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# The role of meaning in inflection: Why the past tense does not require a rule

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## Abstract

How do we produce the past tenses of verbs? For the last 20 years this question has been the focal domain for conflicting theories of language, knowledge representation, and cognitive processing. On one side of the debate have been similarity-based or single-route approaches that propose that all past tenses are formed simply through phonological analogies to existing past tenses stored in memory. On the other side of the debate are rule-based or dual-route approaches which agree that phonological analogy is important for producing irregular past tenses (e.g., *think* → *thought*), but argue that regular past tenses (e.g., *walk* → *walked*) are generated via a +*ed* rule and that a principled account of regular inflection can only be given by recourse to explicit rules. This debate has become a crucial battleground for arguments concerning the necessity and importance of abstract mental rules, embracing not only language processing, but also the of nature cognition itself. However, in centering on the roles of phonological similarity and rules, the past tense debate has largely ignored the possible role of semantics in determining inflection. This paper presents five studies that demonstrate a striking and decisive role of semantic similarity in inflection. In fact, semantic factors appear to be more important in inflection than the grammatical considerations put forward by the dual-route account. Further, these new findings provide a new way of discriminating between the claims of single-route (similarity-based) and dual-route (rule-based) approaches. It appears that inflection is carried out through analogical reminding based on semantic and phonological similarity and that a rule-based route is not necessary to account for past tense inflection. © 2002 Elsevier Science (USA). All rights reserved.

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## 1. Introduction

Since Rumelhart and McClelland (1986) first presented their connectionist model of the English past tense system, inflectional morphology has taken on a particular significance in debates about the nature of cognition. Arguments about the mechanisms by which words get inflected (e.g., to indicate the tense of verbs or to make singular nouns plural) have gone far beyond the particularities of inflection simpliciter. Inflection has become the example domain—and hence a battleground—for wider debates about the nature of linguistic knowledge and knowledge representation (MacWhinney & Leinbach, 1991; Pinker, 1991, 1999, 2001; Pinker & Prince, 1988; Plunkett & Marchman, 1993).

The debate centers on the question of whether the representation of declarative knowledge, such as rules, needs to be explicit in cognition. In Rumelhart and McClelland's model, rules are replaced with weighted connections in a connectionist pattern associator, and rule-like behaviors emerge from the adjustment of the weights of connections. Although this model—and other similar architectures—have been adept at simulating some aspects of human performance in inflection (e.g., Daugherty & Seidenberg, 1994; Hahn & Nakisa, 2000; MacWhinney & Leinbach, 1991; Plunkett & Marchman, 1993; Westermann, 1998, 2000a, 2000b) they have been fiercely criticized by advocates of rule-based approaches for failing to ultimately capture the essential nature of inflectional behavior: specifically, it is claimed that *regular* inflection is explicitly guided by mental rules (Clahsen, 1999; Marcus, Brinkmann, Clahsen, Wiese, & Pinker, 1995; Pinker, 1991, 1999, 2001; Pinker & Prince, 1988; Prasada & Pinker, 1993).<sup>1</sup> Thus the past tense debate has taken on a special significance for the study of language: If models without explicit rules are incapable of accounting for—or modeling—as relatively simple an aspect of language as past tense inflection, then this has severe implications for the relevance of connectionist or similarity-based approaches to more complex linguistic phenomena (see Seidenberg & Hoeffner, 1998).<sup>2</sup>

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<sup>1</sup> While many differences in the processing of regular and irregular forms in inflectional morphology have been noted, it is often impossible to make principled distinctions between the underlying causes of these processing differences. For phenomena such as priming differences, acquisition effects, and frequency effects, both sides can and do claim differences in the data as evidence for their models (see, e.g., Ellis & Schmidt, 1999; Hahn & Nakisa, 2000; Sonnenstuhl, Eisenbeiss, & Clahsen, 1999; Marcus et al., 1995; Ullman, 1999; Westermann, 2000a,b).

<sup>2</sup> For example, there is a strong parallel to be drawn between the debate on the right way to model inflection and the debate regarding the modeling of reading aloud (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Coltheart, Curtis, Atkins, & Haller, 1993; Harm & Seidenberg, 1999; Plaut, McClelland, Seidenberg, & Patterson, 1996; Plaut & Booth, 2000; Seidenberg & McClelland, 1989).

