Can word formation be *understood* or *understanded* by semantics alone?

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Abstract

Arguments concerning the relative role of semantic and grammatical factors in word formation have proven to be a wedge issue in current debates over the nature of linguistic representation and processing. In the present paper, we re-examine claims by Ramscar (2002; *Cognitive Psychology, 45,* 45-94) that it is semantic rather than grammatical factors that influence the choice of regular or irregular past tense forms for English verbs. In Experiment 1, we first replicated Ramscar's (2002) experiment, which showed semantic influences on choice of past tense inflection. A novel verb, *splink*, was introduced in a semantic context that was reminiscent of an existing regular or irregular rhyme verb: *blink* or *drink.* Participants favored the past tense form (*splinked* or *splank*) that matched that of the semantically similar verb. In Experiment 2, we introduced novel verbs in a context suggesting that they were grammatically derived from nouns (i.e., denominals). Some current symbolic processing models propose that regular past tense forms should be preferred for such forms. When Ramscar's (2002) original contexts for derivational verbs were re-tested in this condition, we replicated his failure to find a preference for regular past tense forms. However, when the contexts were modified to make the grammatical process more salient, we did find a preference for regular past tense forms, suggesting that the derivational status might have been ambiguous in the original materials. In Experiment 3, we tested whether acceptability ratings for regular or irregular past tense forms of grammatically derived verbs could be explained by semantic distance metrics or by ratings of noun-to-verb derivational status. Ratings of semantic distance and grammatical derivation were orthogonal factors in Experiment 3. Only derivational status predicted acceptability ratings for regular past tense forms. Taken together, the present results suggest that semantic factors do not explain the regularization of irregular verbs in derivational contexts, although semantic factors can affect the choice of past tense forms in certain circumstances.

Why do we say that we have *understood* something rather than *understanded* it? Common sense tells us that it is because we have heard others saying it this way and we incorporate some conventionalized form into our linguistic system. But sometimes there is no opportunity to witness the past tense form of a verb because it is either vanishingly rare or has been created anew with the evolution of the language. For example, *googled* seems to have come into the language as easily as *google*, without requiring a model for the past tense. As English speakers, we know that there is a default *–ed* affix, which applies in the absence of any attested irregular past tense form. An exception to this rule seems to be the case where a novel verb shows phonological similarity to a cluster of verbs that all share a similar pattern of irregular inflection. For example, if we create a new verb, *to spling*, we might be temped to analogize it to the cluster of irregular verbs that includes *ring-rang, sing-sang, fling-flung* and choose either *splang* or *splung* rather than *splinged* as the past tense form. Such analogical assimilation to existing clusters of items is known as a *gang effect* (Bybee, & Moder, 1983; Marchman, 1997; Stemberger & MacWhinney, 1988).

We have then two routes to productive past tense formation: Adding *–ed* and analogical generalization based on similarity-based gang effects. But we are still left with several puzzles. For example, another recently created verb in the technological revolution is *to ping*. The term refers to executing a specific UNIX routine, which indicates the distance to a particular computer on a network, much like the sound that is reflected back in a sonar system. To form the past tense of *ping,* we resist the analogy to the aforementioned cluster of *-ing* verbs and we say that we *pinged* the computer – not that we *pang* or *pung* it – even though we might never have heard this verb used in the past tense. Why then, do we tend to think that the past tense form of the novel verb *spling* is *splang* or *splung*, but that of *ping* is not *pang* or *pung*?

To begin to address this riddle, let us return to the case of *understand-understood*. This compound verb takes a past tense form like its component irregular verb *stand-stood*. However, when we use the noun *grandstand* as a verb, we now say that someone *grandstanded* rather than *grandstood,* and there is now no analogy to the irregular verb *stood*. One explanation for this discrepancy is that the verb *to stand* is not a proper component of the compound verb *to grandstand*, because the latter bears no semantic relation to the core meaning of *to stand* as in *to be in an upright position*. However, it is also not clear that this meaning has anything to do with *stand* in *understand* either. An alternative explanation for why *grandstand* avoids irregular inflection is because of its grammatical derivation (Kiparsky, 1982; Williams, 1981). The verb *to grandstand* is derived from

the noun *grandstand*. If irregular inflectional forms are stored in the lexicon rather than being computed in the grammar, then they should only be available in cases where the verb itself is stored in the lexicon. If, on the other hand, a verb must be derived from a noun, then a past tense form will not be available because nouns do not have past tense forms as nouns. *Understand* is not derived from a noun and therefore is not so constrained. In neither case is semantic similarity relevant to determining the acceptability of regular or irregular inflection. Returning to the verb *to ping*, this is derived from the noun *ping*, and thus resists assimilation to the *ing-ang* gang.

Invoking noun-to-verb derivation to explain the use of regular versus irregular past tense forms has its roots in the theory of lexical phonology pioneered by Kiparsky (1982, 1983) and further explored within the Words and Rules dual model of the lexicon (Pinker, 1991, 1999; Pinker & Price, 1988; but see also Clahsen, 1999; Marcus, 2001; Marslen-Wilson & Tyler, 1998; Ullman, 2001). The Words and Rules dual model began its life as a reaction to the early connectionist model of past tense formation developed by Rumelhart and McClelland (1986). In this connectionist model, regular and irregular past tense forms were created within a single network of associations that involve patterns of activation between sets of phonological features representing present and past tense forms of verbs. This type of model obviates the need for explicit rules and their requisite symbolic structures, such as variables representing syntactic categories like Noun and Verb.

Contrary to the single-level connectionist accounts, the Words and Rules dual model suggests that there are two kinds of word formation processes: Those that result from similarity-based analogical generalization to stored forms in the lexicon (e.g., *spling-splang* from *sing-sang*), and those that occur as a result of the application of rules (e.g., V → V+ed). The term "rule" refers in this context to processes that combine or order symbolic representations over syntactic categories like Noun and Verb.

Prasada and Pinker (1993) showed that people's acceptability ratings for irregular past tense forms of novel verbs are predicted by the degree of similarity to phonological clusters of irregular forms in the lexicon (like the *ing-ang* cluster). No such similarity scaling was found for regular inflections, suggesting that they are not part of an associative memory structure in the same way (for converging evidence, see also Ullman, 1999). On the other hand, Alegre and Gordon (1997) found that high frequency regularly-inflected forms are subject to a frequency effect in lexical decision experiments that involved written words. Since frequency effects are a hallmark of lexical storage, such effects suggest that high frequency regular inflections can be stored in memory. Storage of

high frequency inflected forms is not ruled out by the Words and Rules dual model (see Prasada & Pinker 1993; Caramazza, Laudanna, & Romani, 1988; Frauenfelder & Schreuder, 1991). This model only stipulates that regularly-inflected forms do not need to be stored in memory, because they can be created on-the-fly by rules that combine category symbols with inflectional morphemes. It might be the case that tasks requiring participants to generate inflectional forms in production are more likely to tap into generative, rule-based, mechanisms than tasks like lexical decision, where accessing stored forms might win out over the compositional route in lexical access.

It is important to note that the kinds of connectionist models that are contrasted with the Words and Rules dual model are only a subset of the set of possible connectionist models. In particular, they are what Marcus (1998) terms "eliminative connectionist models", which are characterized by their rejection of symbolic representations in favor of distributed representations over sub-features. In distributed representations, elements that are traditionally captured by category symbols are replaced by emergent states of a network of features whose connection strengths are differentially activated through learning. In contrast to eliminative connectionism, other kinds of connectionist networks might have dedicated local nodes that represent categories or past tense forms (cf. Plunkett & Marchman, 1993), which, Marcus (2001) claims, are computationally equivalent to symbolic representations.

Dual model theorists generally agree that connectionist networks that incorporate local representations of lexical items are the best way to model the "Words" part of the dual model. "Words" are stored representations in associative memory structures (i.e., neural networks), which generalize past tense forms on the basis of shared phonological features and whose connections are strengthened through increasing frequency in the input to learning. Contrary to many claims, connectionist networks are also useful as a medium for rule-based processing in language. Such models can be made to emulate symbol manipulation by allowing dedicated ("localist") nodes for grammatical categories. In fact, connectionist networks are particularly useful when one is concerned about performance rather than competence, and one wishes to model the interface of grammatical constraints and other aspects of information processing in linguistic tasks that might be in competition with the underlying grammatical constraints.

As the debate about the representation of past tense forms has evolved within the psycholinguistic community, it has become about whether symbolic systems referring to grammatical categories are required to account for linguistic processes or whether distributed

representations can do the job and whether we can dispense with grammar qua symbol manipulation. In addition to having different views about the nature format of the linguistic processor, debates also rage around the forms of interactions existing between the components of the language system. In particular, do semantic representations influence the choice of past tense forms in generating regular or irregular past tense forms of verbs. In the present paper, we address this debate from the perspective of homophones.

Inflectional status and the homophone problem

Rumelhart and McClelland's original connectionist model of past tense formation was extensively critiqued by Pinker and Prince (1988). In this paper, they noted that the model did not have representations for lexical items and therefore could not account for the fact that homophonous verbs often differ as to whether they take regular or irregular past tenses. Examples include *rang the bell* vs. *ringed the city,* or pairs like *lie-lay* and *lie-lied*. One potential non-symbolic solution to this problem is to include a semantic representation of the verb meaning as part of the connectionist network. The distinct meanings of the regular and irregular homophones of verbs serve to keep the representations similarly distinct and allow one verb meaning to gravitate toward the regular pattern and the other to the irregular pattern (cf. Lakoff, 1987; Joanisse & Seidenberg, 1999).

In addressing the role of semantic factors, Pinker and Prince (1988) and Kim, Pinker, Prince, and Prasada (1991) note that similarity of meaning does not appear to support generalizations of past tense forms. For example, the semantically related verbs *hit, slap* and *strike* take three completely distinct paths in forming the past tense (*hit, slapped* and *struck*). These cases suggest that the associative memory structure that supports generalization of inflectional patterns within the lexicon is modular in nature, and is based on similarity of form but not meaning. In one attempt to introduce semantic representations into a network that generates past tense forms, Joanisse and Seidenberg (1999) had each word assigned to a unique node (coded as a unique number) that was supposed to be a proxy for a complex distributed representation of semantic features. However, the singularity of this representation ensured that these nodes actually marked words only as lexical items and shielded them from potentially problematic analogical generalizations based on shared semantic features. For example, if *hit, slap* and *strike* had had distributed semantic representations instead of singular lexical representations, then they would all share semantic features relating to something like "agonistic action upon an object or person." If those distributed representations were put into play in

a general association network, then they would pull the "hitting" verbs together as a semantic "gang" in the same way that the shared phonological features create a phonological gang like the *ing-ang* gang. One might circumvent past tense generalization on the basis of semantic features by modularly isolating phonology from semantics. But such a separation would also prevent semantic features from defining the distinction between homophonous forms, and we would be back where we started with the homophone problem. By employing singular lexical nodes, Joanisse and Seidenberg (1999) create an essentially symbolic representation of each lexical item, albeit within a network representation (for similar criticisms see Pinker, 2001). Once such local representations of categories or lexical items become part of the system, the goal of eliminating symbols is vacated and then there is no principled reason to resist other symbolic representations like those standing for morphological elements like *-ed*, and syntactic categories like Noun and Verb.

The Words and Rules dual model does not stand or fall on the issue of whether or not there are semantic generalizations for past tense inflection. However, if it turned out, after all, that semantic generalizations can drive the choice of regular or irregular inflection, then this would remove a major linchpin from the argument against single-level connectionist models that use only distributed representations. Such models could, in good faith, include distributed semantic representations in their networks and thereby distinguish between homophonous forms that differ in regularity of inflection (e.g., *lie-lay* vs. *lie-lied*). In the absence of such evidence, Pinker and Prince (1988) and Kim et al. (1991) have proposed that differences in inflectional status for homophonous forms can be explained by grammatical processes involving derivation of verbs from nouns, as noted earlier.

To determine whether English speakers are influenced by grammatical or semantic properties in their choice of past tense forms, Kim et al. (1991) employed verbs that were prototypically irregular. These verbs were presented in contexts indicating that they were either denominal – i.e., derived from nouns – or deverbal – i.e., verbs that involved secondary or metaphorical meanings from the prototypical meaning of the basic irregular verb (Clark & Clark, 1979). For example, *to fly* is prototypically represented as *birds fly south in winter*, the denominal as *fly out to center field* in baseball, and the deverbal as *fly off the handle*. Participants rated whether they preferred the irregular form (*flew*) or the regular form (*flied*) as the past tense of such verbs. Regular forms were preferred over irregular forms if the verb had been derived from a noun (denominal), whereas a preference for irregular past tense forms appeared when a verb was used in both its prototypical sense and its secondary metaphorical sense (deverbal).

Kim et al. (1991) addressed a proposal by Lakoff (1987) claiming that whether a new verb will be inflected as regular or irregular does depend on its semantics. According to this proposal, the extent to which verb meaning deviates from the prototypical meaning of a verb should predict the degree of acceptance of the regular over the irregular form. Specifically, more distant meanings are expected to lead to regular inflection. To test this proposal, Kim et al. had people rate the semantic distance of the denominal and deverbal verbs in their items from their respective prototypical verb meanings. These ratings were then regressed against the acceptability ratings obtained for the regular and irregular past tense forms of the verbs. Unfortunately, denominal verbs were generally rated as more distant in meaning from the prototypical form, thus introducing a confound between semantic distance and derivational type. Because of this confound, it was necessary to partial out the effects of derivational type first, and then examine the residual variance accounted for by semantic distance. Examined in this way, semantic distance accounted for almost none of the residual variance. Although these data argue against the role of semantic distance in regular versus irregular inflectional preference, the correlation between derivation and semantic distance makes such an analysis less than ideal.

In a more recent article, Ramscar (2002) offered new and potentially important evidence that the choice of regular or irregular inflection can, in fact, be influenced by semantic associations, contrary to Kim et al.'s (1991) conclusions. Not only did Ramscar's results suggest a role for semantic similarity in this process, but they also suggested that grammatical derivation plays essentially no role in people's judgments about whether a verb should have a regular or irregular past tense form. Such radically contrasting conclusions cannot coexist, and at least one side must be wrong; the present paper attempts to adjudicate between the two positions.

