointing out that many people find both *dreamed* and *dreamt* acceptable, and thus would give high ratings both to *She dreamed that she was falling out of a plane* and *She dreamt that she was falling out of a plane.* To encourage subjects to attend to the contexts of the sentences, they were told "to rate how the entire sentence sounds, not just the verb itself. In fact, a particular verb can sound good in one context and bad in another. . . . So remember to read the sentences carefully so you understand their meanings perfectly well before making your judgment." To emphasize this point, the following example was given in which the context of a verb determines whether or not it takes a regular or irregular past tense form: *hanged/?hung the criminal, hung/*hanged the painting.* Note that this example does not exemplify the noun/verb contrast being studied. Subjects were also explicitly instructed that their judgments were to be based on their "own intuitions of colloquial speech, and not necessarily what is 'proper' or 'standard' or 'formal'." The following example was given in which the irregular past tense form is somewhat stilted, yet prescriptively deemed the *correct* form: "You might think that *slew* sounds weird or stilted [as the past tense form of *slay*] and *slayed* sounds a bit better, but that the 'proper' form is *slew* and thus you might be tempted to give *slew* a high rating. We ask you not to reason this way; just rate how natural the sentence sounds *to you.*" Finally, subjects were instructed not to give high ratings to forms "that would be used only 'jokingly' or in a kind of a word game. For example, the Legal Seafood restaurant is famous for serving a kind of fish called scrod. As a joke, they used to give away t-shirts that said 'I got scrod at Legal Seafood.' This is an example of word play; no one would really use the word *scrod* in their ordinary speech as the past tense of *screw* (unless they were making a joke). If you share this judgment, then you would give a low rating to that sentence."

Results

Irregular past tense forms were rated better than regular past tense forms for deverbal verbs, and regular past tense forms were rated better than irregular past tense forms for denominal verbs. The mean ratings are given in Table 1 (p. 188) and shown in Figure 1 (p. 188). A four-way analysis of variance (ANOVA) was performed on past tense ratings, with subjects as the random variable; the independent variables were item version, order version, verb root (denominal/deverbal), and past tense form (regular/ irregular). As predicted by the grammatical category hypothesis, the interaction between the verb root and past tense form variables was highly significant, $F_{\text{subjects}}(1, 30) = 517.60, p < .001$. A three-way ANOVA (Order Version × Verb Root × Past Tense Form) was performed on past tense ratings, with items as the random variable. The interaction between the verb root and past tense form variables was again highly significant, $F_{\text{items}}(1, 36) = 155.80, p < .001$.

TABLE 1
Mean Ratings of Past Tense Forms by Verb Root from Experiment 1

Verb Root	Past Tense Form	
	Regular	Irregular
All Items		
Denominal	4.32	2.37
Deverbal	2.03	5.23
No Capitalizaton/Spelling Differences		
Denominal	4.23	2.59
Deverbal	2.14	5.23
Existing Denominals		
Denominal	5.23	2.42
Deverbal	1.84	6.67
Novel Denominals		
Denominal	3.81	2.02
Deverbal	1.77	6.11
Novel Compounds		
Denominal	4.19	2.46
Deverbal	2.21	4.32

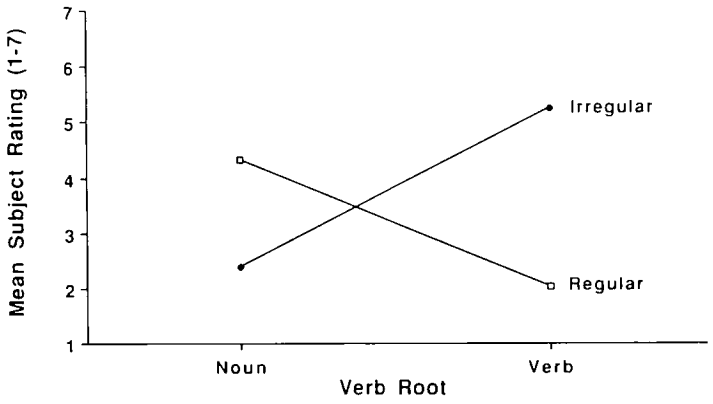


Figure 1. Mean ratings for regular and irregular items as a function of whether the verb was derived from a verb or a noun; data from Experiment 1 (MIT undergraduate subjects).

Some of the items had differences in spelling or capitalization between the denominal and deverbal versions of a given verb. To show that the effect is not confined to morphemes that are marked as different lexical items by these orthographic devices, subject- and item-based analyses were performed with only the items for which there were no spelling or capitalization differences between denominal and deverbal forms. The mean ratings for these items are given in Table 1; the crucial interaction between verb root and past tense form was significant with both random variables: $F_{\text{subjects}}(1, 30) = 407.42$, $p < .001$; $F_{\text{items}}(1, 23) = 99.04$, $p < .001$.

The interaction between the verb root and past tense form variables was significant in separate four-way subject-based ANOVAs and in separate three-way item-based ANOVAs on past tense ratings for Subexperiment A, F_{subjects} (1, 30) = 750.54, $p < .001$; F_{items} (1, 7) = 57.63, $p < .001$; Subexperiment B, F_{subjects} (1, 30) = 323.07, $p < .001$; F_{items} (1, 7) = 99.82, $p < .001$, and Subexperiment C, F_{subjects} (1, 30) = 200.46, $p < .001$; F_{items} (1, 20) = 109.92, $p < .001$.

It is conceivable that although not all the irregular subclasses function as rules, some do. Mean ratings and results of separate two-way subject- and item-based ANOVAs (Verb Root × Past Tense Form) on past tense ratings for each of the phonological subclasses of the irregular past tense verbs (as defined in the Appendix of Pinker & Prince, 1988) are given in Table 2 (p. 190). In all the subject-based analyses, the interactions between verb root and past tense form variables were significant, and the interactions in the item-based analyses were significant in most cases.

In fact, for *each of the 37 verbs,* the signed difference between regular and irregular past tense ratings for the denominal item is greater than that for the corresonding deverbal item. Furthermore, the irregular past tense form was rated better than the regular past tense form for each deverbal verb, and the regular past tense form was rated better than the irregular past tense form for 33 of the 37 denominal verbs. The four denominal verbs that had higher irregular past tense ratings than regular past tense ratings were: *broadcast, three-hit, out-blow, out-fling* (see Appendix A for item means).

The pattern of results for all analyses were similar to that shown in Figure 1, with the exception of the seven no-change irregular verbs: *hit, set, hurt, cast, shed, beat,* and *split.* The mean regular rating (3.85) and the mean irregular rating (3.69) for the denominal items of no-change verbs are virtually identical, though the difference was in the direction predicted by the formal grammatical theory, and subjects' near indifference still contrasted sharply with their strong preference for irregular forms for the corresponding verbs with verb roots. The interaction between the verb root and past tense form variables in a two-way ANOVA on past tense ratings is highly significant, F_{subjects} (1, 31) = 57.81, $p < .001$, F_{items} (1, 6) = 23.32, $p < .01$. Although all no-change verbs in English end in a *t* or *d,* the indifference between regular and irregular past tense forms for denominals is not due to this phonological factor, but to something about the no-change verbs in particular. Verbs ending in a *t* or *d* that were not no-changers in English did not elicit the same indifference, but behaved similarly to all the other verbs. This is shown by the relevant interactions in two ANOVAs with subjects as the random variable: When a factor is added contrasting no-change verbs with all the verbs that do not end in a *t* or a *d,* it takes part in a 2-way interaction with past tense form variable, F_{subjects} (1, 31) = 24.61, $p < .001$, and in a 3-way interaction with past tense form and verb root variables, F_{subjects}

TABLE 2
Mean Rating of Past Tense Forms by Verb Root and Results of ANOVAs (Verb Root × Past Tense Form) from Experiment 1 by Phonological Subclass

Phonological Subclass/*F* and *p* Values	Verb Root	Past Tense Form: Regular	Past Tense Form: Irregular
T/D+0	Denominal	3.85	3.69
(hit, set, hurt, cast, shed, split, beat)	Deverbal	2.28	5.07
F_{subj} (1, 31)=57.81***			
F_{item} (1, 6)=23.32**			
T/D with laxing class	Denominal	3.98	1.48
(read, light, meet)	Deverbal	2.11	4.75
F_{subj} (1, 31)=98.14***			
F_{item} (1, 2)=7.89, n.s.			
Overt *T* ending	Denominal	3.65	2.11
(buy, leave, mean, sleep)	Deverbal	1.47	5.16
F_{subj} (1, 31)=113.03***			
F_{item} (1, 3)=32.06*			
Overt *D* ending	Denominal	5.28	1.53
(flee, tell)	Deverbal	1.72	2.91
F_{subj} (1, 30)=79.13***			
F_{item} (1, 1)=127.37, n.s			
E—ɔ ablaut class	Denominal	5.27	1.80
(steal, break, wake)	Deverbal	1.80	6.42
F_{subj} (1, 31)=282.27***			
F_{item} (1, 2)=82.93*			
I—ae/ ' — ' group	Denominal	3.97	2.57
(strike, ring, drink, sink, shrink, stick, fling)	Deverbal	2.20	5.59
F_{subj} (1, 31)=248.00***			
F_{item} (1, 6)=21.85**			
x—u—x/o+n	Denominal	4.52	2.33
(know, fly, blow)	Deverbal	2.59	5.33
F_{subj} (1, 31)=31.58***			
F_{item} (1, 2)=145.55**			
e—U—e+n	Denominal	4.28	2.53
(shake, take)	Deverbal	2.78	4.00
F_{subj} (1, 30)=22.04***			
F_{item} (1, 2)=184.18*			
ay−o−I+n	Denominal	5.69	2.16
(drive, write)	Deverbal	1.53	5.47
F_{subj} (1, 30)=228.18***			
F_{item} (1, 1)=31.88, n.s.			