Proponents of the dual-route account have claimed that rules are necessary in inflection because without recourse to abstract grammatical rules, speakers could not solve the “homophone problem” (this is explained in detail below). This paper examines first whether semantics can solve this problem. Second, it contrasts the use of semantic information in inflection with the grammatical, rule-based account of homophone inflection, demonstrating that semantics better explains and predicts human performance in inflection tasks. Finally, it shows that semantic effects can be used to test the claimed in principle superiority of rule-based accounts in accounting for past tense inflection. The discovery that semantics can be (and is) used to resolve the homophone problem obviates the necessity of a rule in past tense inflection.

## 2. Dual-route and single-route accounts of inflection

### 2.1. *Dual-route or rule-based approaches*

How are verbs modified in order to indicate tense? The traditional account of this process in generative linguistics held that the past tenses of irregular forms are memorized by rote and all other—regular—forms are generated by a rule, e.g., in English, VERB + *-ed* (see Pinker, 1999). However, this account fails to capture both the fact that irregular past tense verbs tend to cluster with other phonologically similar past tense verbs (e.g., *sing/sang*, *spring/sprang*, *ring/rang*; *stink/stank*, *drink/drank*, *sink/sank*, etc.) and empirical evidence that novel verb stems can be inflected irregularly if they are phonologically analogous to existing irregular verb forms (Bybee & Moder, 1983). Verbs such as *ring/rang* and *sing/sang* can form the basis for productive analogies that determine the inflection of phonologically similar nonce verbs, e.g., *spling/splang*. Production varies in proportion to a nonce’s phonological similarity to prototypical patterns among existing irregular forms: the more phonologically similar a nonce to a pattern, the more likely it is to be irregularized (Bybee & Moder, 1983).

Irregular nonce generalization is incompatible with a simple story about rote memory storage and the indexing of a fixed set of memory items (Pinker, 1991, 1999). Thus, the dual-route theory of inflectional morphology (Marcus et al., 1995; Pinker, 1991, 1999, 2001; Pinker & Prince, 1988; Prasada & Pinker, 1993) modifies the idea of a simple list of irregular verbs to include an associative memory component to account for graded irregular productivity. Lexical memory, which stores irregular forms, is supplemented with a component that allows generalization by phonological analogies to novel verb stems.

Although the dual-route account allows for the analogical processing of irregular verbs, it maintains that an abstract rule is used to process regular

verb forms, and to act as a default in instances when analogical processing in memory fails, or where an irregular form is systematically precluded for grammatical reasons (i.e., verbs derived from nouns cannot be irregular, Pinker & Prince, 1988; this is discussed in detail below).

The rules put forward in the dual-route account are symbolic: the range of circumstances in which the rule can be applied need have only the membership of a particular syntactic category (“noun” or “verb”) in common. Hence a rule is a substantive mental mechanism that operates on a symbolic representation over an entire syntactic category (Hahn & Nakisa, 2000). For example, the rule for the English past tense would be something like: VERB + *-ed* (which unpacks to: concatenate the suffix *-ed* to the verb stem to form the past tense of a verb). Basing regular forms on a general rule like this is held to account for their extensive productivity: the suffix can be added without regard to the similarities (or otherwise) that hold between the verb stem to be inflected and any previously encountered regular forms.

### 2.2. *Single-route or similarity-based approaches*

Unlike the dual-route account, the single-route account posits a uniform architecture to process inflection. The basic claim here is that the memory mechanisms that even the dual-route theory accepts are “uncontroversially needed to capture irregular patterns” (Marcus et al., 1995, p. 195) can also serve to explain and model regular patterns of inflection as well. Since, on the single-route account, both regular and irregular inflections are carried out by analogy to forms stored in memory, this leads to a fundamental difference between the two accounts when it comes to knowledge representation: while the dual-route account involves both memory-based processing (for irregular inflection) and explicit, rule-based symbolic processing (for regular inflection), the single-route account proposes that all processing can be accounted for by (complex) analogies in memory, without the requirement for the explicit representation of rules.