Although there are classes of semantically-related verbs with distinct past tense forms like *slap, hit,* and *strike*, this is not always the case. Ramscar (2002) provided the example of, *blink* and *wink,* which are closely related, both semantically and phonologically, and exhibit regular inflections, despite being part of the *-ing/-ink* gang of irregulars (cf. *think, sink, sing, string, fling, cling*, etc.). It should be noted, however, that this *wink-blink* example is probably the only case in the English language that shows common inflectional form for rhyming semantic associates. In other cases of semantically related rhyming verbs, one generally sees disagreement in the choice of past tense inflectional form. That is, one verb tends to be regular and the other irregular (as with *ring-rang* and *ding-dinged*). On the other hand, Ramscar's proposal that semantic influences might require

phonological support could explain why *slap, hit* and *strike* fail to pattern with one another in their choice of past tense forms. That is, the phonological dissimilarity might have a stronger pull in inhibiting the influence of any semantic similarity for these verbs.

Ramscar proposed that semantic generalizations can occur in the process of deciding on the appropriate past tense form for a novel verb. If a novel verb reminds the learner of an existing verb in the language (i.e., shares semantic and/or phonological properties), then the regular or irregular status of the established verb will be a model for the inflection of the novel verb. For example, if one hears the novel verb *to sprink*, and learns that its meaning closely resembles the existing verb *to drink*, then there will be a tendency to inflect for past tense by analogy to the existing verb (i.e., *sprank*). On the other hand, if the meaning of *to sprink* closely resembles the verb *to blink*, then people will tend to prefer the regular inflection, as found in the analogous existing verb.

Ramscar's (2002) paper consisted of five experiments, which are briefly described here. The first experiment established the single-trial as the method of choice for investigating inflectional preferences in novel verbs. This experiment showed that choice of inflectional form can be influenced by a preceding example. Ramscar therefore favored designs with large numbers of participants each responding to a single item. Next, Ramscar demonstrated that semantic similarity can affect whether people choose a regular or irregular past tense form to inflect a novel verb as noted above. This was followed by an experiment in which the context suggested that the novel word was a noun that was converted into a denominal verb. In this experiment, denominal status had no effect on whether participants employed a regular or irregular inflection, contrary to the results of Kim et al. (1991).

Ramscar argued that Kim et al.'s (1991) experimental design failed to consider whether people actually agree on the origin of the verb. To rectify this problem, Ramscar had participants rate how strongly they felt that the verb was derived from a noun or a verb. In fact, for some of the items, subjects did not agree with Kim et al. on derivational status. For example, they rated the verb *to lie*, meaning *to prevaricate*, as not being derived from the semantically related noun *lie* (a falsehood). Rather, they rated it as a distinct verb in its own right, with neither the noun nor the verb being derived from each other. Similarly, raters did not agree that *to broadcast* was derived from a noun either. When Ramscar (2002) fed the ratings of denominal status into the regression analysis along with the ratings of semantic distance from the base verb, only semantic distance accounted for a significant proportion of the variance in acceptability judgments for regular versus irregular past

tense forms. Grammatical derivation did not account for any appreciable variance in the regression model.

The final experiment re-evaluated claims about the construction *to fly out to center field*, which is the basis for Kim et al.'s (1991) paper title "Why no mere mortal has ever flown out to center field." Ramscar tested this construction on baseball-naïve British participants, introducing *to fly out* as a verb derived from the noun *fly ball*. He showed that, amongst these participants, there was no preference for the regular over the irregular past tense inflection, and they were quite happy to have wingless batters who *flew out* rather than *flied out* to center field.

For those who believe that grammatical effects of verb derivation are crucial in determining regular versus irregular inflection for denominals, the set of results obtained by Ramscar is troubling to say the least. For connectionist modelers who wish to include semantic representations in their models, these results are a windfall. So, can we accept these results as indicating a dominant role for semantics in word formation?

In the present paper, we report a series of experiments that involved fairly minor changes to Ramscar's experimental procedures. In Experiment 1, we replicated his findings showing that semantic reminiscence can indeed determine whether people favor regular or irregular past tense inflections for novel verbs. In Experiment 2, we investigated further the question of whether derivational history does, or does not determine whether a verb is inflected in the regular or irregular form. We argue that the context in which denominal verbs were introduced in Ramscar's (2002) original experiments were problematic. In our studies we made minor changes in these contexts. These minor changes radically altered whether regular or irregular past tense inflections were preferred by participants.

In previous experiments carried out by Kim et al. (1991) and Ramscar (2002), ratings of derivational status and semantic distance were correlated and so differentiating the effects of these two variables was problematic. In addition, the stimuli included items that were problematic in their ascription to denominal status in Kim et al.'s original experiment. In Experiment 3 we constructed a new set of stimuli in which derivational status and semantic distance were not correlated and had participants rate the acceptability of past tense forms. In this way we were able to disentangle the effects of grammatical status and semantic distance in determining preferences for regular or irregular inflection.

Experiment 1: Effects of Context on Past tense Inflections in Novel Verbs

Our first experiment attempted to replicate Ramscar's (2002) Experiment 2, where he found that when a novel verb such as *to sprink* shared semantic and phonological properties with the verb *to drink*, participants preferred the irregular past tense form *sprank* assimilating to *drank*. But when the meaning of *sprink* was close to a regular verb like *blink* or *wink*, then it was more likely to be inflected like its semantically associated regular verbs as *sprinked*. The change in the procedure that we introduced in Experiment 1 was primarily one of convenience. Many of Ramscar's participants were tested verbally in Shopping Malls in Edinburgh, a testing population we were unlikely to replicate in New York City. We preferred to use written pencil and paper protocols that could be administered in large undergraduate classes. In addition to the added convenience, we also felt that the written protocol would provide a more structured setting in which to administer these experiments and might be less open to experimenter influence. To change the procedure in this way, it was necessary to establish that the basic results could be replicated with this modified design and that the results would generalize to a population speaking a different English dialect.

Method

Participants Students at Columbia University volunteered in all of the experiments presented in this paper. No participants took part in more than one experiment. Only the data of those participants who considered English to be their native language were retained for analyses. Three hundred participants were included in Experiment 1.

Materials We used the written passages originally created by Ramscar (2002; Exp. 2) to elicit the past tense of the two novel verbs *frink* and *sprink*. The passages are shown in Table 1. The context passages had been designed to suggest meanings for the novel verbs to be similar to either (a) *to drink*, a verb that rhymes with *frink*/*sprink* and has an irregular past tense form, (b) *to blink/wink*, verbs that also rhyme with *frink/sprink* but have a regularly-inflected past tense, or (c) *to meditate*, a verb that is not phonologically related to *frink*/*sprink* and has a regular past tense form. Data from Latent Semantic Analyses (Landauer, Dumais, & Laham, 1998) confirmed that each context was specifically related to the target verb (see Ramscar, 2002 for details). The novel verbs were highlighted and appeared in their infinitive form (*to frink*, *to sprink*). The context passage served to define the meaning of the novel verb when it was introduced. Later in the passage, there was a fill-in-the-blank that would be felicitous for a verb in the past tense form. Participants were

instructed to fill the blank with the past tense of the novel verb. Passages were matched so that before and after the fill-in-the-blank section, the wording was identical. Context passages and task instructions were printed on a separate page from the fill-in-the-blank sentence. This was so as to avoid the possibility that participants would look back to the previous text in a way that would not be available in the spoken context of Ramscar's original experiment.

Table 1 about here

Procedure The instructions closely followed those used by Ramscar (2002). Participants were asked to read the passage and were informed that it contained a novel word – recognizable because it was italicized – and a blank. Participants were invited to fill the blank "with the form of the italicized word that you think is appropriate to the context in which you find the blank." Instructions included the following statements: "It is important that the form you choose matches the context of the sentence. Please concentrate on how the new form of the novel word 'sounds' in the context, not on how it might be spelled … there is no correct answer in this task; you should provide the response that you feel is the most appropriate." Participants wrote their choice of verb form in the underlined space. Each participant was presented with a single passage and thus provided a single response. Ramscar's (2002) original design also included a training passage. Prior to the test item, participants were presented with the following example, which was designed to clarify the task:

> "A single *wucterium* can be very dangerous. When they breed and multiply, a buildup of _____ can prove lethal." You might choose to fill in the blank with *wucteriums* or *wucteria* or anything else, depending on what seems appropriate to you."

To ascertain whether this training might bias irregular responses in the main task, we only included it for half of the participants. To summarize, three variables were manipulated in Experiment 1: (a) the novel verb (*frink* vs. *sprink*), (b) the presence or absence of the *wucterium* example, and (c) the meaning suggested by the context (drinking vs. blinking/winking vs. meditate). To satisfy the twelve levels (2x2x3) of these variables, we employed twelve groups of participants, each of which was composed of 25 individuals.

Results and Discussion

Responses were scored as (a) *regular* if the *–ed* affix was appended to the stem (*frinked*, *sprinked*), (b) *irregular* if the stem was modified (as in *frunk/frank* or *sprunk*/*sprank*), and (c) *other responses*, which consisted of incorrect inflections (e.g., *frinks*, *sprinking*) or context-related words (e.g., *blinked*, *meditated*, *consumed*). Table 2 shows how responses were distributed across conditions. Almost invariably (96%) the irregular responses comprised the inflections *sprank* and *sprunk* or *frank* and *frunk*, which resemble the irregular inflections *drank* and *drunk*. The nature of the irregular responses strongly suggests that the phonology of the novel verbs (probably along with the context) reminded participants of the verb *to drink* (and its irregular inflection), which in turn affected the choice of the irregular inflection. Responses classified as "other responses" were relatively rare (<12%) and were evenly distributed throughout conditions. The inclusion or exclusion of the training condition with *wucterium* had no effect on responses ($\chi^2(2) < 1$), and so these conditions are grouped together in further analyses. With respect to regular and irregular inflection, there was a strong effect of novel verb form. Regular inflections were chosen more frequently with *frink* (63% vs. 43%; ($\chi^2(1) = 12.8$, $p < .001$); irregular inflections were more numerous with *sprink* (49% vs. 26%; ($\chi^2(1) = 16.4$, $p < .001$). The preference for the regular inflection *frinked* was also reported by Ramscar (2002) and is likely to reflect the avoidance of the irregular inflection *frank*, a homophone and homograph of the existing adjective and proper name. Such avoidance suggests that *frink* was an unfortunate choice of item in the original design, and that results should be considered separately for *frink* and *sprink*.

Table 2 about here

Participants' responses were highly influenced by semantic context. The *blink*/*wink* context and the *meditate* context showed similar rates for regular inflection (65% and 58%, respectively $\chi^2(1) = 1.0$, $p = .3$; 58% and 48% without *frink*). By comparison, regular inflections were much less common in response the *drink* context (36%; both $\chi^2(1)$s > 9.6, p's $< .01$; 22% without *frink*). The effect of semantic context on choice of inflection replicates that obtained by Ramscar (2002). The effect is thus independent of the response modality—Ramscar's study used spoken responses whereas written responses were used in the present study. This common pattern of responding

established that written protocols could be used in the following experiments without concern for differences in response mode.

As Ramscar (2002) pointed noted, the results are very interesting for the case in which the novel form resembled the meaning of *to meditate* because this is a regular verb but shares no phonological similarity to the novel verb. Could semantic reminding alone cause a preference for a similar inflectional form? Participants in our study showed a slight preference for the regular inflection (58%), although Ramscar (2002) had found a stronger effect (70%). Like the *blink*/*wink* condition, the nonce verbs were regularly inflected much more frequently than if there had been no semantic context. By comparison, in Ramscar's Experiment 1, where a neutral context that did not remind readers of an existing verb, participants overwhelmingly preferred to inflect *sprink* and *frink* like an irregular verb (72% of the responses). This pattern of results suggests that semantic similarity is sufficient to influence inflection and to overwhelm the competition presented by the attraction of phonologically similar verbs in an irregular class.

It is interesting to note that *meditate* is also closely related to the meaning of *think*, which coincidentally is also phonologically similar to the novel test verbs *frink* and *sprink*. The Latent Semantic Analysis (Landauer et al., 1998), used by Ramscar to assess whether his materials could evoke a certain verb, indicates that *thinking* is related to the passage in question even more than the actual verb: *meditating* (semantic distances, expressed as cosines: .46 vs. .15, respectively; note that higher values indicate closer semantic relation; further details about this type of analysis will be presented in Exp. 3). If semantic features enter in tandem with phonological features into the associative network that determines the choice of irregular inflection, one would predict that a significant proportion of responses should have been of the form *frought/splought,* by analogy with *think-thought*. In fact, we did not find a single response of this kind in a group of one hundred participants tested in this condition (Ramscar (personal communication) reports only a "very few" such responses in his data). The rarity of responses that followed the conjoined semantic and phonological similarity of *to think* suggests that there are strong, but unspecified constraints on when semantic similarity can take effect and when it cannot. One might suggest that the *-ought* past tense pattern is too small a gang to attract analogical generalization. However, in addition to *think-thought*, it also includes *bring-brought, seek-sought, fight-fought, buy-bought*, thus constituting a sizeable collection of verbs including some that are very frequent. It might be the case that the semantic similarity between *meditate* and *think* is simply too obscure. However, this begs the

question why the definition of *to sprink* as "drinking vodka and eating pickled fish" should resemble *to drink* in meaning more than *think* resembles *meditate.* How is it that the former provides overwhelming generalization to the irregular past tense form, but the latter induces not a single generalization in our data. Notice that the Microsoft thesaurus entry for *meditate* returns *think* as a synonym, whereas entering *drink* returns no terms that include the objects of consumption in their meaning. One possibility for the lack of generalization is that the actual word, *think* does not sit well in the context sentences that were developed for these procedures. Consider the test sentence for this condition:

> "In 1996, emitting a steady, low humming sound, cancer patient Ivan Borovich _____ around two weeks or so."

The form *meditated* fits well into this sentence context, but *thought* borders on being ungrammatical here. If reluctance to use *think* as a model for past tense generalization for *sprink* is due to its lack of fit in the specific context of the sentence, then this suggests that the effects in this experiment are not simply associations of semantic features.[1] If the semantic features for *meditate* were strongly activated, then semantic features for *think* should be similarly activated. Because *think* has the advantage over *meditate* in rhyming with *sprink*, then one would predict quite strong activation of *thought* as a model for the past tense of *sprink*. On the other hand, if past tense generalization only occurs if the "reminding" verb can literally fit in the same slot in the sentence, then this is a very different kind of generalization mechanism from that envisioned within current explanations of past tense elicitation task that appeal to generalization based on shared semantic features. This is not a fatal flaw, but it does require a new kind of model be specified to allow only this kind of generalization.