* $p<.05$. ** $p<.01$. *** $p<.001$.

(1, 31) = 70.90, $p<.001$. However, when verbs ending in *t* or *d* that are not no-changers are contrasted with verbs that lack a *t* or a *d* ending, neither of these interactions is significant.

Discussion

The results of this experiment provide evidence against both the word-level phonology and the semantic centrality theories. The word-level phonology theory predicts that all the verbs used in the experiment, being homophonous with irregular past tense verbs, should have had higher ratings for irregular past tense forms than for regular past tense forms. The semantic centrality theory predicts that all the verbs used in noncentral senses should have had higher ratings for regular past tense forms than for irregular past tense forms.

On the other hand, the results strongly confirm the predictions of the formal grammatical theory: Regular past tense forms are preferred to irregular past tense forms for denominal verbs, and irregular past tense forms are preferred to regular past tense forms for deverbal verbs. This was true for the data overall, with enormous levels of statistical significance both with subjects and items as random variables, for items not involving spelling or capitalization differences, for existing denominals with metaphorical deverbal counterparts, for novel denominals with metaphorical counterparts, for novel compound denominals with novel compound deverbal counterparts, and for each phonological subclass of irregular past tense verbs. In fact, the pattern of results predicted by the formal grammatical theory held for *each verb.*

EXPERIMENT 2

Many nonlinguists attribute conformity with grammatical principles to explicit training in composition and grammar in school. The regularization-through-derivation effect offers a very clear test of this assumption. Simple though the principle is, it appears that no one who has not studied modern generative grammar has been able to grasp it, let alone teach it, and this includes professional editors, prescriptive grammarians and other mavens, pundits, and language experts. For example, the following appeared in the ombudsman's column of the *Boston Globe* (Kierstead, 1989):

> A woman wrote: "I join other readers in lamenting the lack of attention given to good writing, spelling, and grammar these days." One article she sent left out a key comma and contained the phrase "he may of been." Another article read, "Martyny subletted a Kenmore square apartment." It's sublet. (p. 15)

Because, for many people, the verb *to sublet* is more transparently derived from the common noun *a sublet* than the rare verb *to let* ("lease"), the offending headline is not surprising, and the ombudsman's implied apology is linguistically misguided.

H.L. Mencken (1936), writing in *The American Language,* noted that

> the effort of purists to establish *broadcast* as the preterite has had some success on higher levels, but very little on lower. "Ed Wynn *broadcasted* last night" is what one commonly hears. (p. 439, note 2)

A modern example of what Mencken referred to can be seen in the style manual *The Careful Writer* by the late language columnist and *New York Times* editor Theodore Bernstein (1977):

> If you think you have correctly forecasted the immediate future of English and have casted your lot with the permissivists, you may be receptive to *broadcasted,* at least in radio usage, as are some dictionaries. The rest of us, however, will decide that no matter how desirable it may be to convert all irregular verbs into regular ones, this cannot be done by ukase, nor can it be accomplished overnight. We shall continue to use *broadcast* as the past tense and the participle, feeling that there is no reason for *broadcasted* other than one of analogy or consistency or logic, which the permissivists themselves so often scorn. Nor is this position inconsistent with our position on *flied,* the baseball term, which has a real reason for being. The fact—the inescapable fact—is that there are some irregular verbs. (p. 81)

Bernstein's "real reason" for *flied* is the semantic centrality theory; he noted that it is restricted to a "specialized" field. Of course, Bernstein was bewildered by the popularity of *broadcasted* because the *real* real reason for *flied,* its derivation from a noun, can also lead to *broadcasted,* if that verb, too, is perceived as being derivable from a noun, in this case, as being "to make a broadcast."

Interestingly, Fowler (1965) correctly focused on derivation, but incorrectly supposed that the relevant derivation was historical etymology, rather than psychological decomposition:

> If etymology is to be our guide, the question whether we are to say *forecast* or *forecasted* in the past tense and participle depends on whether we regard the verb or the noun as the original from which the other is formed. If the verb is original (= to guess beforehand) the past and p.p. will be *cast,* as it is in that verb uncompounded; if the verb is derived (= to make a forecast) they will be *forecasted,* the ordinary inflexion of a verb. The verb is in fact recorded 150 years earlier than the noun, and we may therefore thankfully rid ourselves of the ugly *forecasted;* it may be hoped that we should do so even if history were against us, but this time it is kind. The same is true of *broadcast;* and *broadcasted,* though dubiously recognized in the *OED* Supp., may be allowed to die. (p. 206)

Surprisingly, *broadcast* itself was one of the few verbs in Experiment 1 for which the subjects were somewhat more consistent with the pleas of the prescriptivists than with the effects of a denominal derivation, though the derivation effect is still visible, as the regular form was rated 1 point better on the 7-point scale, and the irregular form 1 point worse, than in the metaphorical verb-root version. This interaction clearly derives from the same forces that were noted in the *Oxford English Dictionary* (OED; Murray, Bradley, Craigie, & Onions, 1989) citation and the remark by Mencken, and that Fowler and Bernstein saw fit to condemn. The reasons why this particular item is one of the poorer instances of the effect in our data will be

TABLE 3
Mean Ratings of Past Tense Forms by Verb Root from Experiment 2

Verb Root	Past Tense Form	
	Regular	Irregular
All Items		
Denominal	4.94	3.36
Deverbal	1.96	6.45
No Capitalizaton/Spelling Differences		
Denominal	4.84	3.68
Deverbal	2.17	6.53
Existing Denominals		
Denominal	5.84	2.53
Deverbal	2.06	6.97
Novel Denominals		
Denominal	4.41	3.59
Deverbal	1.53	6.69
Novel Compounds		
Denominal	4.80	3.56
Deverbal	2.09	6.16

demonstrated in Experiments 4 and 5. For now, it suffices to note that prescriptive language guides have spectacularly misunderstood the effect we are studying here, so they are unlikely to promulgate it via formal education.

In this experiment we use our materials to assess the extent to which noncollege-educated subjects might unconsciously be sensitive to a principle that is too subtle for the world's leading authorities on "correct" usage to discover.

Method

Subjects. Eight subjects responded to an advertisement in the *Boston Herald,* a tabloid. The ad solicited noncollege-educated, native English-speaking persons over the age of 21 for the purpose of filling out a psychology questionnaire. Subjects were paid for their participation.

Materials, Design, and Procedure. The questionnaires and instructions were the same as those used in Experiment 1.

Results

Irregular past tense forms were rated better than regular past tense forms for deverbal verbs, and regular past tense forms were rated better than irregular past tense forms for denominal verbs. The mean ratings are given in Table 3 and shown in Figure 2 (p. 194). A four-way ANOVA (Item Version × Order Version × Verb Root × Past Tense Form) was performed on past tense ratings with subjects as the random variable. The interaction between the verb root and past tense form variables was highly significant, $F_{subjects}(1, 6) = 228.44$, $p < .001$. A three-way ANOVA (Order Version × Verb Root × Past Tense

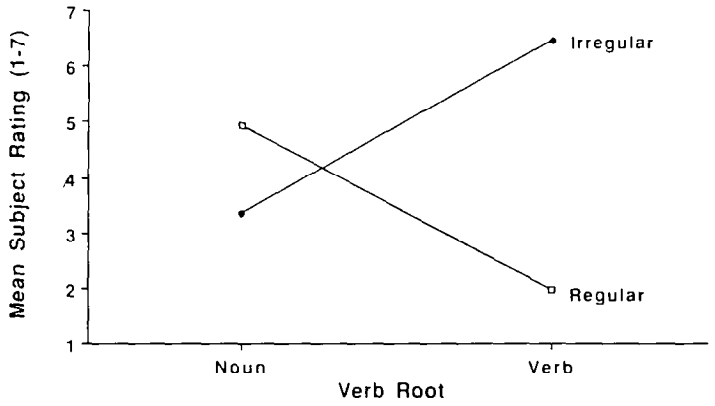


Figure 2. Mean ratings for regular and irregular items as a function of whether the verb was derived from a verb or a noun; data from Experiment 2 (noncollege-educated subjects).

Form) was performed on past tense ratings with items as the random variable. The interaction between the verb root and past tense form variables was highly significant, $F_{\text{items}}(1, 36) = 180.90$, $p < .001$. Both analyses were also significant when items involving a capitalization or spelling change were omitted: $F_{\text{subjects}}(1, 6) = 134.65$, $p < .001$, $F_{\text{items}}(1, 23) = 163.98$, $p < .001$.