### 2.3. *The homophone problem*

Proponents of both dual- and single-route accounts agree that phonological similarity plays a critical role in irregular past tense inflection. However, as Pinker and Prince (1988) have noted, there is a critical flaw in the hypothesis that *all* inflection can be accounted for by phonological information alone: phonological similarity cannot account for the inflection of homophone verb pairs that have different past tense forms (e.g., *brake* → *braked*, *break* → *broke*). Since phonologically identical verbs can have different past tense forms, something else, in addition to phonological similarity, is required in order to explain past tense inflection. According to the dual-route theory, that something else is grammatical information and rules

(Pinker, 1991, 1999, 2001; a detailed account of this mechanism is given below). This paper examines whether there might not be a simpler solution to the homophone problem, one that does not require different mental mechanisms for the processing of regular and irregular past tense forms: namely, whether difference of meaning can account for the different patterns of inflection in homophone verbs.

#### 2.4. *Semantics and inflectional morphology*

The issue of whether semantic similarity plays any role in determining past tense inflection is controversial.<sup>3</sup> For example, MacWhinney and Leinbach's (1991) model of inflection includes a semantic component (weighted input vectors to the connectionist pattern associator) to distinguish the different "semantic features" associated with say *break* and *brake* to output *broke* and *braked*. This component is not motivated by, or intended to model, specific semantic features or particular empirical findings regarding semantic influences on inflection, and it has been criticized by Kim, Pinker, Prince, and Prasada (1991) and Pinker (1999), who argue for the "independence of semantics and past tense form."

The past tense form of a verb does not directly depend in any way on recurring semantic distinctions. For example, consider the verbs *slap*, *hit* and *strike*. They are similar in meaning, but they have different past tense forms: *Slap* has the regular past tense form *slapped*, *hit* has the no-change irregular past tense form of *hit*, and *strike* has the irregular past tense form of *struck*. Thus similarity of meaning does not imply similarity of form. Conversely, phonological clusters of irregular past tense verbs are not semantically cohesive: Similarity of form does not imply similarity of meaning, either. Consider the *sting/stung* class of irregular past tense verbs: *sting*, *sing*, *drink*, *shrink*, *swing*, *sling*, *spring*, *stink*, *ring*. There is no set of semantic features that seems to distinguish these verbs from those that take different past tense forms, nor is there a set of semantic features that partitions this set of verbs into those that have a past tense form that changes the vowel into an *a* and those that change the vowel to a *u*. Semantic features would not help in learning these distinctions; they would just get in the way. (Kim et al., 1991, p. 178; see also Pinker, 1999, p. 110)

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<sup>3</sup> Although many models of adult language production do suggest a role for semantics in selecting an inflected form (e.g., Garrett, 1975, 1982; Stemberger, 1985).

While the arguments of Pinker and Kim et al. rule out a simple, baldly deterministic role for semantic similarity in inflection, they do not eliminate the possibility of *any* semantic influence on the inflection process. The verbs *slap*, *hit*, and *strike* may be semantically similar, but they are phonologically dissimilar. However, the purpose of semantic information in MacWhinney and Leinbach's (1991) model was to influence inflection in cases where phonological information alone is insufficient to guide the process (such as the inflection of regular and irregular homophones like *braked* versus *broke*). Nothing in the arguments presented by Pinker and colleagues rules out semantic similarity playing a role in inflection that is conjoined in some way to phonological similarity (as would be the case if semantics were used to resolve the processing of homophones).

The existence of phonologically similar verbs that take different patterns of inflection provides a good area in which to explore the idea that semantic similarity may play a part in inflection in tandem with phonological similarity. For example, the class of irregular past tense verbs *sting*, *sing*, *drink*, *shrink*, *swing*, *sling*, *spring*, *stink*, etc. has two obvious exceptions: *blink* and *wink*. Despite their phonological similarity to this class of irregulars, both *blink* and its semantic near neighbor *wink* are regulars (and interestingly, they share semantic as well as phonological similarities with one another). If semantics does play a part in inflection (alongside phonology), one would predict that getting participants to inflect a novel verb form (e.g., *frink*) that is phonologically similar to both regular (e.g., *blink*) and irregular (e.g., *drink*) verbs should result in different patterns of inflection depending on whether *frinking* is perceived to be semantically closer to *drinking* or *blinking*.