As Ramscar (2002) pointed out, generalizations of past tense forms that are based on semantic similarity do not necessarily militate against the Words and Rules dual model. It is quite possible for semantic generalizations to occur in the case of irregular verbs. Even regular verbs could be stored in the lexicon and provide a model for generalization, so long as there are some processes that clearly require compositionality with regular inflection. What does distinguish the Words and Rules dual model is the claim that verbs are attracted to regular inflection if they were derived from nouns (i.e., are denominal) as opposed to being derived from verbs (i.e., deverbals). The symbolic variables of noun and verb and derivational systems that require symbolic representations are not

available within eliminative connectionist theories, which lack symbolic structures and allow only distributed representation, and hence cannot be used to explain a preference for regular inflection in the case of denominals.

The next experiment reexamines the question of homophony and whether differences in inflectional preference are to be explained by grammatical derivational processes, a claim that Ramscar position disputes.

Experiment 2: Effects of Denominal Status on Past tense Inflection in Novel Verbs

Ramscar's third experiment on novel denominal verbs was similar in design to our Experiment 1, differing mainly in the context passage in which the verb's meaning was defined. In the new context, the novel verb was intended to be denominal. To this end, the novel word first appeared as a noun and then as a verb (see the example in Table 3). According to Kim et al. (1991), the grammatical derivational process of converting a noun into a verb (i.e., denominalization) should block irregular inflection and there should be a strong tendency to use the regular form of the past tense. Contrary to this prediction, Ramscar (2002) found that participants were no more likely to use the regular past tense inflection on a novel verb when it was preceded by a noun context than when the noun context was absent.

Table 3 about here

Ramscar's failure to observe an effect of grammatical derivation requires the cautionary interpretation reserved for negative findings. It is indeed possible that the failure to reveal an effect of grammatical derivation reflects aspects of the experimental design more than a genuine absence of an effect. There are reasons to suspect that probably this is the case here as well. Upon closer inspection, Ramscar's denominal context passage appears to have several shortcomings that could lead to a failure to guarantee that participants interpreted the novel verb as being derived from the noun. The heart of the problem is that one cannot equate order of mention with derivational status. When, in a passage, a word appears first as a noun then later as a verb, this order of mention is not indicative of the direction of linguistic derivation. For example, the first-mentioned noun could be a noun derived from a verb (a deverbal noun), whereas the second-mentioned verb could be an

underived basic form. Alternatively, the noun and verb could both be basic, without any linguistic derivational relation between them.

Ramscar (2002) attempted to deal with this problem by having people rate on a 7-point scale whether they thought that the verb was "being used in a normal 'verb-like' way or if it was being used as a verb in relation to a noun"(p. 65). The ratings strongly favored the verb-from-noun derivation when the novel word was also shown as a noun. But such results might not necessarily reflect processes involving derivational morphology. Of the two conditions tested, only one included a noun version of the novel word. It is not surprising that the novel verb was more likely to be rated as being a "verb in relation to a noun" than when references to the noun were absent. Raters who were asked whether a verb was being used "in relation to a noun" were probably explicitly looking for nouns in the passage to make their judgments. On the other hand, participants in the main condition, who were simply doing the past tense generation task, probably had a different agenda, producing whatever grammatical form felt best, regardless of whether there was a noun in the passage. Even though ratings from naïve speakers can tell us something about how participants perceive noun-to-verb relations, one needs to be careful that such ratings are not influenced by extraneous differences in procedures.

Other problems relate specifically to the passage about *drinking*, which is of particular theoretical relevance because it is in this context that – at least in some accounts – denominalization should induce regular infections (*e.g., sprinked*). Upon closer examination of the wording of the *drinking* passage, we found that this passage might not clearly promote a denominal reading. The first noun mention indicates that "… a *sprink* is the Muscovite equivalent of the Spanish Tapas" (see Table 3). Here, *sprink* could be a basic noun (cf. *an aperitif*), it could be a noun derived from a verb (cf. *a drink*), or it could be neither (cf. *a snack/to snack*, which can be both noun and verb, with neither appearing to be more basic). The later occurrence in the passage of the verb *to sprink* in which "… patients all *sprink* in the onset of good weather …" gives no particular indication that the verb is linguistically derived from the preceding noun. In our experiment, we created a new passage that we felt would more strongly favor a denominal interpretation of the test verb. The new passage is given in Table 3 (enhanced passage). In the enhanced passage, we established more thoroughly that the base meaning of the novel word *sprink* was a noun defining it as a kind of vodka. Unlike Ramscar, who used the novel word only once as a noun and once as a verb, our context used *sprink* as a noun three times preceding the three verb usages and once following. The passage also

explicitly mentions the meaning of *sprinking* – i.e., to imbibe *sprink*. We thus defined the verb meaning and its relation to the noun more clearly than in Ramscar's passage, where the verb is mentioned only once in the sentence "… patients all *sprink* in the onset of good weather."

Finally, we found that Ramscar's original passage contained a redundant argument structure in which "…Ivan Borovich *spinked/sprank* around 35 vodka shots and 50 pickled sprats." Since *to sprink* was supposed to mean "to consume vodka and sprats," the inclusion of these items as the object of the verb becomes oddly redundant. We therefore left the contents of the shots implicit in the denominal verb meaning presented in the new passage.

To test whether our enhanced passage had made the denominal status of the novel verb more salient than in Ramscar's original passage, a group of raters compared the two passages and judged which was more likely to be an instance of a verb that came from a noun. Of course, there are many other aspects of the passage that had changed in our version, not least of which was pure length and number of noun mentions. Be that as it may, if anything we have done increases the likelihood that the verb will be treated as a denominal, then the question is whether the incidence of regular past tense usage would increase compared to both our first experiment and Ramscar's original denominal passages.

Method

Participants

Three groups of 85 participants were tested in each of the different versions of the elicitation task. An additional group of 26 participants rated the items for semantic reminiscence, and a further group of 86 participants judged the lexical characteristics of novel words.

Material and Procedure

A. Elicitation Task Experiment 1 revealed that participants preferred the regular inflection *frinked* while avoiding the irregular past tense *frank*, probably because this is a real word. The inflated rate of regular inflection makes *frink* a dubious candidate for an experiment in which the choice of regular inflection is critical. For this reason, we decided not to include *frink* in Experiment 2, and used only *sprink*. *Sprink* was included in three passages: (a) Ramscar's passage from his Experiment 2 (our Experiment 1) in which *sprink* appeared as a simple verb meaning: "to consume vodka and sprats;" (b) Ramscar's passage from his Experiment 3 in which *sprink* was first a noun, then a verb; (c) a new passage in which we attempted to make the denominal status of *sprink* more salient. Passage (a) can be reviewed in Table 1 (example C); passages (b) and

(c) are presented in Table 3, and we refer to them as *original passage* and *enhanced passage*, respectively. In each of the passages, the novel word was highlighted, and a blank appeared embedded in the identical test sentence. As in Experiment 1, participants first read the passage then filled in the blank where the past tense form of the verb was called for. Again, each participant contributed a single response.

B. Semantic Reminiscence Ratings If the enhanced passage were to receive more regular responses in this experiment, it could be argued that we created a context only weakly reminiscent of the meaning of *drinking.* According to Ramscar's claim of semantic determination of past tense formation, this would reduce the influence of the irregular form *drank* in determining the form of the past tense. To control for the semantic similarity of *sprink* to the existing verb *drink*, a group of 26 raters judged how strongly each passage reminded them of the concept *drinking*. The two passages were presented in a counterbalanced order across subjects. Ratings were given on a 7-point scale, where 1 was defined as "*not at all reminiscent*" and 7 "*strongly reminiscent*." Instructions emphasized that ratings should relate to the verb *to drink*, not the noun *drink*.

C. Denominal Status Judgments Our manipulations of the enhanced context were aimed at increasing people's perception that the novel verb was derived from a noun. To evaluate whether this had been successful or not, the original and enhanced passages were each shown to independent raters who were asked to judge which of the two passages was more likely to have "a verb that came from a noun". Denominalization was explained by analogy to the word *e-mail*, a word that started out as a noun, but was later used as a verb. Order of presentation of the two passages was counterbalanced.

D. Proper Noun Judgments A second issue of concern was that, in the enhanced context, *sprink* might have been interpreted as a proper noun—a brand name of Vodka like *Absolut* or *Skyy*. A proper name like *Lee Child* is not normally inflected unless one is using the name in a kind of quasi-quoted context as in: "You mean there are two *Lee Childs*?" or perhaps when one is using the name of the author, *Lee Child*, as a way of referring to his books, as in: "I read three *Lee Childs* this month." However, one would definitely not inflect this name with an irregular form as in: "You mean there are two *Lee Children*?" (see Marcus, Brinkmann, Clahsen, Wiese, Woest, and Pinker (1995) for evidence from German plurals, but also Hahn & Nakisa, (2000) for counter evidence that first names can be irregularly inflected in German). If proper names do

resist irregular inflection, then such resistance might also explain why participants might not use the irregular *sprank* if *sprink* is construed as a proper name in the enhanced context.

There are two possible construals of the nominal status of *sprink* in the enhanced context: Either it could be a proper name, as in a brand of vodka, or it could be a kind of vodka, in the same way that bourbon is a kind of whiskey, but is not a proper name. To determine which interpretation predominated, raters who had previously judged the denominal status of *sprink*, were then asked to decide whether, in the enhanced context, *sprink* was (a) "a brand name like *Johnny Walker* or *Jim Beam*" or (b) "a type of vodka, just like *bourbon* and *single malt* are types of whiskey."

Results and Discussion

Item ratings In comparative ratings of denominal status, 60/86 raters (70%) judged that *sprink* was more likely to be a verb derived from a noun in the enhanced passage than in the original passage ($\chi^2(1) = 13.4$, $p<.001$). We were therefore confident that our manipulation was successful in creating a more salient denominal status for the novel verb, and we could test whether this enhancement had the effect of eliciting more regular past tense forms than in the original experiment. The enhanced passage was also rated as significantly more reminiscent of *drinking* than the original passage (means: 3.8 vs. 2.9, respectively; $t(25) = 2.8$, $p < .01$). Therefore, any increase in regular past tense responses could not be ascribed to a decreased semantic similarity to the irregular form *drink,* from which semantic generalizations are said to emanate. Finally, in testing whether people interpreted *sprink* in the enhanced passage as a kind of vodka or a proper name, the vast majority of raters (83/86, 97%; $\chi^2(1)= 74.4$, $p<.001$) favored the interpretation that *sprink* was a kind of vodka, comparable to bourbon or single malt, rather than a brand name. This ruled out the possibility that participants disallowed irregular past tense forms because of a proper name interpretation for the novel verb.

Past Tense Elicitation As in Experiment 1, responses in the Elicitation Task were classified as *Regular, Irregular* or *Other* (see summary in Table 4). Of the responses coded as *Irregular,* 99% were either *sprank* or *sprunk*. Just like Ramscar (2002), we found that there was no significant difference in use of regular or irregular inflection between the simple verb context and Ramscar's original denominal context (Regular: 27% vs. 35%, $\chi^2(1) = 1.34$, $p = .25$; Irregular: 58% vs. 56%, respectively; $\chi^2(1) = 2.7$, $p = .1$). The introduction of the new and improved denominal context led

to a significant difference overall between the original and enhanced passage ($\chi^2(2) = 6.6$, $\underline{p} = .04$). In particular, regular inflections were chosen more frequently in the enhanced passage than in the original passage (54% vs. 35%, respectively; $\chi^2(1) = 6.1$, $\underline{p} = .01$).

Table 4 about here

The results of this experiment suggest that when an enhanced context is employed, a denominal verb is more likely to be inflected with a regular past tense than a verb that has not undergone grammatical class change. These results serve to confirm our suspicions that there were shortcomings in Ramscar's original attempts to induce a denominal reading for his verbs. The results support the claim that regular inflection is conditioned by grammatical constraints that make reference to syntactic categories like noun and verb.

We note that preference for the regular over the irregular past tense forms in the enhanced denominal condition, although significant, was not overwhelming (54% vs. 42%). Notice that 30% of our independent raters were also not moved to favor our enhanced context as being more denominal than Ramscar's original context. It is possible that some participants still did not construe the novel verb as being derived from the noun. Such construal is not mandated by our context, it was only made more perspicuous. It remains plausible that the verbal usage of *sprink* could be interpreted as a parallel verb, not derived from the noun (like *snack*, where neither verb nor noun appear to take precedence) or possessing indeterminate status with respect to derivation. Moreover, any attempts to induce a denominal interpretation must compete with the strong tendency for *sprink* to assimilate to the gang effects that overwhelmingly predispose its irregular inflection, all other things being equal. Our results do not support the claim that regular inflections are preferred because the meaning of the new verb is more distant from the core meaning of the irregular verb. Recall that the denominals in the enhanced context were actually rated as more reminiscent of the verb *to drink* than in the original context. Therefore, the preference for regular past tense forms is contrary to this account.

To the extent that the present results do show an effect of derivation, they are actually consistent with one of the other results from Ramscar (2002). In one condition (modeled after Kim et al., 1991), a novel denominal verb was introduced using the context: "Last week I borrowed my neighbor's *sprink*. I went and _____ several pieces of hard wood with it." Participants produced

regular past tense forms (e.g., *sprinked*) 87.2% of the time when they completed this passage. This result differs from the one obtained by Ramscar (2002) with the denominal condition, where *sprink* referred to consuming vodka and sprats, and regular responses did not predominate. This result also departs from another experiment reported by Ramscar (2002), in which novel verbs were tested in a minimal context with no denominal reading: "Every Friday Sam likes to *sprink*, last week he ____ a lot." In this basic verb condition, the reverse pattern occurred: *Sprink* was used in the irregular past tense form (*sprunk/sprank*) 85% of the time. One possible interpretation of the overwhelming preference of *sprinked* in the wood-cutting context is that this framework allows a straightforwardly felicitous reading of *sprink* as a denominal verb.

Despite the strong reversal of inflectional preference in the wood-cutting context, Ramscar (2002) rejected grammatical derivation as an explanation. Instead, based on data from the Latent Semantic Analysis, he suggested that the denominal context had semantically primed existing verbs such as *chop*, *hammer* or *slice*. These verbs all have regularly-inflected past tense forms, which were hypothesized to have prime the novel verb. Given our present results, which show effects of denominalization not explainable in terms of semantic similarity to existing regular verbs, we suggest that Ramscar's rejection of denominalization to explain his results may not be justified. Taken together with the present results we find strong evidence on both fronts that denominalization can indeed lead to regularization of inflectional processes, as predicted by grammatical theory and not explicable within eliminative connectionist frameworks. Further evidence converging on these conclusions will be presented in the next experiment.