The interaction between the verb root and past tense form variables was significant in separate four-way subject-based ANOVAs and in separate three-way item-based ANOVAs on past tense ratings for Subexperiment A, $F_{\text{subjects}}(1,6) = 133.10$, $p < .001$, $F_{\text{items}}(1, 7) = 55.69$, $p < .001$, Subexperiment B, $F_{\text{subjects}}(1, 6) = 83.74$, $p < .001$, $F_{\text{items}}(1, 7) = 72.08$, $p < .001$, and Subexperiment C, $F_{\text{subjects}}(1, 6) = 119.03$, $p < .001$, $F_{\text{items}}(1, 20) = 93.47$, $p < .001$.

Discussion

The results from this experiment replicate those from Experiment 1 and provide further support for the formal grammatical theory over both the word-level phonology and semantic centrality theories. This conflicts with the unfounded stereotype that uneducated people speak according to a simpler or more concrete grammar, and is to be expected given the fact, commonplace among linguists, that most prescriptive language instruction actually consists of minor features of a standard written dialect rather than the actual principles underlying speakers' knowledge of language.

EXPERIMENT 3

Although the results from Experiments 1 and 2 support the formal grammatical theory and provide evidence against the word-level phonological theory, there is an obvious escape hatch for the semantic centrality theory as long as there is no independent measure or criterion for determining what

counts as "central" or "extended" in meaning. We have assumed that metaphoricity, compounding, and denominalization all entail nearly equal degrees of extendedness. But one could argue that denominal verbs are, on the whole, *more extended* in meaning than metaphorical deverbal verbs. In the extreme case, if the denominal items from Experiments 1 and 2 were very extended and the deverbal items were, in fact, relatively central, then both the formal grammatical theory and the semantic centrality theory would be consistent with the results. Obviously, an independent measure of centrality of meaning is needed to evaluate this possible counterexplanation.

In this experiment, we solicit subjects' ratings of the centrality of the sentences used in Experiments 1 and 2. Using this measure, we then test whether the data from Experiment 1 are explained equally well by the semantic centrality theory and by the formal grammatical theory. This can be done using a regression analysis: Given a predictor consisting of our independent measure of centrality of meaning, and a partially confounded binary predictor that codes whether a verb was derived from a verb or from a noun, the regression will tell us whether the centrality factor predicts a significant proportion of the variance of regularization strength among items when the confounded effects of grammatical category are mathematically held constant, and whether grammatical category has a significant effect when the confounded linear effects of centrality are held constant. For the semantic centrality theory to be correct, the significant effect in Experiment 1 must be predicted by semantic centrality, not by formal grammatical category, when their effects are disentangled across the full set of denominal and deverbal items.

A second prediction of the semantic alternative is that centrality should predict the goodness of irregular past tense forms of both denominal and deverbal verbs from Experiment 1, because any difference between denominal and deverbal verbs should be purely incidental. For reasons we discuss in full later, the grammatical category theory is consistent with some small effect of centrality, but only if it is confined to denominals. (This is because the derivation might be short-circuited in some speakers for very central denominal senses, leading them to derive the verb directly from a related verb, for example, when *to sublet* is perceived as coming directly from *to let*, rather than via *a sublet*). However, no effect at all should obtain within the deverbal items.

Method

Subjects. Twenty-four native English-speaking MIT undergraduates were paid for their participation in the experiment.

Materials. The denominal sentence pairs and the deverbal sentence pairs from Experiment 1 were modified such that past tense forms of verbs were changed to nonpast forms where possible. This could not be done for cer-

tain sentences with adjectival passive participles such as the colloquial, *I'm completely shaked-out/shaken-out.* For these items, both regular and irregular participle forms were provided, so that subjects could choose and rate the form they preferred. For each verb, a third pair of sentences was constructed in which the verb was used in its concrete central sense; it was with respect to these sentences that we could assess the degree of semantic extendedness. An example of each of these items is given in (7):

(7) a. **Deverbal verb used in a central sense.**
Some metal things manage to stay afloat in Lake Erie, like tin cans.
It's a sure bet that rocks will sink when thrown into the lake.

b. **Deverbal verb used in a metaphorical sense.**
When guests come, if they arrive with slides, my hopes for a lively evening quickly sink.
When I see Bob and Margaret carrying boxes, my hopes sink instantly.

c. **Denominal verb.**
When guests come, I hide the dirty dishes by putting them in boxes or in the empty sink.
If Bob and Margaret come early, I'll quickly box the plates and sink the glasses.

Design. There were three versions of the experiment, each given to a random third of the subjects. Each version included either the denominal, the metaphorical deverbal, or the central verbal item for any given verb such that each version had the same number (± 1) of denominal, metaphorical deverbal, and central sense items.

Procedure. Subjects were told that they would see a verb in its stem form, followed by a pair of sentences. The pair of sentences would use that verb and make its intended meaning clear. They were then asked to rate how "central" or "extended" the meaning of the verb (underlined in the second sentence) is, based on "a gut feeling as to whether it is 'central' or 'extended'." The subjects were told that the rating scale ranged from 1 to 7, where 1 means *is a central, basic meaning,* and 7 means *is an extended, distant meaning.* What was meant by central and extended was made clear by an example using the word *to boot:*

> There is a relatively central sense: *The boy ran up to the dog and booted him* means that the boy kicked the dog. Then there is a slightly extended sense: *The bouncer booted the drunk out of the bar.* Here, the bouncer may not have literally kicked the drunk; he merely removed him by force. A more extended sense can be see in: *The boss was fed up with his assistant's incompetence and booted him out of the company.* Here, no one even physically moved. A different kind of extension can be seen in: *The officer booted the illegally-parked car.* It means that the officer put a clamp called "the Denver boot" on the wheel of the car. Finally, there is the expression: *I booted up my computer.*

> Here, the extension is so distant that most people don't even know why the word is *boot* at all.

Subjects were also instructed to concentrate only on the meaning of the verb that is conveyed in the sentences, and not on spelling or capitalization:

> Sometimes a word will sound like another word, but will not be related to it at all. For example, the word *walk* and the word *wok* (Chinese frying pan) are pronounced similarly, but neither is an extension of the other. We are not only talking about spelling. For example, *a tire* (what's on a wheel) and *to tire* (to become fatigued) are unrelated even though they're spelled the same, whereas *Tastee-Freez* (a kind of ice cream) is related to *tasty* and *freeze* even though they're spelled differently. If a word seems totally unrelated to the target word, don't rate it at all; check off the box that says "unrelated." But if you sense any relation at all, even if it is a very weak one, please give us your rating.

For the items in which both regular and irregular past tense forms were presented, subjects were instructed to circle the form they preferred and to rate the centrality of that form. Items judged to be unrelated to the given verb stem were translated to a rating of 8.

Results and Discussion

A multiple regression was performed on the rating data for the 74 items (37 verbs, each in the denominal and deverbal versions) from Experiment 1. Specifically, the data to be accounted for consisted of the signed difference between the mean ratings of an item in its regular form and in its irregular form; deverbal and denominal versions constituted separate items. Thus, we are seeing which variables predict the strength of the tendency to regularize. One predictor consisted of the mean centrality rating for each item. The other corresponded to the grammatical derivation of the item, and had a 1 for each row corresponding to a denominal item, and a 0 for each row corresponding to a deverbal item. The two predictors correlated .77, reflecting the fact that denominals were generally less central than deverbals. The regression analysis showed that the derivation of a verb uniquely accounts for a significant amount (22.8%) of the variance of regular minus irregular past tense ratings from Experiment 1, $F(1, 71) = 53.80, p < .0001$. Centrality uniquely accounted for a very small (0.6%) and nonsignificant proportion, $F(1, 71) = 1.28, p = .26$. An additional 46.6% of the variance was accounted for by the confounded effects of grammatical category and centrality.

Though the unconfounded predictive power of centrality was tiny, we wanted to see where it came from. Two simple regressions were performed on the signed difference between the mean ratings of the regular and irregular forms for each verb from Experiment 1. One regression included only denominal items; the other included only deverbal items. In each case centrality was the sole predictor. There was a small but measurable correlation between centrality and regular minus irregular ratings for denominal items,

$r(35) = .25$, $p = .14$, but no correlation between centrality and regular minus irregular ratings for deverbal items, $r(35) = -.01$, $p = .96$.

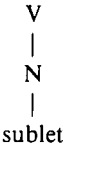
In sum, the semantic centrality theory is not supported by the results of the multiple regression: Grammatical category uniquely predicts a significant proportion of the variance in the degree to which a verb can have a regular past tense form (23%), and semantic centrality by itself predicts virtually none (1%). This shows that the results from Experiment 1 were, in fact, due to the grammatical category of a verb's root, and not to a confounded semantic factor. Furthermore, the semantic centrality theory is inconsistent with the fact that the 1% of the regularizability variance predicted by semantic centrality is confined to the denominal items. This result implicates some difference between the denominal items and the deverbal items independent of semantic centrality. In Experiments 4 and 5, we show that this asymmetry between denominal and deverbal items derives from factors that influence the path of the derivation of a verb.