### 2.5. The study of nonce inflection: a methodological qualm

Before examining the role of semantic similarity in inflection in this way, it is important to consider the best way that patterns of nonce inflection might meaningfully be studied (a topic has that been little considered previously). In previous studies (e.g., Bybee & Moder, 1983; Prasada & Pinker, 1993), participants have been required to produce past tense forms for a number of nonce verbs in sequence. As such, these studies have not controlled for the possibility that immediate previous experience with one inflected form might influence the pattern of subsequent novel, productive inflectional behavior.

There are a number of reasons to suspect that order effects might occur in nonce inflection tasks. Syntactic priming effects (e.g., Bock, 1986), where previously encountered syntactic structures have been observed to affect subsequent syntactic production, indicate one cause for concern in this respect. Further, there is considerable evidence that there are priming differences between regularly and irregularly inflected words and their stems

(e.g., Marslen-Wilson, Tyler, Waksler, & Older, 1994; Sonnenstuhl et al., 1999; Stanners, Neiser, Herson, & Hall, 1979), with regular verb stems priming their inflected past tense forms more than irregular verb stems.

These factors raise two main questions. First, does the experience of encountering one nonce inflection immediately prior to producing another nonce inflection influence subsequent inflection patterns (prior form biasing could have an unintentional influence on the patterns of inflection subsequently observed)? Second, do previous encounters with regular and irregular forms produce different levels of priming with respect to subsequent inflections? In the latter case, the evidence suggests that repeated inflections might tend to favor regular inflection, creating a trend toward increasing regularization in the production of nonce verbs.

### 3. Experiment 1

In this experiment participants carried out a simple nonce inflection task after being given an example of either the regular or irregular form of a different, phonologically distinct nonce (a task designed to reproduce the conditions of repeated inflection). If there was no effect of prior forms on the inflection process, it was expected that the proportion of regular and irregular forms produced by participants would be unaffected by the example they had seen. On the other hand, if other forms did influence the inflection of subsequent nonce verbs, then it was expected that the verb forms participants produced would be affected by the form of the examples.

#### 3.1. Participants

Participants were 182 visitors to a shopping mall in Edinburgh, Scotland, and 140 undergraduate students at the University of Edinburgh. All were native English speakers who participated voluntarily in the study.

#### 3.2. Materials

A set of cards presented a passage containing the nonce verbs *frow*, *sprink*, *cleed*, *frink*, or *spling* in highlighted form. Later, the cards presented an underlined form of the past tense of the nonce verb in either its irregular (e.g., *frew/cleed/splung*) or regular (*frowed/cleeded/splinged*) form.

A second set of cards presented a similar paragraph that contained a highlighted phonologically dissimilar nonce verb (either *cleed*, *spling*, *frink*, or *sprink*)<sup>4</sup> in a context where it was obviously in its infinitive tense (e.g., to

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<sup>4</sup> All of these nonce verb stems were rated with a mean of 5.5 or above on a 1–7 scale (where 7 = “perfectly good and natural”) in a naturalness rating task in Prasada and Pinker (1993).

Table 1  
Examples of the “example” and target passages used in Experiment 1

Example passage 1—Irregular
Every Wednesday, John likes to <i>frow</i> . Last week, John <u>frew</u> a lot.
Example passage 2—Regular
Every Wednesday, John likes to <i>frow</i> . Last week, John <u>frowed</u> a lot.
Target passage
Every Friday, Sam likes to <i>sprink</i> . Last week, Sam _____ a lot.

cleed) and then later a blank that required its past tense to be given (see Table 1). A further set of example cards were created that contained a noun – *wucterium*—and a context that required its plural (which was given as *wucteria*).

### 3.3. Procedure

All participants were asked to read a piece of text containing a highlighted novel word and then a blank. Participants were instructed to fill the blank with “the form of the highlighted word that you think is appropriate to the context in which you find the blank. It is important that the form you choose matches the context of the sentence.” Participants were asked to “concentrate on how the new form of the novel word ‘sounds’ in the context, not on how it might be spelled.”