Experiment 3: Effects of Semantic Distance and Denominal Status in Real Verbs

In this experiment we ask whether grammatical derivation plays a role in determining a preference for regular past tense inflection, in denominal verbs that are homophonous with existing irregular verbs. That is, we explore whether the verb *to fly* will be inflected as *flied* when introduced as a denominal verb. Recall that with these homophonous verbs Kim et al. (1991) found a preference for regular past tenses when the verbs were introduced as denominals, and a preference for irregular past tenses when the verbs were presented as deverbals. Thus, participants preferred *flied out to center field* (denominal) and *flew off the handle* (deverbal). Semantic distance effects were negligible, accounting for almost none of the variability in the data.

In their analysis, Kim et al. (1991) had participants rate the semantic distance of the verb meanings from the typical meaning of the irregular verb (*birds fly south in winter*), thus establishing a continuous scale on this factor. They could then correlate semantic distance ratings with acceptability ratings for regular past tense forms.[2] The problem with this analysis was that the two predictors (grammatical status and semantic distance) correlated very strongly ($r = 0.77$). While grammatical derivation accounted for 22.8% of the residual variance, the contribution of semantic distance was almost negligible (0.6%). Kim et al. (1991) concluded that grammatical status, rather than semantic distance, is critical in determining preference for regular past tense inflection.

In evaluating this experiment, Ramscar (2002) raised the issue that Kim et al.'s method for determining whether or not a verb is derived from a noun was based entirely on their own judgments. He suggested that such judgments appeared to be unjustified in some cases, and that this method of determining grammatical status was possibly circular: Kim et al. might have assigned verbs as denominal on the basis of their tendency to take the regular or irregular inflection, rather than by truly independent criteria. Furthermore, given the high degree of correlation between ratings of grammatical status and semantic distance in Kim et al.'s items, it is not possible to determine whether one or both factors account for the correlated portion of the variance.

Ramscar (2002; Exp. 4) addressed these concerns by reevaluating Kim et al.'s (1991) materials. Rather than relying on Kim et al.'s intuitions about derivational status, Ramscar had participants rate whether they thought the verbs classified as "denominal" in Kim et al.'s materials were actually derived from nouns. Since ratings of denominal status were still correlated with semantic distance, Ramscar analyzed effects of each of the variables (semantic distance and denominal status) after partialling out the effects of the other variable. Partial correlations on semantic distance significantly predicted ratings of past tense acceptability for both regular ($r = .61$) and irregular ($r = -.71$) forms. Ratings of denominal status predicted neither of these ratings after semantic distance was partialled out.

How is it possible that two studies using essentially the same materials could come to such radically different findings? Why did a change from using intuitions to ratings lead to a complete reversal of effects? Part of the answer probably lies in the use of highly inter-correlated measures of grammatical derivation and semantic distance. Ramscar was able to decouple the variables to a certain degree, by showing that participant ratings of derivational status did not always agree with Kim et al.'s (1991) ratings. To the extent that this realignment weakened the correlation between

grammatical status and inflectional preference, so too did it increase the proportion of variability in past tense ratings accounted for by semantic distance.

Before accepting Ramscar's results at face value, it is important to consider the data in more detail. Ramscar's data in this experiment are represented graphically in Figure 1A as a scatterplot with regression line. Here we concentrate on regular past tense forms because of their theoretical significance – these are the forms that the Words and Rules dual route account expects to appear with denominal verbs. Although Figure 1A shows no significant relationship between derivational ratings and ratings for the regular inflection (r = .058), it appears that the lack of correlation is accounted for by three outliers: *Lie, broadcast,* and *brake*. In each case, raters did not consider these verbs to be derived from nouns, even though their regular past tense forms (*lied, broadcasted, braked*) were rated as highly acceptable. In Figure 1B, we re-plot the data with these items deleted, which now yields a significant correlation between ratings of derivational status and regular inflection (r = .46; $p < .05$).

Figure 1 about here

Kim et al. (1991) proposed that the verb, *lie* (prevaricate) means "*to tell a lie*" and hence implies a noun *lie* as the derivational source. But the noun meaning is not obligatorily implied in the verb meaning: You can lie with your eyes; you can lie with silence ("*speak now or forever hold your peace*"). *Broadcast* and *brake* also exist as verbs quite independently of their related nouns. Even Kim et al. (1991) speculate that participants in their studies may not have categorized these verbs as denominals (p. 192), which appears to have been quite prescient.

Is it justified to include data from *lie, broadcast,* and *brake* in an analysis of the role of derivational status on inflectional preference? These verbs are not considered to be derivational forms yet their inclusion in the analysis serves to destroy the correlation between these variables. The Words-and-Rules model only claims that true denominal verbs should show a preference for regular inflection. Deverbal verbs are essentially metaphorical extensions of base verbs (e.g., *to fly off the handle* still invokes a notion of flying) and inherit their past tense forms from the base verbs. As such, they should also be irregular if their base verbs are irregular. The theory makes no prediction about verbs that happen to sound like another irregular verb, but are not related to that verb through metaphor, and neither are they derived from a noun. Therefore, the failure of

participants to show a preference for the irregular form in the case of *lie, broadcast,* and *brake* provides no basis for the evaluation of the Words-and-Rules theory and should be excluded as we have done in Figure 1B.

By proposing the exclusion of such verbs from the analysis, we are left with the question of how speakers do actually determine that a verb like *lie* (prevaricate) is regular or irregular if it is neither denominal nor related to *lie* (be supine). Notice that most of the experimental items used by Kim et al. (1991) and Ramscar (2002) were novel or rare denominal verbs like *shedding the tractor* (putting the tractor in the shed) or *drinking your friends* (supplying drinks to your friends). In the absence of previous experience with such uses, only productive generalization or rule-based processes could account for choice of the past tense form.

These novel items were chosen for the specific purpose of testing effects of denominal status on past tense inflection. By design, their meanings rather transparently reflect that they are derived from nouns. In contrast, the three renegade verbs *lie*, *broadcast* and *brake* are well established and conventional. Thus, their past tense forms are also established in the language and are available in the input to language learning.[3] These past tense forms need not be created anew by participants in these experiments.

How the established past tense forms for *lie, broadcast,* and *brake* end up being regular or irregular can be explained through diachronic rather than synchronic processes. For example, the noun *lie* and the verb *to lie* (both prevaricate) originated from distinct roots in the 10th century, becoming homophonous only through convergent sound change. So, historically, there is no derivation from the noun to the verb. The verb originated in the 10th century from a Teutonic strong (irregular) verb *leah*, then switched to a weak (regular) verb in the 14th century as *lye* or *ligh*. On the other hand, *lie* (be supine) originated in the 12th century from the Northumbrian term, *licgan*, then evolved through some thirty different forms until settling down as *lye/lie* between the 15th and 17th centuries. The irregular past tense settled as *lay* around the 12th century, before its current indicative present tense form (*Oxford English Dictionary, online version*). *Broadcast* and *brake* show similarly complex historical trajectories.

The checkered histories that determine the origins of present and past tense forms unravel like species on the Galapagos Islands. Clearly, for many centuries people were not using semantic distance metrics to determine how to inflect *lie* since the two verbs did not converge as homophones until five to seven hundred years after the introduction of the first form. The

snapshot one gets from an experiment designed to test past tense formation for novel cases is relatively unrelated to how those forms emerge as established verbs in the lexicon. Established conventional forms evolve historically and, if sufficiently frequent in the language, can be learned directly and accessed through stored representations. We cannot expect such verbs to gravitate toward irregular past tense forms just because they end up sounding like another unrelated irregular verb in Modern English. In particular, no such prediction can be derived from the Words-and-Rules account. Since Ramscar's (2000) correlational analysis included the verbs: *lie, broadcast* and *brake,* it required precisely such a relation between the unrelated homophones. When the renegade verbs are removed from the analysis, as in Figure 1B, then derivational status and past tense inflection do now show the predicted correlation.

Unconfounding Derivation and Semantic Distance

Because ratings of denominal status and semantic distance are highly correlated in the materials used by Kim et al. (1991), and later by Ramscar (2002), it is impossible to determine which of the factors accounted for the variance in past tense ratings or if they both influenced ratings. To resolve this problem we need to develop materials in which ratings of denominal status and semantic distance are not correlated. In Experiment 3, we developed verb stimuli in which denominal forms were rated as semantically more related to the core irregular verb, and the deverbal form was rated as more distant.

Ramscar (2002) concluded that semantic distance from the core irregular verb meaning determined inflectional choice for homophonous verbs in his experiments. According to this account, denominal verbs in Experiment 3 should show higher acceptability ratings in the irregular inflection than deverbal homophones. This is because the former would be rated as closer in meaning to the core irregular verb. Regular past tense forms should be preferred for the semantically more distant deverbal verbs on Ramscar's semantic account. Contrasting predictions follow from accounts that propose that the grammatical process of denominalization promotes regular inflectional choice. Under the grammatically-based account, regular forms should be rated as more acceptable for denominals than for deverbals.

The design of our experiment required collecting several ratings concerning properties of the test verbs to ensure that they met the appropriate design characteristics with respect to semantic

relatedness and to eliminate other differences between test items that might possibly confound the results.

Method

Materials and Design The design of the present experiment mimicked that of Ramscar's (2002) Experiment 4, which itself was modeled after Kim et al.'s (1991) Experiment 1. We collected several types of ratings concerning the set of test verbs. These included: (a) ratings of semantic distance from the core irregular verb; (b) derivational status; (c) acceptability of the regular and irregular past tense forms. For reasons that we explain below, we also collected ratings of whether the verb meanings were novel or familiar. The materials and procedures used for the different ratings will be presented in turn. In addition LSA cosines were computed as an alternative to the semantic distance ratings.

(a) Semantic Distance Ratings Task Participants (N = 50) rated how distant the meanings of denominals and deverbals were from the meanings of their corresponding prototypical irregular verbs. For example, on one item, raters were presented with the deverbal context passage for "feeding the liquor", which meant: To add body to the flavor of liquor. They rated the distance between this meaning and that of the prototypical meaning of the verb exemplified in the context sentence: "The mother bird feeds worms to the babies." We selected thirteen test verbs that are canonically irregular in their basic core form like *feed-fed*. For each verb we constructed three types of passages. In a first passage, the verb appeared with a meaning that we considered to be prototypical. In the two other passages the verb appeared in one context that was designed to evoke a denominal interpretation, and the other a deverbal interpretation (see Table 5A for examples). Half of the raters (n=25) were tested on denominal items, and half (n=25) on deverbals.

Context passages were designed to be brief, yet provide sufficient information about meaning and grammatical properties. In many cases, both deverbal and denominal verbs had meanings that would be unfamiliar to the participants. These were either made up or they were real meanings listed as "archaic" in the *Oxford English Dictionary* (online version). The passages referred to historical contexts for archaic verb meanings, or to futuristic contexts for made-up verb meanings. Passages for denominals and deverbals were equated for mean number of words ($t<1$). Test verbs never appeared with an irregular inflection (past tense or past participle) in the passages used for semantic distance ratings. The whole set of sentences used in the task is presented in Appendix A.

Table 5 about here

To validate our intuitions as to the typicality of verbs in the core prototypical contexts, the verbs in these passages were judged by twelve raters. Raters were instructed "to rate *how typical* the present meaning of a word seems when you consider the use of that word in general." The examples "*catch a ball*" and "*catch a cold*" were given to illustrate typical and non-typical word use, respectively. Typicality judgments were expressed on a 7-point scale, where 1 equaled "not at all typical" and 7 equaled "very typical." Typicality ratings for these passages were generally high (min. = 4.4, mean = 6.15).[4]

Individual booklets were prepared for participants who rated semantic distance from the core irregular verb for either denominal or deverbal verbs. Participants only saw one type of verb context (denominal or deverbal) in their booklets and verbs were in different randomized orders for each participant. The critical verbs were highlighted by underlining them (see examples in Table 5A). Beneath each pair of passages there was a 7-point scale, where 1 was labeled as "strong reminding" and 7 as "no reminding." The ratings in this experiment were scaled in the opposite direction to that used in Experiment 2 for semantic reminding where high scores indicated high semantic reminding. The reversal was done to be compatible with Ramscar's (2002) Experiment 4 after which the present study is modeled. Higher ratings on the scale now indicate greater semantic distance of the derived verb meaning from that of the core irregular verb.

Participants were asked to compare the verb highlighted in each pair of passages (prototypical and derived) and to rate the extent to which "the activity or action of the verb described in the [derived] passage reminded you of the typical meaning of the verb illustrated in the other passage." Participants were invited "to consider all the possible things that you usually associate with this use of the word" as well as "to consider the use of the word as presented in the whole context of the passage." The task was illustrated using the same examples as used by Ramscar (2002, p.73). We also presented 6 warm-up items at the beginning of the task to get participants accustomed to the rating procedure. Different orders were used in this task, as well as in the other tasks of Experiment 3.

(b) Grammatical Derivation Ratings Task Participants in this task (N = 47) rated whether verbs were derived from homophonic verbs or nouns. The passages used in this task were those used with

deverbals and denominals in the Semantic Distance Rating Task. Specifically, participants were asked to indicate whether a given verb "has been made from a noun, or whether it is a verb that is just a verb." An example (from Ramscar, 2002, p. 74) was used to illustrate their task: "consider a word like 'fly.' In the sentence "Birds *fly* south in winter," you might decide that 'fly' is being used in an ordinary, *verb-like* way. But consider the following example: "To promote business, the pesticide shop always stands a man in a giant fly costume at the entrance to greet customers. Whenever someone enters the shop, the greeter performs 'the fly.' One afternoon I saw him *fly* 40 customers." In this latter example, you might decide that the underlined instance of 'fly' is a verb made from the noun 'fly.' That is, it's being used in a *verb-from-noun* manner." Participants were instructed to provide their ratings on a 7-point scale, where 1 "means you feel the verb is definitely being used in a verb-like manner, and 7 means the verb is definitely being used in a verb-from-noun manner." The task was introduced by three practice trials. Beneath each passage there was a seven-point scale with 1 marked as "definitely "verb-like" use" and 7 as "definitely "verb-from-noun" use." Booklets were prepared following the same procedure outlined in the Semantic Distance Rating Task. Note once again that participants saw only one variant of the verb (either the denominal or the deverbal).