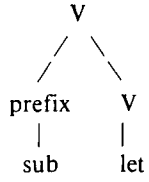
EXPERIMENT 4

The results from the previous experiments support the formal grammatical theory and disconfirm the word-level phonology and semantic centrality theories by the standards of psychology experiments, where unconfounded and statistically significant effects are deemed sufficient to establish the psychological reality of some factor. The grammatical category theory exceeds this criterion because *every* item in Experiment 1, not just a significant fraction, showed the predicted interaction. However, we will show that the theory can be pushed even farther: It can explain even apparent partial counterexamples like the four items that showed only an interaction, but not both simple main effects (i.e., whereas the signed difference between ratings for irregular and regular past tense forms was smaller for denominals than for deverbals, the difference for these items was not large enough to flip the preference and make the regular form *better* than the irregular form for denominal verbs).

Recall from the quote from the *Boston Globe* ombudsman that both the regular (*subletted*) and irregular (*sublet*) past tense forms of the verb *to sublet* are acceptable to many speakers. The formal grammatical theory is consistent with this indifference *if* the two past tense forms are derived from different roots: a noun root for the regular past tense form, and an irregular verb root for the irregular past tense form. That is, if the verb *to sublet* is derived from the noun root *sublet,* it should have the exocentric, irregularity-blocking structure (8a), and its past tense form should be *subletted.* But if the verb *to sublet* is derived from the verb root *let,* it should have the properly headed, irregularity-passing form (8b), and thus, should maintain the irregular past tense form of its verb root. According to this proposal, people do not represent the category of the root as some fuzzy value inter-

mediate between nounhood and verbhood, but are uncertain as to which of these two exact analyses is appropriate.

(8) a. 

b. 

As mentioned, one of the four denominal items with a higher rating for the irregular past tense form was the verb *to broadcast* (as in the sentence, *Last week, I think he broadcast/broadcasted the news every night*). This is predicted if the verb *to broadcast* has two possible derivations, one from an irregular verb root, and one from a noun root. This is not implausible, because, although the verb is easily thought of as derived from the noun (*news*) *broadcast,* it is also conceivably decomposed as a compound headed by the irregular verb *to cast.* In fact, according to the *OED,* the verb *to broadcast* (*the news*) was originally taken from the verb *to broadcast* (*seeds*), meaning "to scatter seeds abroad with the hand," and even for nongardeners there may be enough transparency of the composition to support the perception among some that *broadcast* is headed by the verb root *cast.* If this could be demonstrated, the reduced effect of derivation for this verb, resulting in an unexpectedly acceptable irregular past tense form, would not be problematic for the formal grammatical theory, because denominalization is no longer implicated.[4,5] (Of course, another possibility, suggested by the quotations from style manuals, is that the weakness of the effect is due to misguided prescriptivist efforts.)

[4] Related examples are certain marginal forms we have noted in speech and writing such as *fair-caught* (= to make a "fair catch" in football; called to our attention by Lila Gleitman, personal communication, October, 1989), *fast-broke* (= to make a "fast break" in basketball), *gunfought* (= to have a gunfight, provided by Paul Bloom, personal communication, January 2, 1990), and *test-drove* (= to take a test drive). Presumably, they are irregular because in each case the word could be reanalyzed as similar to an adverbial-verb compound with the verb as the head, as in the attested nondenominal *When I student-taught* (i.e., in an internship, while still a student teacher). Indeed, in each case the verb serving as the second member of the compound could have been used grammatically by itself within the sentence context (e.g., *I test-drove/drove the new car; He fair-caught/caught the football*).

[5] One unique case is *the workers struck,* meaning "went on strike." According to the *OED,* the verb came from the expression *to strike the machinery* (i.e., shut it down), the action that symbolically began the work stoppage. This sense of the verb survives today in *striking the sails* and *striking the set* (in drama productions). Thus, the original coining of the word in its labor context respected the grammatical category theory, as it was an irregular verb derived from an existing irregular verb. This irregular form survives by some combination of prescriptiveness, surviving parallel forms, and metaphoricity. Interestingly, many people report *struck* as a learned, not quite natural-sounding form. This ambivalence is no doubt caused by the fact that the motivation for the original derivation is no longer very transparent and the deverbal noun *a strike* has become more basic.

There are other cases in which one might find that denominalization could be bypassed or short-circuited by an alternative derivation from a verb root. One plausible cause might be semantic similarity between a verb root and the denominal verb ultimately derived from it. For instance, though the verb *to fly out* is usually construed as being derived from the compound noun *fly ball,* it is also clearly related in meaning to the verb root *fly* and is even applicable if the ball is personified as its agent. This is occasionally seen elsewhere in sports descriptions, as in *Kareem got blocked* or *Kevin is rejected;* the verbs literally refer to the ball, not the person.

Such explanations, of course, must be supported by some independent measure of likelihood of short circuiting. There is mild support from Experiment 3, where centrality judgments for denominal items did account for a small but measurable amount of variance in the regularization strength among denominal items from Experiment 1, while, crucially, accounting for none of the variance in the deverbal items. It is plausible that the centrality of the meaning of the denominal form with respect to that of the original verb is a surrogate for whatever factors lead a person to perceive a supposedly denominal verb as derived directly from the original verb. If so, some effect of centrality is to be expected, opposite in direction to the overall effect of grammatical category. However, centrality has no way of affecting deverbals. In this experiment we test for the possibility of a short-circuiting effect more directly.

Method

Subjects. Twelve native English-speaking MIT graduate students were volunteers in this experiment.

Materials. The context sentences of the denominal items were taken from Experiment 1. Because the meanings of many of the denominal verbs from Experiment 1 were opaque outside the context of the initial sentence, the nouns themselves were taken for use in the rating task.[6] Sentences were constructed with a central use of the corresponding verb. The deverbal sentences from Experiment 1 were not used because they had been constructed to exemplify a highly noncentral sense, and if there is an effect of meaning, it should relate the nominal reading to the central sense of the verb root. An example is in (9):

(9) When it starts to get cold up north, most birds fly south for the winter.
Wade Boggs has a bad habit of hitting fly balls into center field.

Procedure. Subjects were presented with pairs of sentences like (9) and were asked to rate the similarity of the underlined words within the context

[6] We assume that the denominal verbs were similar in meaning to the nominal form from which they were derived, and that, in this task, similarity is transitive.

of the respective sentences on a 7-point scale, where 1 means *very dissimilar in meaning* and 7 means *very similar in meaning*. They were instructed to ignore differences in spelling, capitalization, or syntactic category when making their judgments.

Results and Discussion

There was a significant negative correlation between similarity judgments in this experiment and the tendency to regularize denominal items in Experiment 1, measured as the mean rating of the regular form of the verb minus the mean rating of the irregular form, $r(35) = -.54$; $p < .001$. That is, the more similar in meaning the two forms were judged to be, the smaller the difference between regular and irregular past tense scores for denominal items in Experiment 1.

Furthermore, we predict particularly high similarity ratings for the four denominal items in Experiment 1 for which the derivation effect was not strong enough to raise the regular ratings above the irregular ratings. The mean similarity rating across all items was 2.30, and the similarity ratings of the four items in question were each above this mean (*three-hit:* 4.33; *out-fling:* 3.25; *broadcast:* 3.00; *out-blow:* 2.75). In a two-tailed, within-subjects t test with subjects as the random variable, the mean similarity rating for these four items was significantly higher than the mean similarity rating of the rest of the items, $t(22) = 3.26$, $p < .005$.

These results support the short-circuit hypothesis by showing that the similarity in meaning between a denominal verb and a verb with a deverbal root predicts to a significant degree when denominalization can be bypassed in the derivation of a verb. This provides further support for the formal grammatical theory by showing that even for the minority of items in which the derivation effect acts more weakly, there is an independently supported explanation for why the effect is diluted.

It is important to note that the short-circuit theory, unlike the semantic centrality theory, is embedded as a special case within a theory of formal grammatical categories. That is, the short-circuit theory predicts when the effect of denominalization, a purely formal notion, might occasionally be bypassed. It contrasts sharply with the semantic centrality theory, which makes no reference to formal operations over linguistic categories such as denominalization, and hence, cannot explain the huge unconfounded effect of grammatical category, or the strict confinement of the small semantic effect to the denominal verbs.

EXPERIMENT 5

In Experiments 1 and 2 we showed that the mapping between particular English stems and their irregular past forms is bypassed when the stem is perceived to have been derived through a nonverb category. In an unpub-

lished paper, Carlson, Keyser, and Roeper (1977), using invented verbs like *dring,* showed that the more general process of mapping a stem *sound pattern* to its corresponding irregular past form is blocked under the same conditions.[7] (The fact that high phonological similarity, as well as strict homophony, is overridden by derivation can be seen in existing English forms like *kinged/*kung the checkers piece, prided/*prode himself on his looks,* and *the engine pinged/*pung.*)

Their study also showed that the mere fact that a verb stem can exist as a noun is not the crucial factor; it is whether the verb in question is perceived as having been derived from the noun. This is exactly the claim behind the short-circuit hypothesis for why the derivation effect is sometimes diminished for certain words: A denominal verb is not perceived as being derived from the corresponding noun. It is also the obvious explanation for why, in English, irregular verbs can coexist with related nouns, as in *buy the car/this car is a good buy* or *read the book/this book is an easy read.* In such cases the verb is perceived as basic, and the noun as having been derived from it. Intuitions of which member of a noun/verb pair is basic presumably involve the semantics of the noun/verb distinction, such as the distinction between entities on the one hand and events or states on the other. For example, *an easy read* can plausibly be thought of as meaning *something that is easy for people to read,* but *to read the book* cannot easily be thought of as having been derived from the noun *read.* Conversely, in noun/verb pairs that involve an instrument (e.g., *high-sticked the goalie*), the noun is typically more basic.[8] Frequency of use as a noun versus a verb may also be correlated with which appears more basic. Note that the fact that semantics and frequency can correlate with regularization does not support the semantic centrality theory or compromise the grammatical category theory, because it is only those factors that independently go into distinguishing nouns from verbs in the language that play a causal role, and no factor specific to the past tense mapping itself.