(c) Past tense Acceptability Ratings Task Participants in this task (N = 50) rated the appropriateness of the regular and irregular past tense forms of verbs. For this task, we changed the last sentence of the passages used in the semantic rating task to require the past tense form. For example, the last sentence of the deverbal passage of *feed* changed from "Arthur was an esteemed maker of liquors whose customers especially praised his ability to feed his liquor" to "… praised the way he fed/feeded his liquor." As in the semantic ratings task, raters' booklets contained either denominal or deverbal passages, but not both. Thus, half of the participants (N=25) saw each of the context types. For each item, both regular and irregular past tense forms were included (see Table 5B). Beneath the passage, there were two seven-point rating scales, one for the verb with regular past tense form, another for the irregular inflection. In half of the booklets, regular forms were shown above the irregular forms, while order of presentation was counterbalanced for the other half. In both scales, 1 was labeled as "very unnatural sounding," while 7 was labeled as "very natural sounding."

The instructions used for this task invited participants to indicate "how natural or acceptable a particular form of a verb sounds to you in a given context." Participants were instructed "to base

your ratings on *your own intuitions* of natural speech, and not necessarily what you have heard is 'proper' or 'standard' or 'formal'." Participants were also asked to note that "this is not a test of grammar; we want to know how natural the word sounds *to you*." Instructions further informed participants "to rate how the form of the word sounds *within the given context*." At the beginning of the task there were six practice trials.

(d) Novelty Ratings Task Novelty was a potential problem if participants were more inclined to produce regular forms for novel verbs. Such a bias could be rooted on the noticeable feature of English that newly coined verbs are overwhelmingly regular. Thus, participants would choose regular forms in our experiment because the verbs are felt to be novel more so than for their semantic or grammatical properties. We then assessed whether there was a systematic bias such that the denominal forms were considered to be generally more novel than the deverbals. Raters (N = 25) were presented with brief definitions of the meanings of denominals and deverbals and judged whether they "had the feeling of having encountered these meanings before." Examples of these definitions are presented in Table 5C. Participants had three options: "yes" ("I am certain I have encountered this way of using this verb before"), "no" ("I feel that I have never encountered this way of using this verb before"), and "maybe." In booklets, the two definitions of a verb were presented one after another, with the three options ("Yes," "No," and "Maybe") shown beneath each definition. Each participant judged the entire set of definitions. Instructions emphasized that participants were not asked "whether the usage is plausible" but whether they feel that they "have actually encountered it." There were three practice trials.

Latent Semantic Analysis Additional data about the semantic characteristics of the context passages for the denominal and deverbal forms were gathered from the Latent Semantic Analysis (LSA). This is a program used for representing word meaning based on the contexts in which it appears in large text corpora (Landauer et al., 1998). For each word in the corpus, LSA derives a point within a high dimensional semantic space. This point functions as a representation of the core meaning of the word. By computing the cosine distance between this point and the point derived from the context passages for our experiment for each verb, we could develop an alternative measure of semantic distance that did not rely on human judgments.

Results and Discussion

The mean ratings of deverbal and denominal forms for derivation and semantic distance are presented in Table 6, which also provides the semantic distances, expressed as cosines, obtained from the LSA. Mean ratings for past tense acceptability are reported in Table 7. For derivational status, participants generally agreed with our intuitions that the verbs classed as "denominal" were, in fact, so. They were more likely to be judged as being derived from nouns than deverbal verbs (average: 4.96 vs. 2.91; $t(12) = 10.0$, $p < .0001$). Participant ratings also agree with our judgments that denominal status and semantic distance were no longer conflated in our materials. In fact, the meanings of the denominal verbs were rated as being closer to the "typical" core meaning of the verb than the deverbal forms (mean ratings: denominal verbs = 3.19; deverbal verbs = 4.58; $t(12) = 4.6$, $p = .0005$). These ratings were also consistent with the Latent Semantic Analysis (LSA). Within the semantic space defined by LSA, the contexts of the denominal forms were closer to the core meaning of the verbs than were the contexts of the deverbal forms (cosine means: 0.53 vs. 0.47; $t(12) = 2.7$, $p = .01$).

Table 6 & 7 about here

A two-way ANOVA with Verb Category (denominal vs. deverbal) and Past tense Form (regular vs. irregular) as independent variables was performed on the past tense acceptability ratings. Figure 2 summarizes the results. Across the board, there was a general tendency to prefer irregular past tense forms over regular past tense forms (means: irregular forms = 5.33, regular forms = 2.77; $F(1, 24) = 92.1$, $MSE = 85.1$, $p < .0001$), but the interaction between category and past tense form was highly significant ($F(1, 24) = 18.7$, $MSE = 17.2$, $p = .0002$). Post hoc analyses revealed that irregular inflections were rated as more acceptable for deverbal verbs than for denominal verbs (means: 5.98 vs. 4.69; $F(1, 24) = 16.7$, $MSE = 10.6$, $p = .0004$), whereas regular inflections were preferred for denominal verbs over deverbal verbs (means: 3.29 vs. 2.26; $F(1, 24) = 12.4$, $MSE = 6.8$, $p = .001$). Finally, with regard to novelty ratings, we found that deverbal verbs were judged to be novel significantly more often than denominal verbs (76% vs. 50%; $F(1, 24) = 8.15$, $MSE = 264.9$, $p = .008$). Therefore, any preference for regular inflection for denominal verbs over deverbal verbs cannot be explained by greater perceived novelty of the denominal verb.

Figure 2 about here

Further analyses were designed to take advantage of the continuous nature of the derivational and semantic measures. Multiple regressions were run to further estimate the contribution of the semantic distance and grammatical origin in acceptability ratings for regular versus irregular past tense forms. All variables were entered together with no predetermined order. In separate analyses, the contribution of meaning was assessed by ratings of semantic distance and LSA cosine values. In addition, to be sure that novelty of the item was not a confounding variable, ratings of novelty were also added to the model. Alternative dependent variables included mean acceptability ratings for (a) regular forms, (b) irregular forms, and (c) the signed difference between these ratings. The latter is a measure that reflects the relative preference for regular or irregular forms. This is preferable to judgments of individual past tense forms (either regular or irregular), because it mirrors the overall plausibility of each of these inflected forms (Kim et al., 1991). The results of these regression analyses are reported in Table 8. Grammatical derivation (denominal vs. deverbal verbs) consistently accounted for a large proportion of the variance (45% to 54%) in judgments about acceptability of past tense forms, even when the contribution of verb meaning was partialled out. Semantic distance to core typical meaning never emerged as a significant predictor of participant ratings of past tense acceptability in either the semantic ratings or LSA analysis. Finally, novelty was also never a significant predictor of past tense ratings in these data.

Table 8 about here

Comparison with Ramscar's Data

Another way to test the role of semantic factors in determining preferences for regular over irregular past tense forms is to contrast the results of our Experiment 3 with those obtained by Ramscar in his analogous Experiment 4. Ramscar's verbs were grouped as deverbal and denominal according to Kim et al.'s (1991) categorization, which resembles the psychological ratings very closely.

Unlike the denominal verbs used in Kim et al. and Ramscar's studies, ours were designed to be close in meaning to their respective prototypical irregular verbs. If there were a strong effect of semantic distance on the acceptability of regular past tense forms, then our acceptability ratings for regular past tense forms should be much lower than those for Ramscar's study because our semantic distance ratings were overall lower for the denominals. By the same token, acceptability ratings for irregular past tense forms should be higher with our items than for Ramscar's items. The data for this comparison are shown in Table 9A.

Table 9 about here

As expected, our denominal verbs were less distant in meaning to the prototypical verbs than those used by Ramscar ($F(1, 23) = 22.8$, $MSE = .96$, $p < .0001$). These semantic differences, however, did not translate into parallel differences for ratings of regular inflection ($F(1, 23) = 1.6$, $MSE = 1.1$, $p = .21$). Only with irregular ratings did a difference emerge that was consistent with the hypothesis of a semantic influence where our denominal verbs were scored as more acceptable in the irregular past tense form than Ramscar's (means, 3.21 vs. 4.69; $F(1, 23) = 13.6$, $MSE = .98$, $p = .001$). Below, we propose an explanation for why the direction of difference was only significant for the irregular denominals.

Similar comparisons can be made with deverbal verbs. The data are shown in Table 9B. Our deverbal verbs were selected as having distant meanings from those of their core verbs, unlike in previous studies where deverbal verbs tended to be rated as closer in meaning with their core verb. Consistent with these expectations, the semantic reminiscence ratings were much higher for our deverbal items than Ramscar's ($F(1, 23) = 30.5$, $MSE = .775$, $p < .0001$). If there were an influence of semantics, our deverbal verbs should also receive higher scores for their regular forms, but lower scores for their irregular forms compared to Ramscar. Neither of these predictions was confirmed (all Fs<1). Thus, out of the four tests of an effect of semantic influence only, one result was consistent with the semantic influences. This exception is explored further below. On the whole, the comparative analysis does not support the claim that semantic distance determines inflectional preference.

Our results, in general, run contrary to those of Ramscar (2002), who reported that denominal status (as rated by participants) did not account for any of the residual variance when semantic

correlations were partialled out. As we pointed out, this analysis required that verbs, not judged to be derived from nouns, to be preferred in the irregular past tense form. We argued, contrary to both Kim et al. (1991) and Ramscar (2002), that determination of inflectional status in such cases is a matter of diachronic rather than synchronic processes. At first blush, our data from Experiment 3 appear to support Kim et al.'s (1991) position that noun-to-verb derivation can predispose a choice of regular inflection for a verb that normally shows irregular inflection. Certainly it was the case that the regression analyses showed effects of derivational status, but no effects of semantic distance.

Similarly, in a straightforward comparison of our data to those of Ramscar, we found that profound differences in semantic distance had no major effects on past tense form preferences. Despite the fact that much of the variability in our data appears to be accounted for by grammatical factors, our data do differ from Kim et al. (1991) in a very significant respect: We found that participants preferred the irregular over the regular past tense forms across the board, whereas Kim et al. found a preference for regular over irregular inflections for the denominal verbs, and vice versa for the deverbal verbs.

Short Circuit Effects

One major difference between our materials and those used in Kim et al. (1991), and later in Ramscar (2002), is that many of our verbs involved double derivations. In order for the denominal verb to be related in meaning to the prototypical verb, we often required that the denominal verb be derived from a noun that was, itself, derived from the original verb. For example, the denominal for *bite*, involved using insect bites (noun) to cure patients, which was called *biting the patients*. Thus, the denominal verb *biting the patients* was derived from *insect bites*, a noun that is derived from the irregular verb *to bite*. This circuitous path of derivation is what allowed us to make the denominal verbs closer in meaning to the core verb than the deverbal verbs. The problem with this approach is that many of the participants might not perceive the verbs as being derived from the noun, but might participate in what Kim et al. (1991) refer to as a "short circuit," whereby the derivational process is finessed in favor of direct access to the core verb, regardless of meaning differences that would normally require a grammatical analysis.

Kim et al. (1991) noted that participant ratings of denominal forms in their data did not always show a preference for regular inflections. They suggested that their participants might have felt that such verbs were not derived from nouns and instead based their inflectional status on phonological similarity to the typical core verb. Kim et al. further noted that, within the "denominal" verbs, such

doubts might be reflected in ratings of semantic similarity between the "denominal" verb and the typical irregular verb meaning. That is, if some verbs were perceived as less denominal than others, then subjects would perceive them to be more similar in meaning to the typical irregular verb. These analyses revealed that, within the denominal verb group, there was an effect of semantic similarity: Denominal verbs rated as more similar to typical verb meanings had higher ratings of acceptability for the irregular form. Although this appears to be an effect of semantic similarity, Kim et al. point out that this effect occurred only in the case of the denominals, and only for the ratings of irregular forms. Semantic distance did not predict acceptability ratings for the class of verbs as a whole nor for the ratings of regular past tense forms

The denominal verbs in our study were designed to be highly similar in meaning to their related core irregular verbs. If the short-circuit mechanism were at work in our data, then the high degree of semantic relatedness for the denominals could explain why, in general, irregular past tense forms for denominal verbs were preferred over regular past tense forms. We can distinguish this account from one that predicts a general effect of semantic similarity on inflectional preference. The short-circuit hypothesis predicts effects only in the case of the denominals, and only for the irregular past tense forms. The semantic account predicts across-the-board effects of semantic distance.

The predictions of the short-circuit hypothesis were tested by examining correlations between semantic distance ratings and acceptability ratings for regular and irregular verbs for the two verb categories. These are shown in Table 10. Semantic distance ratings correlated with only one variable: Irregular past tense ratings for denominal verbs ($\underline{r}$= -0.52, $p<0.05$, 1-tail). This is exactly as anticipated by the short-circuit hypothesis. We replicated the earlier pattern of results of Kim et al. (1991) with a new set of items differing considerably in semantic and grammatical characteristics.

Previously, in the analysis of the data from Experiment 3, we compared the data on semantic distance effects with those obtained by Ramscar (2002), taking advantage of the reversal of semantic distance ratings for the denominals and deverbals in two experiments. As in the present case, the analysis comparing our two experimental results also found semantic effects *only* with denominal verbs and *only* with the irregular past tense. The selectively of the semantic effect observed in this comparison is again in line with the short-circuit hypothesis.

Taken together our results strongly support the interpretation that similarity in meaning to the core irregular verb can have a competitive influence in pulling denominals into the fold of accessing past tense forms directly from the irregular prototype. Given the complexity of the derivational

process in our items, we suspect that the competitive pull of the irregular past tense form could be extremely strong when it was sufficiently similar in meaning to the derived form. Be that as it may, we remind the reader that these results stand in contrast to Ramscar's proposal that semantic distance determines preference for regular past tense forms, regardless of supposed derivational history. In the end, the only factor that affected judgments of acceptability for regular past tense forms was whether the verb was derived from a noun.

Insert Table 10 about here

General Discussion

The purpose of this paper has been to evaluate the relative roles of semantic and grammatical processes in determining whether verbs should be inflected with a regular or irregular past tense form if they are homophonous with a core verb that is typically irregular. We contrast two kinds of accounts. The first involves what we term *eliminative connectionist models* that eschew symbolic representations and attempt to account for grammar in terms of emergent states within a distributed associative network of connections between low-level features of form and/or meaning. On the other hand, there are models of the "Words and Rules" variety that take seriously the need for representations for lexical items at all levels, for distinct symbolic representations of syntactic categories and morphological elements in rule-based processes, and for associative memory structures to represent stored lexical forms such as root verbs and their irregular past tense forms. Theorists adhering to the latter kind of model have pointed out that semantic properties do not appear to influence choice of past tense inflection (cf. *hit, strike, slap*). Although such a prohibition is not central to symbolic models, it does provide ammunition against accounts that propose distributed semantic representations as a way to solve the homophone problem. Ramscar's initial finding—and our replication in Experiment 1—go a long way to licensing the inclusion of semantic mechanisms of some sort in the process of past tense formation when a novel verb reminds the hearer of another verb that is either regular or irregular. But we are concerned that the specificity of the situation found in Ramscar's experiments—where inflection is generalized on the basis of a novel verb reminding the user of an existing verb—might be the exception rather than the rule in

everyday language use. Semantic activation of a more general type might not affect choice of regular or irregular inflection in cases where "reminding" is less transparent.

Does the dual model account for the present data?

How does the availability of symbolic representations and the existence of two kinds of linguistic processing (stored vs. computed) solve the homophone problem and provide a model of language processing that is commensurate with the data that we have presented in this paper? In attempting to answer this question, we must explain the following outcomes from Experiment 3:

1. Denominalization ratings predicted acceptability ratings of regular past tense forms.
2. Semantic distance ratings did not predict acceptability of regular past tense forms.
3. Semantic distance ratings did predict acceptability of irregular past tense forms for denominal verbs only.
4. There was a general preference for irregular past tense forms in our items overall. This is in contrast to previous studies where regular past tense forms were preferred for denominal verbs.

In general, these outcomes support the following conclusion: Derivational status influences decisions about the acceptability of regular past tense forms, and these choices are unaffected by semantic distance from the irregular homophone base verb. In Experiment 3, denominal status was relatively weakly perceived because of the requirement in their construction that grammar and meaning to be put in competition. To the extent that the denominal status of items was not perceived by participants, then this would force them to fall back on the "short-circuit" route by which semantic similarity to an existing irregular verb led to high acceptability for the irregular past tense forms in these cases. The present data are in line with the account originally proposed by Kim et al. (1991), and replicate the specific predictions of the short-circuit analysis. However, our data present a case where the short-circuit route provides much stronger competition and, in many cases, trumps the noun-to-verb derivational route that leads to preferences for the regular past tense form. The present data do not support Ramscar's (2000) claim that only semantic distance predicts past tense acceptability, although it does allow semantic factors to play a more subtle role in the process.

In attempting to account for this array of facts, we need to ask two questions: 1. Do we need symbolic representations of syntactic categories like noun and verb attached to lexical items? 2. Do we need a dual model that distinguishes between stored and computed representations, including

computations involving derivations from noun to verb? In attempting to account for our data, and to adjudicate between various models, we must distinguish between formal linguistic models that attempt to capture "pure" grammatical principles, on the one hand, and models of language processing that may attempt to capture the interface between grammatical systems and processing constraints on the other hand. This is basically a form of the competence-performance distinction. A purely grammatical model of noun-to-verb derivation might characterize an idealized noiseless system, but fail to capture the competitive forces at work when a real language user attempts to make sense of the use of a word in a novel context. A connectionist-type network, on the other hand, can capture many aspects of information processing that involve graded learning and performance, particularly when that gradation is the result of competition between representations and processes of activation or inhibition within associative memory structures.

Fortunately, we do not need to consider these as opposing models of language use, since the connectionist models can embody linguistic principles if they are designed to do so. Even though connectionism itself sprang from an attempt to expunge symbolic rule systems from cognitive science, connectionism itself is a medium in which many different kinds of representations are possible, including symbolic representations. As Marcus (2001) points out, dedicated localist nodes that represent categories in connectionist systems are formally equivalent to symbolic representations. With hybrid connectionist architecture that contains localist nodes representing categorical information, it is possible to capture the interaction of the categorical systems of grammar, and the graded nature of information processing.

The dual model also postulates that there are two kinds of linguistic processing: Those that reflect the operation of associative memory over stored representations, and those that reflect combinatorial rule-like processes that do not show characteristics of associative memory. The dual model therefore requires a stronger defense than merely stipulating the existence of symbolic representations. A connectionist architecture with symbolic representations in the form of localist category nodes might still participate within a single-level associative memory structure that did not distinguish between stored and computed representations. For example, one might have a symbolic representation for verbs and the regular –ed past tense form, but nevertheless derive the "default" nature of its application as an emergent property of its distributional properties in the language rather than have it be the result of the application of default rules.

Symbolic representations of syntactic categories like noun and verb would be useful in accounting for the data of Experiment 3. Ratings of noun-to-verb derivational status factored strongly into determining whether a regular or irregular past tense form is favored. On the other hand, the fact that participants in the present experiments have enough uncertainty to rate derivational status on a continuous scale might suggest that grammatical derivation is not an all-or-none phenomenon in the minds of actual language users. Variability in ratings of derivational status could be said to reflect a squishy notion of "noun-to-verb-ness." On the other hand, variability in ratings could also reflect the relative certainty or uncertainty of a derivational reading of a verb that is in competition with other possible interpretations. It seems likely to us that there are multiple possible competing analyses of the structures and derivational histories underlying the novel complex constructions and so uncertainty about the appropriate analysis is to be expected. This does not negate the need for categorical representations; it merely puts the analysis in competition with other analyses.

In the kind of dual model that could usefully account for the present results, each stored word would have a dedicated lexical node—an index that represents the identity of the lexical item. Each of these lexical nodes would be connected to a set of semantic features, a set of phonological features, and a set of categorical features that defines its syntactic properties (cf. Caramazza, 1997; Dell, 1986; Levelt, Roelofs, & Meyer, 1999). Each set of semantic and phonological features would link the lexical item to other items that shared those features within an associative network. Each established distinct homophone would be represented by a distinct lexical node (cf. Caramazza, Costa, Miozzo, & Bi, 2001; Dell, 1990; Jesheniak & Levelt, 1994; Miozzo, Jacobs & Singer, 2004). For example, a noun like *shed,* and the irregular base verb *to shed* would each have their own lexical representations with distinct sets of syntactic and semantic features, sharing only phonological features. An extended use of the verb *to shed*, which would be classified as "deverbal" in the current set of studies, may or may not have a distinct stored lexical representation. Cognate polysemous verbs could have independent representations in some cases and not in others or there could be a graded differentiation whereby overlapping sets of semantic features might show degrees of independence between different polysemous versions of a verb (for a discussion of these issues see Caramazza & Grober, 1973; Klein & Murphy, 2001; Murphy, 2002).

When a verb and noun are homophonous, the following possibilities exist:

(a) The verb and noun are unrelated (e.g., *a garden shed* vs. *to shed tears*).
(b) The noun and verb are related but neither seems to take priority and hence no discernable derivational relation can be assumed (e.g., *a snack*/*to snack*).
(c) The noun is derived from the verb (*to walk* → *a walk*).
(d) The verb is derived from the noun (*a shed* → *to shed the tractor*).

With respect to the relationship between noun and verb, one must consider whether the derived form is well established in the language or if the relation is rare or novel and requires the employment of computational resources to derive an appropriate representation of structure and meaning. In the cases examined in the our experiments, participants were required to access existing forms that shared phonological feature sets (i.e., are homophones), but did not share all of their semantic features with the novel words.

In discussing how the past tense form developed for a verb like *lie (prevaricate)*, we noted that some established verbs' past tense forms can be traced through historical processes of language change that would become conventionalized through common usage within the language community (Bybee, 1995). In other cases, where the usage and/or meaning is more novel, the preferred past tense form must be determined online. It has been the task of the present study to examine whether this online determination of past tense form is influenced by grammatical and/or semantic factors. The current data are consistent with the influence of grammatical processes in determining regular past tense preferences, but that this grammatical analysis is in competition with direct access via the short circuit to the semantically related core irregular verb.

A processing model that could account for the present data would need to take account of competition between different routes to lexical inflection. As Alegre and Gordon (1997) point out, the notion of a dual route model for inflection is ambiguous in the psycholinguistics literature. The dual route model we have discussed in this paper, as proposed by Pinker (1991) and his colleagues, concerns the distinction between stored (irregular) and computed (regular) forms in language. The other kind of dual model in psycholinguistic research addresses how regularly-inflected forms are accessed in the language processing (Anshen & Aronoff, 1988; Burani & Caramazza, 1987; Caramazza, Laudanna & Romani, 1988; Frauenfelder & Schreuder, 1991; Laudanna, Badecker & Caramazza, 1992; Schreuder & Baayen, 1995; Stemberger &

MacWhinney, 1988). The latter dual model proposes that regularly-inflected forms can be stored in memory (if sufficiently frequent in the language) and/or they can be computed and that these two access routes are in competition during language processing.

In the same way, we can envisage the present experimental tasks as creating competition between different routes to past tense formation for the denominal verbs. One analysis links the novel verb to a related noun – a form that does not have an associated irregular verb. Since access to an irregular form is not available through this route, then the processor settles on the default regular –ed form, which is always available for inflectional processing. If, on the other hand, the link to the noun meaning is less transparent, and derivation fails, then a competitive analysis—the short circuit—directly accesses the original irregular verb (from which the noun itself was likely derived, and to which an associated irregular past tense form is attached). Under this competition model, when the meaning of a denominal verb transparently reflects its derivation from the noun (as indicated by high denominal ratings), then this form more strongly activates the route that assigns it a regular past tense form. When the derivational relationship is not highly activated, then phonological and general semantic similarities will win over and make direct access to the original prototypical irregular past tense form more salient. Such a competition model predicts precisely the set of correlations we find in the present analysis.

Even though the competition model outlined here embodies the classic characteristics of a connectionist model of language processing (e.g., Macwhinney, 1989), it nevertheless requires an underlying representation that naturally blocks the irregular inflection from being applied when a verb is perceived to be derived from a noun. It requires that syntactic category labels be part of the representation for one of the competitive routes to past tense formation, and that the notion of derivation also be part of that representation.

Our results show that noun-to-verb derivation and semantic distance jointly determine the competitive strength of regular inflections. Indeed, it is not enough that verbs be semantically unrelated to the core irregular verb for them to block the application of the irregular past tense forms; they must also be perceived to be derived from a different syntactic category. In proposing the present processing model, we must also explain how it is that greater semantic distance does not seem to make it harder for deverbal forms to access the original core verb and its irregular past tense form. In other words, why shouldn't semantic distance be a factor in the competition model in the same way that perception of derivational status appears to be? Why

should greater semantic distance for metaphorical forms not create an impediment to accessing the irregular past tense form and instead lead people to fall back on the default regular form?

One possible answer to this question is that participant impressions of overall semantic distance or relatedness are not what links a semantically distant form and the core verb. For example, even though the uses of the verb *to fly* in the contexts of *flying off the handle* and *birds flying south in winter* have almost no semantic relationship, perhaps what counts is a more narrow interpretation of relatedness. In the present line of research, the notions of *core meaning* and *prototypical meaning* have been used almost interchangeably to refer to verb uses that reflect the most commonly understood meaning for the irregular verb. Perhaps this is a mistake. Although such common uses of verbs do reflect their *prototypical uses*, we should perhaps be more careful about what we mean by a *core meaning*. One construal of a core meaning of a verb is that verb meanings include abstract representations of event, motion, and participant information that is invariant across uses of the verb. For example, the core meaning of *flying* would include a schematic representation specifying only motion through the air, and where the manner of such motion would be left optional for specific uses of such a verb. Thus, even in the case of *flying off the handle*, the core meaning of *fly* would still be accessed in understanding this metaphorical use of the term. On the other hand, dressing up in a fly costume and "flying the customers", would have no access to the core meaning of the verb *fly*. If access to core meaning, rather than similarity to the prototypical usage, is what is at stake, then metaphors and deverbal forms carry the core meanings throughout and are not hindered in their access to the irregular past tense form, which also embodies the representation of this core meaning. Hence there is no scalarity when it comes to semantics, so long as the core remains intact.

To summarize, the first experiment in this paper did show effects of inflectional preference through semantic reminiscence with existing verbs. This tells us that semantic influences are not totally isolated from morphology. However, we suspect that the kind of narrow reminiscence required by the current experiments to generalize past tense forms is probably quite rare in everyday language processing and may not be indicative of a more general role for associative memory in determining inflectional choice. In the second experiment, we found that when grammatical processes of derivation are made salient, then this can influence inflectional form choice. Finally, in Experiment 3, when semantic distance and grammatical derivation were put to a fair test, we find no

evidence that semantic distance played any role in determining past-tense inflection. For the past tense to be *understood* or *understanded*, meaning alone is not enough.

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Appendix Passages used for rating Semantic Reminiscence (SR) and Past Tense (PT) with the verbs of Experiment 3

To bend

A. Typical use The plumber bends the pipe to fit under the sink.

B. Deverbal form Sailors in centuries past called the task of fastening a ship's cable to the ring of its anchor "bending the cable." It was important that all sailors know how to bend a cable, and most did it quickly and proficiently after a few days of practice. Another useful skill was bending two ropes, which meant joining them together with a bowline knot. Sailors on the HMS Mariana
   SR: decided to bend ropes whenever they needed a really long rope.
   PT: bent/bended ropes whenever they needed a really long rope.

C. Denominal form The Nile has more bends in it than any other river in the world. For example, the Amazon (another river of comparable length) has 20% fewer bends in it. In the 19th century, when a boat had to travel around a very sharp bend in the river, the boat crews referred to this as river-bending the boat. Captain Mohamed of the SS Nile Princess
   SR: likes to boast that he can river-bend his ship around the Nile better than any other Captain in history.
   PT: once boasted that he river-bent/bended his ship around the Nile better than any other Captain in history.

To bite

A. Typical use The dogs might bite the boy.

B. Deverbal form Early Puritan settlers felt it was a virtue to suppress displays of emotion and passion. An example of this attitude can be found in the diary of Miles Smith, a Puritan from Massachusetts. His restrained temper was considered model behavior, and he encouraged his restless young son to "bite in thine desires, and do not let them loose, lest they spread to thine brothers." The son, however, had other ideas.
   SR: He just did not want to bite in his desires.
   PT: He felt that he had bit/bited in his desires quite enough already.

C. Denominal form Doctors in the 16th century believed that one could cure many diseases by either bleeding patients with leeches or placing glass jars containing small garden snakes on their skin, so that they would be covered in bites. Before the doctors perfected this technique, they would sometimes accidentally use poisonous snakes and harm their patients. It is believed that physicians of this era
   SR: used to bite about half of their patients in this manner.
   PT: bit/bited about half of their patients in this manner.

To blow

A. Typical use The clarinet player has to blow into his instrument to make a sound.

B. Deverbal form In early descriptions of natural history compiled by English monks, the act of an insect depositing eggs was called "blowing eggs." It was widely assumed that this was how

insects reproduced, but few scientists knew anything about the hatching process, its various stages, or how long it took. William Morton, a 17th-century naturalist who specialized in insects, recorded details on hatching times

SR: by allowing exotic insects to blow eggs in slabs of meat he had laid out especially for that purpose.