Carlson et al. (1977) presented subjects with novel verbs whose phonological form suggested that they might have irregular past tense forms by

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[7] We thank Tom Roeper and Greg Carlson for informing us of the study and for providing us with a copy of the paper, data, materials, and instructions.

[8] Although there are cases where the derivation may be ambiguous, Kiparsky (1983) explained the counterexample *string/strung/*stringed* by providing evidence that the verb is not derived from the noun *string,* but instead is a manifestation of an abstract meaning that jointly underlies the noun and the verb. He pointed out that the clear cases of derivation from an instrument noun pertain to actions involving the narrow class of objects specified by the instrument noun (e.g., **She taped the picture to the wall with pushpins*). But not all noun-verb pairs manifest this specificity and hence transparent directionality; for example, *He brushed his coat with his hand. String* belongs to this latter class; its referent action does not require string at *all: He strung the tree with Christmas lights; String him up with a rope!; Tarzan strung his bow with a vine.*

analogy to clusters of existing irregular past tense verbs. These novel forms were presented in contexts that suggested different derivations of the verb. In particular, a novel word was presented in the first of a pair of sentences either as a basic verb (see 10a), a basic noun (see 10b), or a deverbal noun (see 10c). All but one of the deverbal noun contexts were "light verb" constructions as in (10c), which suggests that the novel noun had been derived from a verb, by analogy to such English constructions as *have a look/drink/try, take a walk/hike/break,* and so on. The other expressed a sound, analogous to *I heard three beeps.* In the second sentence of each pair, subjects were asked to fill a blank space with the appropriate form of the novel word in the initial sentence. The context required a past tense form of a verb.

(10) a. **Novel word used initially as a verb:**
It is astounding the way cats can *plive.*
Just the other day, I saw one that backed up and _____ right past me at full speed.

b. **Novel word used initially as a basic nominal:**
Last week, I borrowed my neighbor's *plive.*
I went and _____ several hard pieces of wood with it.

c. **Novel word used initially as a potentially deverbal noun:**
Last night, Max had himself a nice, long *plive.*
He _____ until well past midnight.

Assuming that subjects would store the novel words as exemplars of the grammatical category suggested in the context sentence, Carlson et al. predicted that subjects would write in more irregular pasts when the stem was initially presented as a basic verb than as a basic noun, for reasons similar to those laid out here. However, the possibility of nounhood itself would not be sufficient to trigger regularization if it was apparent to subjects that the noun itself had been derived from a verb, and that the verb to be inflected was in fact that original verb, not a new one derived from the noun.

Approximately 120 subjects were each presented with eight basic verb contexts, four basic noun contexts, and four deverbal noun contexts. Sixteen novel words with sound patterns similar to English irregular verbs were presented, counterbalanced in order and assignment to conditions. As Table 4 (p. 204) shows, a higher percentage of irregular forms were written in for verbs presented initially as verbs (19.3%) than verbs presented initially as basic nouns (10.2%). For verbs presented initially as nouns, which looked like derivations of the verb to be rated, irregular forms were written in at a rate slightly lower than that for verbs presented initially as verbs (16.0%), but still higher than that for verbs presented initially as basic nouns.[9] There

[9] All percentages are based on the assumption that there were in fact 120 subjects; Carlson et al. (1977) only reported the total number of irregular past tense responses for each verb, pooled across subjects.

TABLE 4
Percentage of Irregular Past Tense Responses in Carlson, Keyser, and Roeper (1977)

Verb	Presentation Context		
	Basic Verb	Deverbal Noun	Basic Noun
dring	46.7	60.0	33.3
kleed	28.3	26.7	20.0
lang	16.7	6.7	6.7
nake	5.0	0.0	6.7
plive	25.0	23.3	3.3
prall	3.3	0.0	0.0
preet	11.7	10.0	3.3
skive	21.7	20.0	6.7
skrib	10.0	3.3	0.0
snike	5.0	20.0	10.0
speeve	6.7	23.3	13.3
spiff	6.7	6.7	3.3
sping	58.3	33.3	23.3
spoog	8.3	3.3	6.7
treave	16.7	10.0	10.0
wight	36.7	10.0	16.7
Overall	19.3	16.0	10.2

was variation in the size of this difference depending on the verb, presumably because some irregular patterns are more easily generalized than others (e.g., compare *sping/spang* to *?treave/treft*), but, over all items, the frequency of irregular past forms for basic noun contexts was less than that for basic verb contexts and less than that for deverbal noun contexts. This is exactly as predicted.

Unfortunately, Carlson et al. did not perform inferential statistics, and the raw data are no longer available. Because their findings complement ours in showing the derivation effect with semiproductive sound patterns rather than existing English verbs, and in showing that the mere existence of a nominal form is not sufficient for the derivation effect (as required by the short-circuit hypothesis), it is useful to attempt to replicate it using methods similar to those employed in Experiment 1.

Method

Subjects. Forty native English-speaking MIT undergraduates were paid for their participation.

Materials. Thirty-two verbs similar in sound to existing English irregular verbs were used (see Appendix B). Sixteen were those used by Carlson et al.; because the irregular past tense forms of some of them were not easily predictable given the stem form, we had 10 MIT students give the possible

irregular past tense forms for those verbs and rank them from best to worst. We used the irregular form ranked highest most often. An additional 16 novel verbs were created; irregular past tense forms were selected on the basis of the English verbs they rhymed with.

Thirty-two sentence pairs were constructed. The initial sentence in 16 of these pairs used a novel word as a basic verb. The initial sentence in the other 16 of these pairs used a novel word as a noun. Of these 16, 8 used the novel word as a basic noun, and the other 8 used it in a form suggesting it was derived from a verb. This was encouraged by using the noun as the object of a light verb and by using durational adjectives, as in the sentences in (11).

(11) a. John had a nice, long drink.
b. John took a quick look.
c. John gave the dog a swift kick.

Each context sentence was followed by a pair of sentences using the novel word in the regular past tense, and in an irregular past tense; they were otherwise identical. In the three respective conditions, the sentence made it clear that the verb was either identical to the context verb, derived from the context noun, or identical to the verb from which the context noun had been derived. An example of each of these items is in (12):

(12) a. **Novel word used initially as a verb:**
Jeremy's mother warned him not to kleed.
When he disobeyed and kled anyway, he was told he couldn't watch cartoons.
When he disobeyed and kleeded anyway, he was told he couldn't watch cartoons.

b. **Novel word used initially as a basic noun:**
Mary got a brand new kleed for her birthday.
She liked it so much, she kled for a week.
She liked it so much, she kleeded for a week.

c. **Novel word used initially as a deverbal noun:**
It has been a long time since I have had a nice, long kleed.
I kled quite often in the old days.
I kleeded quite often in the old days.

Design. The sentences and novel verbs were paired in four random orders, with the constraint that a particular novel verb was paired with a basic noun context, a deverbal noun context, and two different basic verb contexts. For each order, a particular item had its regular past tense form presented before its irregular past tense form half the time. Subjects were randomly given one of the eight versions of the experiment such that an equal number of each of the versions of the questionnaire were distributed.

Procedure. Subjects were told that they would be rating the naturalness of sentences containing certain past tense forms of novel words on a 7-point scale, where 1 means *very unnatural sounding;* and 7 means *very natural sounding.* Subjects were instructed: (a) to read the first and second sentences carefully, and then to rate how good the past tense form of the novel verb in the second sentence sounded in the context of the two sentences, and (b) to read the first and third sentences carefully, and then to rate how good the past tense form of the novel verb in the third sentence sounded in the context of the two sentences. Subjects saw the examples from the instructions of Experiment 1 that emphasized that their ratings for the regular and irregular past tense forms of a given verb should be independent, and that they should attend to the context sentences.

Results and Discussion

As in the Carlson et al. study, different stems elicited widely varying degrees of acceptance of irregular forms (e.g., subjects gave moderately high ratings to *spling/splung* but not to *nake/nook*). This raises the danger of a floor effect: Low ratings for irregular past tense forms across the board may obscure any difference between stems presented initially as a noun and those presented initially as a verb. Thus, analyses were performed only on those stems whose mean rating for the irregular past tense form, averaging over the three conditions, was higher than 4, the exact midpoint of the 7-point rating scale. This criterion, based on all and only the irregular past tense ratings for each novel stem, is independent of the predictions of the formal grammatical theory.

Using this criterion, 10 of the 32 stems were eliminated: *clare/clore, lang/lung, nake/nook, plare/plore, prall/prell, skrib/skrobe, snike/snoke, spiff/spuff, sprink/sprunk,* and *spoog/spug.* The mean ratings of regular and irregular past tense forms of the remaining items for the three contexts types are given in Table 5.