PT: after exotic insects blew/blowed eggs in slabs of meat he had laid out especially for that purpose.

C. Denominal form In the futuristic novel *Electric Dreams*, the latest vacuum cleaner from Hoover has a switch that reverses the flow of air from a sucking action to a blowing action. Reversing the action in this manner is known as "blowing the Hoover." This action is powerful enough to act as a small leaf blower. Joe Smith, a character in the novel, decided that this capability was so useful that he

SR: used to blow the Hoover almost exclusively, hardly ever using it for house cleaning.

PT: blew/blowed the Hoover almost exclusively, hardly ever using it for house cleaning.

To breed

A. Typical use The owner of the ranch breeds cattle.

B. Deverbal form In Renaissance times, parenting manuals looked quite a bit different than they do today. Though printed literature was not yet widespread, well-connected doctors obtained current medical information and passed it along to the people they treated, who then passed it along by word of mouth. One pamphlet on infant care read, "About the seventh moneth after ye byrthe, it is natural for a childe for to breed teeth." Agatha, a new Renaissance parent, was concerned after hearing this information because her daughter

SR: began to breed teeth when she was only 4 months old.

PT: bred/breeded teeth when she was only 4 months old.

C. Denominal form In the 19th century, when a new lot of puppies was delivered from the breeding kennels to a dog store, the first order of business in the store was to assign a breed name to each of the new puppies they received. They referred to this as "breeding the inventory." Shop assistants generally found no difficulty in breeding the common types that came in, such as German Shepard, Great Dane and Bulldog. However,

SR: it takes an expert to breed the rarer types of dogs, such as Bernese Mountain Dogs.

PT: the rarer types that were part of the inventory, such as Bernese Mountain Dogs, could be bred/breeded only by the experts in the store.

To feed

A. Typical use The mother bird feeds worms to the babies.

B. Deverbal form Long ago, liquor makers used various processes to alter the flavor and quality of their brews. Preserving a liquor with certain chemicals made it last longer, "fining" the liquor clarified the color, and "feeding" it added body to the flavor. Arthur was an esteemed maker of liquors whose customers especially praised

SR: his ability to feed his liquor.

PT: the way he fed/feeded his liquor.

C. Denominal form Farmer Jones, a farmer in Medieval times, looked at the two horse troughs in his
barn – one for animal feed and the other for water. He decided that both troughs were low, so he went to the store room and got a bucket of water and a bag of feed, and he
SR: began to water one trough and to feed the other.
PT: watered one trough and fed/feeded the other.

To hold

A. Typical use The tennis player holds the racket.

B. Deverbal form In the Dark Ages, keeping watch over sheep was called "holding" a flock. Simon the Younger had little to do during those years, and the danger of night-time marauders making off with unwatched sheep was always great, so he found himself holding the family flock most nights. He was a careful watchman and actually enjoyed his nights with the sheep.
SR: He would hold the flock from dusk until dawn, and though he counted sheep all night, he rarely fell asleep at all.
PT: He held/holded the flock from dusk until dawn, and though he counted sheep all night, he rarely fell asleep at all.

C. Denominal form The term 'choke hold' defined a whole class of moves in wrestling in ancient Rome. Some of these were legal and commonly used, while others were not allowed because they were too dangerous. It could be hard to distinguish between a legal choke hold and an illegal one, which is why some wrestlers of the time liked this type of move so much. One wrestler relied on this sort of move almost exclusively—in fact, he
SR: used to choke hold every one of his opponents.
PT: choke held/holded every one of his opponent.

To make

A. Typical use The blacksmith makes horseshoes.

B. Deverbal form Scientists of the 19th century attempted to sort animals into different classes, families, and species. They referred to this process of classification as "making species." For example, thousands of sea birds lived along the coast of the Isle of Gioi. There were clearly many different species present, but the exact number of species was unknown. Taxonomists of the time set themselves the task of answering this question. As they began their observation and record-keeping, they
SR: would eventually make nearly two hundred kinds of birds.
PT: made/maked nearly two hundred kinds of birds.

C. Denominal form Andy, a worker at a horse carriage factory in the 1800s, was in charge of attaching carved emblems to the carriages to indicate their make. Several hundred carriages came through the assembly line every day, and he moved among them, screwing on the insignias to mark each carriage with the manufacturer's make. This task is called "making," and on regular days he would make for 8 hours. Often he worked overtime; he
SR: planned to make for 12 hours.

PT: made/maked for 12 hours.

To sell

A. Typical use The children sell lemonade at their stand.

B. Deverbal form Medieval vengeance was never something to be taken lightly, and revenge was sure to be exacted when a victim felt his honor had been violated. Vengeance could be mild, such as public humiliation, or it could be far more serious, sometimes including gruesome tactics. Serious vengeance was referred to as the victim "selling" the offender's crime dearly, or at great cost. Theft and slander were not treated lightly, but murder was the crime that friends and relatives of victims
SR: would most dearly sell for.
PT: most dearly sold/selled for.

C. Denominal form Merchants during the Renaissance used different strategies to convince potential customers to buy their products. In some cases, it worked well to wine and dine clients, while in others, a formal presentation was called for. Some merchants were known for employing harsh tactics, threatening and intimidating clients who seem weak or indecisive. This technique was called a "hard sell." One successful merchant was such an expert at using this method that he
SR: could hard sell his way all around Europe.
PT: hard sold/selled his way all around Europe.

To slide

A. Typical use The dog slides across the ice.

B. Deverbal form Centuries ago, people sometimes referred to falling asleep as "sliding." It was not uncommon for someone to slide on a rock in the sun or a patch of grass when there was no work to be done. Sliding in the middle of the afternoon was not considered to be a sign of laziness. Gretchen
SR: liked to close her eyes and slide in the shade of a tree on hot afternoons.
PT: often closed her eyes and slid/slided in the shade of a tree on hot afternoons.

C. Denominal form One of the first modern playgrounds was built in 1804. The park had tire swings, see-saws, and a fully-equipped sandbox. However, the park had no slides for the children to slide on. Eventually some wood carvers furnished the park with 6 slides. The workmen who put up the slides call this "sliding the park." When the mayor visited the finished playground, he was happy to see that
SR: the city had finally been able to slide his favorite park.
PT: the park was slid/slided.

To sling

A. Typical use The hiker slings his bag over his shoulder.

B. Deverbal form In Medieval times, meringue was already being made and put on lemon pies. However, back then, beating or whipping egg whites was called "slinging" them. The best pie makers of the time knew that it was important to sling the egg whites quickly and without stopping, for an extended period of time, until the meringue stood up in white peaks. This

method produced meringue with a superior texture, and was the signature of the best bakers. Juliana's meringue was particularly good because she

SR: would sling the egg whites until they were extremely stiff.
PT: slung/slinged the egg whites until they were extremely stiff.

C. Denominal form Harry, a Medieval soldier, broke his arm and it was in a sling for 3 months. He needed to have it in a sling for so long because it was a very bad break, and the sling was the best way to immobilize the arm while it was healing. Harry was reluctant to return to get a new sling put on his arm, because it had taken the doctor 3 hours to finish slinging it when he had been there the first time. However, this time the doctor

SR: was able to sling Harry's arm in just 15 minutes.
PT: slung/slinged Harry's arm in just 15 minutes.

To slit

A. Typical use The baker slits the top of the loaf of bread.

B. Deverbal form In the 1700s, the country was full of slitting mills where sheets of iron were processed into light rods. This process, known as "slitting," was extremely important for the local economy in Pittsburgh and other Western Pennsylvania iron and steel towns. Typically, a slitting mill would slit about 600 tons of iron a day, but during the recession, they

SR: were only able to slit about 400 tons daily.
PT: slit/slitted only about 400 tons daily.

C. Denominal form Musashi, the famous swordsman of the Dark Ages, was quite particular about his suit of armor. The slits in the visor, he claimed, needed to be perfect. A slit made too wide would be dangerous, but slits that were too narrow would obscure his vision.

SR: He used to slit his own helmet because he didn't trust the blacksmiths to do it.
PT: Every time he picked up new armor from the blacksmith, he would inspect the visor first to see whether it had been slit/slitted well.

To speed

A. Typical use The car speeds by.

B. Deverbal form "Speed bonnie boat like a bird on the wing" is the first line of a song about an incident in Scottish history in which Bonnie Prince Charlie was smuggled off the mainland to the Isle of Skye. In this case, "speed" does not refer to traveling fast, but to meeting with success in an endeavor. Another example of this usage: "The movie Braveheart was about the Scottish patriot WilliamWallace, who

SR: was finally able to speed well in the struggle against England."
PT: finally sped/speeded well in the struggle against England."

C. Denominal form Officer O'Reilly, a police cadet in the year 2409, was extremely proficient at catching drivers in his speed trap on Astro Route 78. Every time he clocked the speed of a driver going by, he referred to this as "speeding" them. On an average day he clocked the speeds of about 25 drivers, but one day he

SR: was able to speed 50 drivers—a new record for Officer O'Reilly.

PT: sped/speeded 50 drivers—a new record for Officer O'Reilly.

To spin

A. Typical use The children spin the top.

B. Deverbal form In the 19th century, it was said that a student who fails miserably on an exam "spins" in it, instead of bombing it, as might be said today. Tom was a student who would have graduated in 1853, but he had an unfortunate habit of leaving his books at the swimming hole on the way home from the schoolhouse, so he

SR: tended to spin in nearly every test.
PT: spun/spinned in nearly every test.

C. Denominal form In the 1700s, a favorite party game for the kids in the Brigham county school was "Spin the Bottle." In fact, they played it so often that they simply referred to the game as "Spin." The town realized that the obsession with Spin had gotten out of control when it became obvious that, for the last five birthdays,

SR: the only thing the children wanted to do was to spin.
PT: most of the children spun/spinned for almost the entire party.

Table 1 Passages used in Experiment 1 (from Ramscar, 2002)

A. Context related to drinking
In a traditional spring rite at Moscow University Hospital, the terminally ill patients all *sprink* in the onset of good weather, consuming vast quantities of vodka and pickled fish. In 1996, his favorite vodka glass in hand, cancer patient Ivan Borovich _____ around 35 vodka shots and 50 pickled sprats; it is not recorded whether this helped in his treatment.

B. Context related to blinking/winking
In a classical symptom of Howson's syndrome, patients all *sprink* in their right eye if they are left handed or left eye if they are right handed, their eyelids opening and closing rapidly and uncontrollably. In 1996, in extreme discomfort due to his bad eye, Howson's patient Ivan Borovich _____ around 35 times per minute for two days, causing severe damage to the muscles in his left eyelid.

C. Context related to meditating
In a controversial alternative therapy at Moscow University Hospital, the terminally ill patients all *sprink* in the afternoons on alternate days, going into a trance-like state that lowers the heartbeat to alleviate pain. In 1996, emitting a steady, low humming sound, cancer patient Ivan Borovich _____ around two weeks or so (the nurses lost count!) without a day off. Afterwards, doctors claim, his cancer was cured.

Note The novel verb (here *sprink*) is italicized. In another condition the novel verb was *frink*. Novel verbs are preceded and followed by identical words in the various passages.

Table 2 Effects of verb form, training, and context on past tense responses (Exp. 1)

	N Responses	Past tense form – N (%)		
		Regular (*sprinked*)	Irregular (*sprank*)	Other (*sprinks, ingest*)
Novel verb				
Frink	150	95 (63%)	39 (26%)	16 (11%)
Sprink	150	64 (43%)	73 (49%)	13 (9%)
Wucterium example				
Present	150	77 (51%)	61 (41%)	12 (8%)
Absent	150	82 (55%)	51 (34%)	17 (11%)
Type of context				
Drinking	100	36 (36%)	53 (53%)	11 (11%)
Blinking/winking	100	65 (65%)	24 (24%)	11 (11%)
Meditating	100	58 (58%)	35 (35%)	7 (7%)

Table 3 Original and enhanced denominal context passages (Exp. 2)

A. Original context passage (from Ramscar, 2002)

A *sprink* is the Muscovite equivalent of the Spanish tapas; it is served in bars, and usually comprises chilled vodka and some salted or pickled fish.

In a traditional spring rite at Moscow University Hospital, the terminally ill patients all *sprink* in the onset of good weather, consuming vast quantities of vodka and pickled fish. In 1996, his favorite vodka glass in hand, cancer patient Ivan Borovich _____ around 35 vodka shots and 50 pickled sprats; it is not recorded whether this helped in his treatment.

B. Enhanced context passage

Sprink is generally considered to be the most popular kind of vodka in Russia. It is distilled using the purest lake water from the Ural Mountains and is blended with a subtle concoction of herbs and spices. The production and consumption of *sprink* has almost doubled since the fall of Communism. In Moscow, *sprink* is consumed so regularly that citizens often refer to this activity as "*sprinking*" or perhaps "*sprinking* one's friends" when they are invited over to indulge in the delicious liquid.

In a traditional spring rite at the Moscow University Hospital, the terminally ill patients enjoy *sprinking* in the onset of good weather, consuming vast quantities of *sprink*. In 1996, his favorite vodka glass in hand, cancer patient Ivan Borovich _____ around 35 shots; it is not recorded whether this helped in his treatment.

Table 4 Production of past tense inflections in original and enhanced denominal contexts (Exp. 2) and comparison with non-derived context (Exp. 1)

	N Responses	Past tense form – N (%)		
		Regular (*sprinked*)	Irregular (*sprank*)	Other (*sprinks, ingest*)
Non-derived (Exp. 1)	85	23 (27%)	49 (58%)	13 (15%)
Denominal – original context (Exp. 2)	85	30 (35%)	48 (56%)	7 (8%)
Denominal – enhanced context (Exp. 2)	85	46 (54%)	36 (42%)	3 (4%)

Table 5 An example of the passages used with the verb *to feed* for Semantic Distance Ratings (A), Past tense Acceptability Ratings (B), and Novelty Ratings (C) (Exp. 3)

A. Semantic Distance Ratings

1. Passage with typical use of the verb *to feed*
   The mother bird feeds worms to the babies.

2. Passage with the deverbal variant of the verb *to feed*
   Long ago, liquor makers used various processes to alter the flavor and quality of their brews. Preserving a liquor with certain chemicals made it last longer, "fining" the liquor clarified the color, and "feeding" it added body to the flavor. Arthur was an esteemed maker of liquors whose customers especially praised his ability to feed his liquor.