In the first comparison we omit the deverbal noun items, because such contexts were not part of the design of Experiment 1. Separate two-way ANOVAs, one using subjects and the other using items as the random variable, were performed on past tense ratings, with verb root (basic noun/basic verb) and past tense form (regular/irregular) as independent variables. The interaction between verb root and past tense form variables was significant in both the subject-based analysis, $F(1, 39) = 8.24$, $p < .01$, and the item-based analysis, $F(1, 21) = 5.78$, $p < .05$.

The second comparison, relevant to the short-circuit effect, includes only items presented initially as nouns, and contrasts contexts presenting basic nouns with contexts presenting deverbal nouns. The interaction between the noun type (basic/deverbal) and past tense form variables was significant in the subject-based analysis, $F(1, 39) = 4.34$, $p < .05$, and marginally signifi-

TABLE 5
Mean Rating of Past Tense Forms from Experiment 5

Past Tense Form	Presentation Context: Basic Verb	Deverbal Noun	Basic Noun
Regular	4.38	4.24	4.34
Irregular	5.13	4.94	4.60
Irregular–Regular	.75	.69	.16

cant in the item-based analysis, $F(1, 21) = 4.17$, $p = .054$. As in the Carlson et al. study, when subjects were presented with nouns in contexts suggesting that they were derived from verbs, they treated the verbs to be rated much like they treated verbs that had only been presented in clear verb contexts.

Thus, both of Carlson et al.'s results are replicated: Subjects are less likely to extend an irregular mapping to a nonce verb perceived as having been derived from a basic noun than to a nonce verb perceived as having a verb root. And, it is not the presentation of the noun itself that is crucial, but whether or not it is perceived as the source of the verb whose past tense form is being considered. This difference is essential to the short-circuiting process that we suggest is responsible for the occasional dilution of the derivation effect.

GENERAL DISCUSSION

Experiments 1 and 2 showed that subjects, including noncollege-educated subjects, tacitly know that phonological and semantic information are not sufficient to determine the past tense form of a verb; rather, the grammatical category of the root of the item is the crucial factor. Experiment 3 showed that this is not due to a confound between derivation from a nonverb category and extendedness of meaning. These effects are pervasive in everyday speech, and in the experiments are highly robust and visible qualitatively in 89% of the items, and quantitatively in 100% of them. Moreover, even the dilution of the effect in some experimental items and the occasional apparent counterexamples in everyday speech can be explained within the grammatical theory, because its necessary and sufficient condition for the regularization effect—that a verb be *perceived,* perhaps unconsciously, as having a noun root, not merely that such a noun exists—may not always be met. The results from Experiments 3, 4, and 5 provide independent support for this explanation. Experiment 5 also provided a replication of Experiments 1 and 2 using novel verbs, thus showing that the effect holds both for extensions of existing words to new senses and for generalizations involving entirely new words.

These experiments clearly show that any theory that tries to account for native speakers' knowledge of the past tense of English verbs has to acknowledge that past tense formation depends on more than phonological and

semantic information, but also makes crucial reference to abstract morphological structure, reflecting the path of derivation of the item, and to formal linguistic categories. Though the experiments speak against theories such as that of Rumelhart and McClelland (1986), we are not suggesting that they refute connectionist models in general, although they do put limits on the extent to which connectionist models (or any models) will weaken or revise theories invoking grammatical rules and structures.

Among the theories that would have difficulty with these results are those that dispense with rules and rely on "analogy" to stored, regularly inflected forms to explain the production of novel regular forms (e.g., Bybee, 1988; Stemberger, 1989). Whereas one might get away with suggesting that people inflect *rick* as *ricked* by analogy with *pick/picked, nick/nicked,* and so on, the hypothesis runs into difficulty in accounting for the current results. First, we have shown that even the more plausible analogy-driven extension of *irregular* patterns (e.g., *dring/drang*) is overruled when the grammatical analysis of the item suggests a nonverb derivation. Second, the computation of regulars in such cases cannot easily be driven by close similarity to stored regulars, because the similarity to irregulars is far higher, and in many cases there are few or no relevant stored regulars to serve as an attractor. For example, there are very few nondenominal monosyllabic verbs whose pasts end in *-inged, -inked, -itted, -etted, -edded,* and *-eeted* (possibly none for *-inged* and *-itted*). Nonetheless, when the irregular was sealed off by denominalization, subjects gave high ratings to regular past tense forms for verbs similar to these sound patterns. It is hard to see how any analogy-driven model could handle the phenomenon unless properties of morphological structure were allowed to gate the analogy process.

These studies have important implications for language acquisition. Because formal grammatical representations, such as lexical category and abstract morphological structure, play a decisive role in determining whether a verb has a regular or irregular past tense form, children must come to represent such structures if they are ever to attain adult competence. In particular, in order to be able to acquire the fact that denominal verbs have regular past tense forms, children have to (a) know that irregularity is a property of roots, not of words; (b) decompose words into abstract morphological structures, so that the irregularity of roots can be passed up to the word through head positions; (c) represent the differences among grammatical categories; and (d) treat regular past tense inflection as having a default status so that it applies whenever it is not specifically blocked by irregularity.

It is not easy to show how children could learn these principles, and there is some evidence that they don't. Gordon (1986, 1989) showed that children distinguish between regular and irregular plurals in a qualitative way. As Kiparsky (1982a, 1982b) noted, most kinds of compounds can contain irregular plurals (e.g., *teethmarks*) but not regular plurals (e.g., **clawsmarks*) in

compound-initial position. The explanation, which is related to the regularization effect studied here, is that irregular plurals are properties of noun roots listed in the lexicon and can go into the rule that combines roots to form compounds, but regular pluralization is a default operation that applies after all other morphological processes are complete and so does not have access to the internal constituents of noun–noun compounds. Gordon found that when 3–5-year-olds were asked what to call a creature who eats "mice," they will often say "a mice-eater," but when asked what to call a creature who eats "rats," they virtually never say "a rats-eater," only "a rat-eater," in perfect accord with the adult principle. Gordon points out that these results are especially striking because the frequency of compounds containing plurals in compound-initial (i.e., nonhead) position is vanishingly rare in English according to standard frequency counts. If children did hear plural forms in compound-initial position, they could notice that all of them contained irregulars, and none contained regulars, and conceivably could have learned the principle. The fact that the crucial input information is absent led Gordon to suggest that the basic organization of the morphological system, which distinguishes regulars and irregulars, is innate.

Many linguists have claimed that their investigations show that the psychology of human language involves some degree of inherent structure dedicated to grammatical representations and processes. At the same time, critics have charged that such constructs are not empirically testable, weak in their effects, confined to educated speakers, products of formal instruction, confounded with semantics, embarrassed by unexplained counterexamples, and learnable from input regularities. Perhaps some of this controversy stems from an unwillingness to accept the methodology of linguistics, with its reliance on judgments of grammaticality and meaning. Using a simple phenomenon and methods more familiar to psychologists, we have shown a case in which all of these skeptical suspicions about the psychological reality of basic linguistic constructs are unfounded.

REFERENCES

Bernstein, T.M. (1977). *The careful writer: A modern guide to English usage.* New York: Atheneum.

Bybee, J.L. (1988). Morphology as lexical organization. In M. Hammond & M. Noonan (Eds.), *Theoretical morphology.* New York: Academic.

Bybee, J.L., & Moder, C.L. (1983). Morphological classes as natural categories. *Language, 59,* 251–270.

Bybee, J.L., & Slobin, D.I. (1982). Rules and schemes in the development and use of the English past tense. *Language, 58,* 265–289.

Carlson, G., Keyser, S.J., & Roeper, T. (1977). *Dring, drang, drung.* Unpublished manuscript, University of Massachusetts, Amherst.

Fowler, H.W. (1965). *A dictionary of modern English usage* (2nd ed.; revised by Sir Ernest Gowers). New York: Oxford University Press.

Gordon, P. (1986). Level-ordering in lexical development. *Cognition, 21,* 73–93.

Gordon, P. (1989). Levels of affixation in the acquisition of English morphology. *Journal of Memory and Language, 28,* 519–530.

Hinton, G.E., McClelland, J.L., & Rumelhart, D.E. (1986). Distributed representations. In D.E. Rumelhart, J.L. McClelland, & the PDP Research Group (Eds.), *Parallel distributed processing: Explorations in the microstructure of cognition: Vol. 1. Foundations.* Cambridge, MA: Bradford Books/MIT Press.

Jesperson, O. (1961). *A modern English grammar on historical principles: Pt. 6. Morphology.* London: George Allen & Unwin Ltd. (Original work published 1942)

Kierstead, R.L. (1989, October 2). Doctors under the skin. *Boston Globe,* p. 15.

Kiparsky, P. (1982a). From cyclical to lexical phonology. In H. van der Hulst & N. Smith (Eds.), *The structure of phonological representations.* Dordrecht, Netherlands: Foris.

Kiparsky, P. (1982b). Lexical phonology and morphology. In I.S. Yang (Ed.), *Linguistics in the morning calm.* Seoul: Hansin.

Kiparsky, P. (1983). Word formation and the lexicon. In F. Ingemann (Ed.),. *Proceedings of the 1982 Mid-American Linguistics Conference.* Lawrence: University of Kansas.

Lachter, J., & Bever, T. G. (1988). The relation between linguistic structure and associative theories of language learning: A constructive critique of some connectionist learning models. *Cognition, 28,* 195–247.

Lakoff, G. (1987). *Connectionist explanations in linguistics: Some thoughts on recent anti-connectionist papers.* Unpublished electronic manuscript, ARPAnet, University of California, Berkeley.

MacWhinney, B., & Leinbach, J. (1990). *Implementations are not conceptualizations: Revising the verb-learning model.* Unpublished manuscript, Carnegie-Mellon University, Pittsburgh. (Paper presented at the Stanford Child Language Research Forum, April, 1990)

Mencken, H.L. (1936). *The American language.* New York: Knopf.

Murray, J.A.H., Bradley, H., Craigie, W.A., & Onions, C.T. (1989). *The Oxford English Dictionary* (2nd ed.; prepared by J.A. Simpson & E.S.C. Weiner). Oxford: Clarendon.

Pinker, S., & Prince, A. (1988). On language and connectionism: Analysis of a parallel distributed processing model of language acquisition. *Cognition, 28,* 73–193.

Prince, A., & Pinker, S. (1988). *The nature of human concepts: Insight from an unusual source.* Unpublished manuscript, MIT and Brandeis University.

Rumelhart, D.E., & McClelland, J.L. (1986). On learning the past tenses of English verbs. In J.L. McClelland, D.E. Rumelhart, & the PDP Research Group (Eds.), *Parallel distributed processing: Explorations in the microstructure of cognition: Vol. 2. Psychological and biological models.* Cambridge, MA: Bradford Books/MIT Press.

Stemberger, J. (1989). *Morphological processing and the repeated phoneme effect.* Unpublished manuscript, University of Minnesota, Department of Linguistics, Minneapolis.

Ullman, M., & Pinker, S. (1990, October). *Why do some verbs not have a single past tense form?* Unpublished manuscript, Massachusetts Institute of Technology, Cambridge. (Paper presented at the 15th Annual Boston University Conference on Language Development)

Williams, E. (1981). On the notions "lexically related" and "head of a word." *Linguistic Inquiry, 12,* 245–274.

APPENDIX A
STIMULI AND ITEM MEANS FROM EXPERIMENT 1

A.1 Existing Denominal versus Metaphorical Deverbal

(The first item in each pair is denominal; the second is deverbal.)

1.	Wade Boggs has a bad habit of hitting fly balls into center field.	
	In yesterday's game he got one hit, and then flied out twice to center field.	4.2500
	In yesterday's game he got one hit, and then flew out twice to center field.	3.9375
	The math professor often flies off the handle at the slightest things.	
	Last week, he flied off the handle when one student talked during class.	1.8125
	Last week, he flew off the handle when one student talked during class.	6.8750
2.	The quarterback had a bad habit of trying to impress the crowd in the grandstand rather than concentrating on the game.	
	He grandstanded to the crowd once too often and got sacked.	4.5000
	He grandstood to the crowd once too often and got sacked.	1.8125
	Reagan was able to withstand the criticism directed against him by his political opponents.	
	Reagan easily withstanded the criticism.	1.7500
	Reagan easily withstood the criticism.	6.7500
3.	Dan Rather usually does the broadcast for CBS on weekdays.	
	Last week I think he broadcasted the news every night.	3.9375
	Last week I think he broadcast the news every night.	6.0625
	The witch was always casting spells on people.	
	Last week I think she casted a spell on my uncle.	3.0625
	Last week I think she cast a spell on my uncle.	6.9375
4.	Brian needed nerves of steel to face the ordeal.	
	Brian steeled himself for the ordeal.	5.4375
	Brian stole himself for the ordeal.	1.3750
	Benzinger was good at stealing bases.	
	Last night, Benzinger stealed second base twice.	1.6250
	Last night, Benzinger stole second base twice.	6.9375
5.	Sam always tells lies when he wants people to think he's better than he really is.	
	He lied to me again last night about how good a golfer he is.	7.0000
	He lay to me again last night about how good a golfer he is.	1.0000
	The cure for cancer currently lies out of reach because scientists don't know enough about how the body works.	
	The smallpox vaccine once lied out of scientists' reach too.	2.1250
	The smallpox vaccine once lay out of scientists' reach too.	5.6250

6.	General Patton ordered his artillery to form a ring around the city.	
	He quickly ringed the city with artillery.	5.0625
	He quickly rang the city with artillery.	2.6250
	Songs of freedom were ringing through the land.	
	Songs of freedom ringed through the land.	1.7500
	Songs of freedom rang through the land.	6.9375
7.	The truck driver applied the brakes suddenly to avoid an accident.	
	He braked the truck suddenly.	5.8750
	He broke the truck suddenly.	1.1875
	The plant superintendant has the job of breaking in new employees.	
	He breaked in half a dozen people this week.	1.5625
	He broke in half a dozen people this week.	6.5000
8.	After she was finished repairing the boat, she set it upright.	
	She righted the boat after she fixed it.	5.8125
	She rote the boat after she fixed it.	1.3750
	After the crash, she had to write off her losses on the car.	
	It was the third time this year that she writed off a loss.	1.0625
	It was the third time this year that she wrote off a loss.	6.8125

A.2 Novel Denominal versus Metaphorical Deverbal

(The first item in each pair is denominal; the second is deverbal.)

1.	He always puts the pig on a spit to roast it over a fire.	
	Again last night, he spitted the pig.	3.7500
	Again last night, he spat the pig.	2.5000
	Whenever I come up with a suggestion, he always spits on it.	
	Again last night, he spitted on my idea.	2.2500
	Again last night, he spat on my idea.	5.8125
2.	When guests come, I hide the dirty dishes by putting them in boxes or in the empty sink.	
	Bob and Margaret were early so I quickly boxed the plates and sinked the glasses.	2.8125
	Bob and Margaret were early so I quickly boxed the plates and sank the glasses.	2.5000
	When guests come, if they arrive with slides my hopes for a lively evening quickly sink.	
	When I saw Bob and Margaret carrying six boxes, my hopes sinked instantly.	2.0625
	When I saw Bob and Margaret carrying six boxes, my hopes sank instantly.	6.5625
3.	Gilligan tied the posts together with a reed.	
	Gilligan reeded the posts together.	4.1250
	Gilligan read the posts together. (pronounce it as "red")	1.0625

Gilligan tried to read the Captain's mind.
Gilligan readed the Captain's mind. 1.0625
Gilligan read the Captain's mind. (pronounce it as "red") 7.0000

4. There is a board game in Japan called "Go," which is very famous and popular.
But last year, chess became so popular, it out-Go'd Go. 3.5000
But last year, chess became so popular, it out-Went Go. 1.4375

I thought my son had to go to the bathroom a lot, but that was before I took his friend along on a trip.
That little boy out-goed my son by a long shot. 1.5625
That little boy out-went my son by a long-shot. 4.1250

5. Funeral directors often have to choose whether to conduct funerals, wakes, or memorial services when families cannot decide.
Although last year they still funeraled most of the dead, they waked a larger number than ever before. 4.8750
Although last year they still funeraled most of the dead, they woke a larger number than ever before. 2.3125

Heavy metal rock bands often play at a volume that can wake the dead, even though citizens complain about the noise.
Although city officials tried to get them to keep the volume down, last week they waked the dead again. 2.0000
Although city officials tried to get them to keep the volume down, last week they woke the dead again. 6.1250

6. The pennant winners didn't have to play in the first round of the playoffs; they got a bye into the second round.
The pennant winners were byed into the second round. 4.6875
The pennant winners were bought into the second round. 1.8750

The pennant winners were good enough to make it into the second round, but the Mafia managed to buy them off and they deliverately lost.
The pennant winners were buyed out of the second round. 1.2500
The pennant winners were bought out of the second round. 6.9375

7. The farmer put all his equipment in the shed for the winter.
After a couple of days, he finally shedded his tractor. 4.6875
After a couple of days, he finally shed his tractor. 2.6875

The poor farmer had to get rid of all his unnecessary equipment; to pay his debts, he had to shed himself of one possession after another.
After a couple of days, he finally shedded his tractor. 2.3125
After a couple of days, he finally shed his tractor. 5.5625

8. It's always a good idea to relax your clients by making sure they are supplied with food and drink at all times.
That's why when MacTavish arrived, I immediately snacked him, drinked him, and fed him. 2.0625

That's why when MacTavish arrived, I immediately snacked him, drank him, and fed him. 1.7500

It's always a good idea to relax your clients by feeding them gossip and pretending to drink up the gossip they give you.
That's why when MacTavish arrived, I immediately fed him lots of gossip, and drinked up everything he said. 1.6250
That's why when MacTavish arrived, I immediately fed him lots of gossip, and drank up everything he said. 6.7500

A.3 Novel Denominal Compound versus Novel Deverbal Compound
(The first item in each pair is denominal; the second is deverbal.)