3. Passage with the denominal variant of the verb *to feed*
   Farmer Jones, a farmer in Medieval times, looked at the two horse troughs in his barn – one for animal feed and the other for water. He decided that both troughs were low, so he went to the store room and got a bucket of water and a bag of feed, and he began to water one trough and to feed the other.

B. Past tense Acceptability Ratings

1. Passages with the deverbal variant of the verb *to feed*
   Long ago, liquor makers used various processes to alter the flavor and quality of their brews. Preserving a liquor with certain chemicals made it last longer, "fining" the liquor clarified the color, and "feeding" it added body to the flavor. Arthur was an esteemed maker of liquors whose customers especially praised the way he fed/feeded his liquor.

2. Passage with the denominal variant of the verb *to feed*
   Farmer Jones, a farmer in Medieval times, looked at the two horse troughs in his barn – one for animal feed and the other for water. He decided that both troughs were low, so he went to the store room and got a bucket of water and a bag of feed, and he began to water one trough and fed/feeded the other.

C. Novelty Ratings

1. Deverbal variant — To feed liquor: To add body to the flavor of liquor
2. Denominal variant — To feed a through: To fill a through with animal feed

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Table 6 Grammatical and semantic ratings for the verbs used in Experiment 3

Verb	Derivation Ratings[1]		Semantic Distance[2]		Latent Semantic Analysis[3]	
	Denominal	Deverbal	Denominal	Deverbal	Denominal	Deverbal
To bend	5.94	2.93	2.65	4.00	0.56	0.63
To bite	4.65	2.53	3.31	4.12	0.36	0.33
To blow	3.27	1.71	3.44	4.88	0.41	0.25
To breed	5.07	1.87	3.21	4.40	0.35	0.24
To feed	4.67	3.06	2.28	4.00	0.44	0.31
To hold	5.39	3.87	2.96	3.80	0.57	0.51
To make	5.29	2.53	4.44	3.80	0.70	0.62
To sell	5.20	3.33	3.00	5.36	0.52	0.30
To slide	5.40	3.12	4.64	5.24	0.35	0.35
To sling	5.47	2.47	4.20	4.48	0.34	0.29
To slit	4.60	3.06	1.76	4.80	0.27	0.23
To speed	5.12	4.33	3.36	5.28	0.46	0.33
To spin	4.53	3.00	2.33	5.40	0.59	0.43
Average	4.96	2.91	3.19	4.58	0.53	0.47

[1] Higher derivation scores on a 1-7 point scale indicate that the verb was derived from a noun (i.e., denominal); lower scores denote judgments that the verb was not derived from a noun.

[2] Based on semantic distance ratings; higher scores on the 1-7 point scale indicate judgments of lower semantic reminding and greater semantic distance

[3] Higher LSA values (expressed in cosines) indicate that words have meanings close to the core irregular verb

Table 7 Mean ratings for past tense acceptability (Exp. 3)

Verb	Regular Past Tense[1]		Irregular Past Tense[1]	
	Denominal	Deverbal	Denominal	Deverbal
To bend	4.24	2.64	4.80	5.40
To bite	2.36	1.44	5.76	6.68
To blow	2.20	1.56	4.92	6.73
To breed	3.72	2.28	5.16	6.28
To feed	2.36	2.56	4.92	6.24
To hold	3.92	1.68	4.96	5.68
To make	2.76	1.44	4.20	6.76
To sell	2.52	1.64	5.72	6.92
To slide	3.80	2.20	2.56	6.08
To sling	3.36	2.36	4.76	5.20
To slit	3.92	4.08	4.72	5.04
To speed	3.88	2.88	3.40	4.84
To spin	3.76	2.72	5.20	5.88
Average	3.29	2.26	4.69	5.98

[1] Ratings were given on a 1-7 point scale; higher ratings indicate more acceptable forms

Table 8 Summary of results from multiple regression analyses (Exp. 3)

Independent variables	Dependent variables	R^2	F(3,22)	t
1a.	Regular Form Ratings	.45	6.09, p = .003	
Derivational Ratings				3.21, p = .004
Semantic Distance				<1
Novelty Ratings				<1
1b.	Regular Form Ratings	.46	6.25, p = .003	
Derivational Ratings				3.36, p = .002
LSA				<1
Novelty Ratings				<1
2a.	Irregular Form Ratings	.50	7.44, p = .001	
Derivational Ratings				4.32, p = .003
Semantic Distance				<1
Novelty Ratings				<1
2b.	Irregular Form Ratings	.50	7.38, p = .001	
Derivational Ratings				4.34, p = .0003
LSA				<1
Novelty Ratings				1.03, p = .31
3a.	Difference (Regular -	.54	8.76, p = .0005	
Derivational Ratings	Irregular Form Ratings)			4.36, p = .0002
Semantic Distance				<1
Novelty Ratings				<1
3b.	Difference (Regular -	.55	8.83 p = .0005	
Derivational Ratings	Irregular Form Ratings)			4.45, p = .0002
LSA				<1
Novelty Ratings				<1

Table 9 Comparison between current data and Ramscar (2002) for effects of semantic distance on past tense acceptability

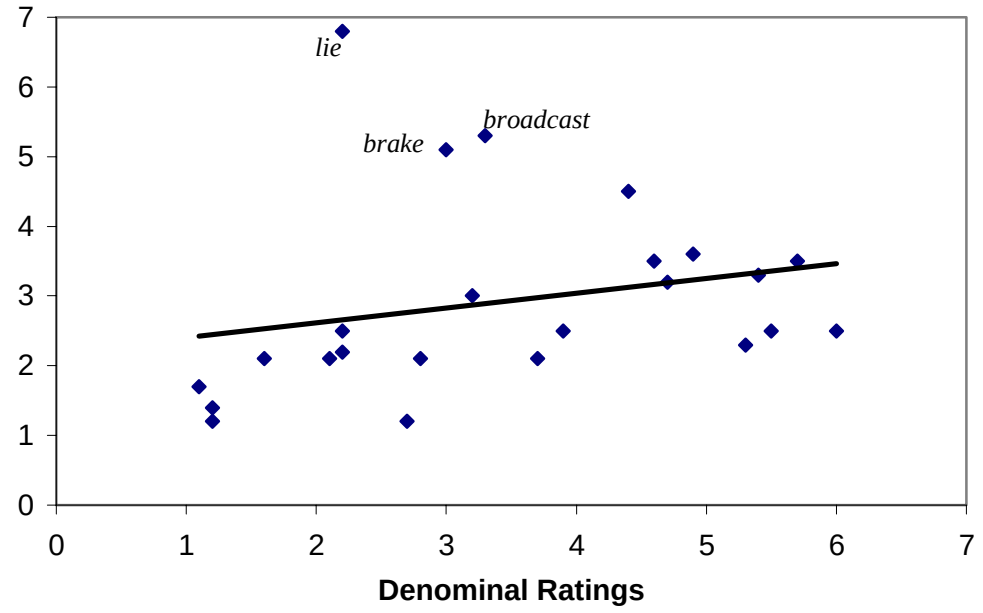
	Mean Ratings/Study	
	Ramscar (Exp. 4)	Gordon & Miozzo (Exp. 3)
A. Denominal verbs		
Semantic Distance	5.08	3.19
Regular Past Tense Acceptability	3.84	3.29
Irregular Past Tense Acceptability	3.21	4.69
B. Deverbal verbs		
Semantic Distance	2.63	4.58
Regular Past Tense Acceptability	2.00	2.26
Irregular Past Tense Acceptability	5.80	5.98

Table 10 Correlations with semantic distance ratings in Experiment 3.

	Past tense Form	
	Regular	Irregular
Denominal Verbs	-.15	-.52*
Deverbal Verbs	.28	-.11

* $p<0.05$ (1-tail), otherwise n.s.

A.



B.

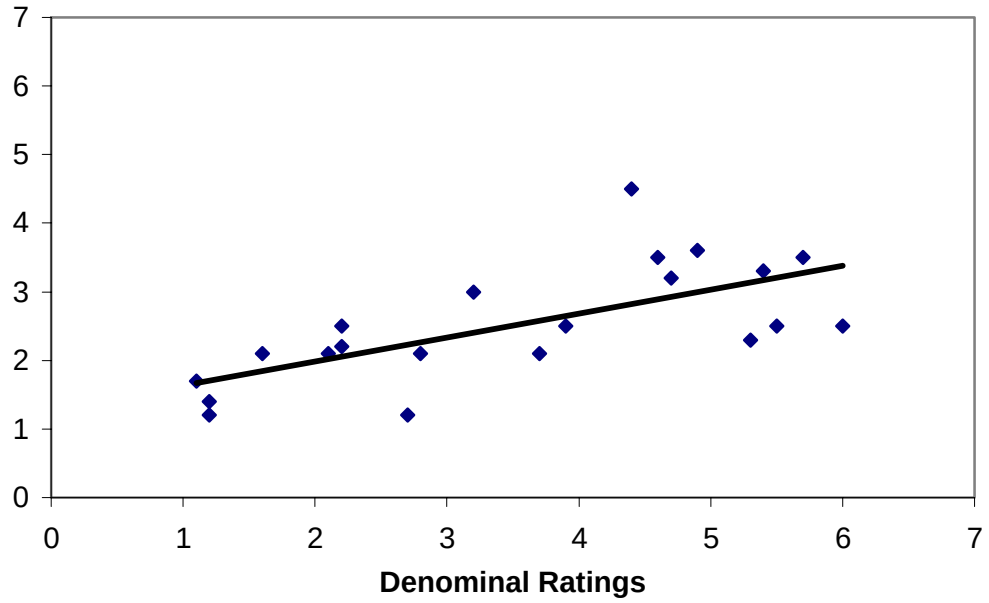


Figure 1 Panel A: Scatterplot and regression line of ratings of denominal status and acceptability of regular past tense form. Data are from Ramscar (2002; Exp. 3). Panel B: Same as Panel A, but with outliers *lie, brake,* and *broadcast* removed. Note that higher ratings indicate verb-from-noun and high past tense form acceptability.

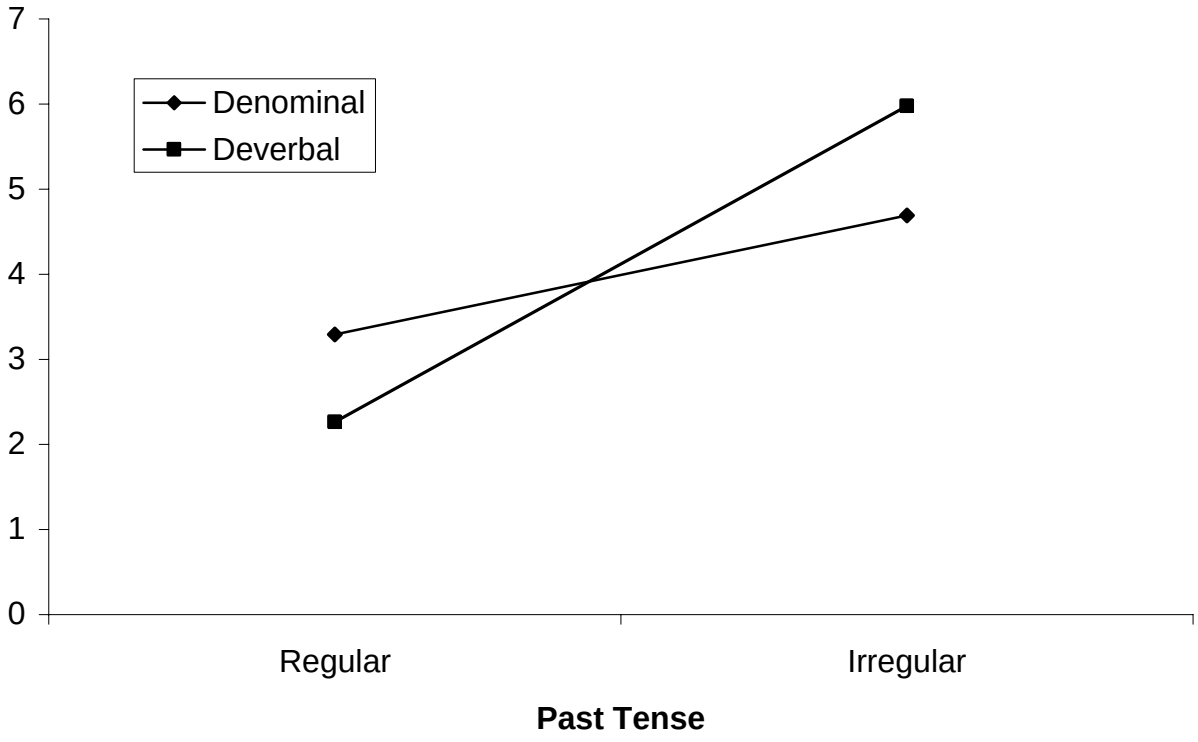


Figure 2 Acceptability ratings for denominal and deverbal variants of the verbs with either regular or irregular past tense forms (Exp. 3). Note that higher ratings correspond to more acceptable verb inflections.

Footnotes

[1] Ramscar (2002) asked participants to indicate the first word that came to mind while reading the context preceding the past tense elicitation sentence for the "meditate" context. According to Ramscar (personal communication) neither *think* nor *meditate* were often given as a response, but most were regular past tense forms.

[2] Kim et al. (1991) only reported the correlation with ratings for regular forms here and did not include correlations for irregulars. They argued that correlations for semantic distance and irregular past tense forms could reflect the mechanism of a "short circuit" mechanism detailed later in this paper.

[3] Even though the past tense for *Broadcast* is established in the language it remains ambiguous between regular and irregular much in the same way that other forms coexist in this manner.

[4] The lower bound for our items was somewhat lower than those reported by Ramscar (2000) (4.4 vs. 5.8, respectively). To directly compare ratings of items across experiments, we asked a new group of twelve raters to judge both our verb contexts and Ramscar's (2002) for typicality. Ratings for our items and Ramscar's were similar on average (5.76 vs. 5.78, respectively). Our items showed slightly higher minimum ratings when the same group of raters was used (4.33 vs. 3.33, respectively). These results do not suggest that our items were particularly problematic in terms of typicality compared to Ramscar's (2002) items, although they do suggest some variability in ratings for typicality. To be certain that this was not a factor in our results, we re-ran the analyses of Experiment 3 excluding the two verbs that had been rated somewhat lower on typicality, namely, *slit* (4.66) and *sling* (4.33) (for all the other items rates were >5.44). The exclusion of these two items made no difference to the analyses of results in Experiment 3.