1. Gretzky got a penalty for hitting the goalie with a high stick.
   Gretsky high-sticked the goalie. 5.8125
   Gretzky high-stuck the goalie. 1.9375

   Pete tried to stick the tape on the wall again and again.
   Pete re-sticked the tape on the wall. 1.6250
   Pete re-stuck the tape on the wall. 5.8750

2. The best way to make lasagna is to interleave the noodles and the spinach leaves.
   You'll like this lasagna; I interleaved the noodles and spinach carefully. 5.1875
   You'll like this lasagna; I interleft the noodles and spinach carefully. 1.6875

   Though it's important to leave your lover now and again to make him appreciate you, don't overdo it.
   Mary over-leaved him, so her lover ditched her for good. 1.3125
   Mary over-left him, so her lover ditched her for good. 3.3125

3. Though the Big Sleep is a very popular cult move, Citizen Kane has been accumulating quite a cult following of its own.
   Citizen Kane may have even out-Big-Sleeped the Big Sleep. 2.9375
   Citizen Kane may have even out-Big-Slept the Big Sleep. 2.5625

   Back at the frat house, everyone is trying to oversleep more times a week than everyone else.
   Last week, I out-oversleeped everyone. 1.6250
   Last week, I out-overslept everyone. 5.6250

4. Pitcher Roger Clemens allowed the Orioles only three hits in the entire game.
   He three-hitted them for the second time this season. 3.1250
   He three-hit them for the second time this season. 4.4375

   Babe Ruth had a tendency to hit the bat slightly under the balls pitched to him.
   Babe Ruth underhitted the ball for the second time that game. 1.6250
   Babe Ruth underhit the ball for the second time that game. 5.5625

5. Martina Navratilova beat Chris Evert in two sets.
Martina two-setted Chris for the fifth time in her career. 4.3125
Martina two-set Chris for the fifth time in her career. 3.1875

He set the table, expecting two guests to arrive.
When they called and canceled, he unsetted the table. 1.7500
When they called and canceled, he unset the table. 5.1250

6. These billboards advertising every brand of cigarettes, from Marlboros to Lucky Strikes, have been in our faces the whole trip.
We've been Lucky-Striked so many times we know the ad by heart. 3.3750
We've been Lucky-Struck so many times we know the ad by heart. 2.8750

To get a really loud tone from this bell, you've got to strike it from underneath.
See the way I understriked it? Do it like that. 2.3125
See the way I understruck it? Do it like that. 5.3125

7. The actor William Hurt has a reputation for attracting the most female autograph-seekers on the set during shooting, but this time Robert Redford attracted an even larger crowd.
Redford finally out-Hurted Hurt. 3.8125
Redford finally out-Hurt Hurt. 3.5625

The actor Sean Penn has a reputation for attacking nosy reporters and photographers in public places, but this time Jack Nicholson managed to hurt even more reporters.
Nicholson finally out-hurted Penn. 1.8750
Nicholson finally out-hurt Penn. 3.6875

8. Both boxers managed to land heavy blows on each other.
But Tyson out-blowed his opponent and won easily. 2.8125
But Tyson out-blew his opponent and won easily. 3.0000

Both women managed to blow hundreds of soap bubbles.
But Sheila outblowed her opponent and won the contest easily. 2.1875
But Sheila outblew her opponent and won the contest easily. 6.4375

9. He put an apple on his son's head, and tried to pull a William Tell.
He did it! He William-Telled the apple without touching a hair. 5.0000
He did it! He William-Told the apple without touching a hair. 1.5000

Story-telling was one of Alex's strongest points.
He story-telled the children for a solid two hours the other day. 1.6250
He story-told the children for a solid two hours the other day. 2.6250

10. Janet was fed up with her husband Sam's recurring flings with pretty young women, four at last count.
For revenge she got a job where she could meet lots of men and after finding her fifth willing partner she had actually out-flinged the guy. 3.3125
For revenge she got a job where she could meet lots of men and after finding her fifth willing partner she had actually out-flung the guy. 3.6250

Janet was fed up with her husband Sam's habit of flinging his dirtyclothes wherever he wanted.

To show him what a mess he was making she started flinging her clothes around too, and in a day she had actually out-flinged the guy.	3.7500
To show him what a mess he was making she started flinging her clothes around too, and in a day she had actually out-flung the guy.	4.8750

11. In that movie, Charlie Chaplin did the best double-takes I've ever seen.

He double-taked every time the cop came over to him.	3.8125
He double-took every time the cop came over to him.	3.0625

If you want to keep costs down, you've got to control students who take double helpings of the main course.

So many students double-taked last night that we quickly ran out of shrimp.	1.5000
So many students double-took last night that we quickly ran out of shrimp.	3.9375

12. I've had so many light beers I'm sick of them. I don't think I could possibly drink another one.

As far as beers are concerned, I'm totally lighted-out.	3.8125
As far as beers are concerned, I'm totally lit-out.	2.2500

The stewardess had been trying to light up her face with a smile so much that day, she couldn't do it one more time.

As far as her smile was concerned, she was totally lighted-out.	2.6250
As far as her smile was concerned, she was totally lit-out.	3.6250

13. The best football teams are those that are meaner on the field than their opponents.

The Dolphins were undefeated in 1974 because they out-meaned the rest of the teams in the NFL.	3.1875
The Dolphins were undefeated in 1974 because they out-meant the rest of the teams in the NFL.	1.4375

The most successful religious leaders are those that pack the most meaning into the fewest words.

Billy Graham was the most successful evangelist in the 1960s because his sayings out-meaned those of his rivals.	1.3750
Billy Graham was the most successful evangelist in the 1960s because his sayings out-meant those of his rivals.	3.8125

14. Sam is always acting like a shrink, psychoanalyzing half the people at the table. But last night we had Jonathan over, and he analyzed ALL the people at the table.

He finally out-shrinked Sam.	3.8750
He finally out-shrank Sam.	2.5625

My wife Hilda was always washing the clothes at too high a temperature, shrinking them beyond recognition, but we hired a

housekeeper last week who ruined six shirts in one load.
She actually out-shrinked Hilda. 2.5000
She actually out-shrank Hilda. 3.6875

15. Babe Ruth hit a line drive to center field.
It was the third time he line-drived in that game. 5.5625
It was the third time he line-drove in that game. 2.9375

Racing car drivers train themselves by driving on a perfectly straight line painted on the track.
Sam line-drived for hours every day before entering his first race. 2.0000
Sam line-drove for hours every day before entering his first race. 4.1250

16. My 6-year-old son will yell "no" at me 10 or 20 times when I try to put him to bed.
Last night, he "no'd" me once too often and I lost my temper. 5.5000
Last night, he "new" me once too often and I lost my temper. 1.1875

There's this guy that says, "Don't I know you?" every time he bumps into me, though I know it's just a line.
Last night, he "know'd" me once too often and I just walked away. 3.1875
Last night, he "knew" me once too often and I just walked away. 4.0000

17. I've had so many milkshakes, thickshakes, and chocolate shakes I couldn't have another shake of any kind.
I'm completely shaked-out. 4.7500
I'm completely shaken-out. 2.0000

I've had to shake so much flour onto this countertop, I couldn't shake another ounce.
I'm completely shaked-out. 4.0625
I'm completely shaken-out. 4.0625

18. When the dog came around scratching incessantly in the house, he decided to get rid of the dog's fleas once and for all.
He de-flea'd the dog. 5.5625
He de-fled the dog. 1.5625

When the dog came around the first time, he managed to flee, and when it came around the second time, he tried to flee again.
He re-flee'd the dog. 1.8125
He re-fled the dog. 3.1875

19. I've been to so many track-meets, I couldn't stand the thought of entering another.
I'm completely meeted out. 4.0000
I'm completely met out. 1.3125

So many dignitaries have had to meet me at airports, I couldn't stand the thought of having another one meet me.
I'm completely meeted out. 2.3750
I'm completely met out. 4.1875

20. There's a trick to making beet stew. In order to make a perfect beet stew, you have to pick out all the beets before you serve it.

The stew Mary served was a lumpy mess; she never de-beeted it.	4.9375
The stew Mary served was a lumpy mess; she never de-beet it.	2.5000

The Cubs are a hopeless team. We had no trouble beating them, and when they challenged us to a rematch, we had no trouble beating them again.

In fact, we re-beated them without breaking a sweat.	1.5000
In fact, we re-beat them without breaking a sweat.	3.8750

21. I've had a banana split every day this week and I couldn't possibly eat another one.

I'm completely splitted out.	2.7500
I'm completely split out.	2.6875

I've been splitting logs every day this week; I couldn't possibly split another one.

I'm completely splitted out.	3.4375
I'm completely split out.	4.2500

APPENDIX B
NOVEL VERBS FROM EXPERIMENT 5

16 Verbs from Carlson et al. (1977)	Other 16 Verbs
dring/drang	clare/clore
kleed/kled	freep/frept
lang/lung	frow/frew
nake/nook	plare/plore
plive/plove	preed/pred
prall/prell	quare/quore
preet/pret	shing/shang
skive/skove	skring/skrung
skrib/skrobe	smeep/smept
snike/snoke	smend/sment
speeve/spove	spling/splung
spiff/spuff	splow/splew
sping/spang	sprink/sprunk
spoog/spug	sprow/sprew
treave/trove	strink/strunk
wight/wought	strow/strew