The 162 participants in the main experimental condition were first presented with a card containing a fleshed out past tense as an “example.” Participants who were going to inflect *frink/sprink/spling* were given either *cleed* or *frow* as an example, while those who were going to inflect *cleed* were given one of *frink/sprink/spling* as an example. Half of the participants were shown the example in which the example nonce was inflected in its irregular form (e.g., *cleed* → *cl**ed*), and half saw the example in which the example nonce was inflected in its regular form (e.g., *cleed* → *cleed**ed*). These cards were then retrieved by the experimenter and removed from the sight of the participant. Once this was done, the participant was given a target inflection card.

A control group of 80 participants were asked to carry out the verb inflection task without seeing any example. Finally, in order to see whether noun pluralization had any effect on verb inflection (and to establish whether plurals could be used as examples in subsequent experiments), another 80 participants were given an inflected noun (*wucterium* → *wucteria*) as the example before carrying out the same nonce-inflection task as the main experimental group. (This last set of materials thus served as both an extra control and also to pretest examples for further experiments to ensure that they did not exhibit priming.)

Participants verbalized their responses, which were transcribed by the experimenter. Only one inflection per subject was obtained.

### 3.4. Results

Of the participants, 68.5% produced a past tense form of the nonce in the inflection task that was consistent with the inflected form of the nonce they had seen in the “example” that preceded inflection; 76.25% of responses were consistent where the example was irregular (*sprink* 80%; *frink* 60%; *cleed* 80%; *spling* 85%) and 61% where the example was regular (*sprink* 65%; *frink* 80%; *cleed* 54.5%; *spling* 45%). The overall bias toward producing a form consistent with the preceding example was significant in a  $2 \times 2$   $\chi^2$  analysis,  $\chi^2(1, N = 162) = 22.949$ ,  $p < .0001$ . Analyses of the individual nonces also showed the consistency bias to be significant: *sprink*,  $\chi^2(1, N = 40) = 6.547$ ,  $p < .05$ ; *frink*,  $\chi^2(1, N = 40) = 5.104$ ,  $p < .05$ ; *cleed*,  $\chi^2(1, N = 42) = 3.938$ ,  $p < .05$ ; *spling*,  $\chi^2(1, N = 40) = 2.976$ ,  $p < .1$ .<sup>5</sup>

In the control group, where participants did not see any example, 77.5% of participants produced an irregular past tense (*sprink* 85%; *frink* 60%; *cleed* 75%; *spling* 90%), which did not significantly differ from the group shown an irregular example group. However, there was a significant difference between the participants who had been shown a regular example and the control: overall,  $\chi^2(1, N = 162) = 24.612$ ,  $p < .0001$ ; *frink*,  $\chi^2(1, N = 40) = 5.104$ ,  $p < .05$ ; *sprink*,  $\chi^2(1, N = 40) = 8.438$ ,  $p < .005$ ; *cleed*,  $\chi^2(1, N = 42) = 2.668$ ,  $p = .1$ ; *spling*,  $\chi^2(1, N = 40) = 4.541$ ,  $p < .05$ .

Finally, participants who were shown an example of irregular plural inflection (*wuacterium*  $\rightarrow$  *wuacteria*) were no different from the controls (who saw no example), producing 78.5% irregulars compared to 77.5% in the control condition (*sprink* 80%; *frink* 65%; *cleed* 75%; *spling* 95%).

### 3.5. Discussion

These results indicate that a person’s inflection of a nonce verb can be influenced by previously witnessed inflections, even in the absence of any strong phonological similarities between the nonces.<sup>6</sup> Further, it appears from these results that regular verb forms exert more influence on the form of succeeding nonces than irregular verb forms. There are a number of possible reasons for this (for example, the results obtained here are compatible with both rule priming and an increased activation of phonologically

<sup>5</sup> Because of low frequencies in some cells, the values given for the analysis of individual nonces *frink*, *sprink*, and *spling* use Yates’ corrected  $\chi^2$ .

<sup>6</sup> For compatible findings with respect to eliciting errors in the inflection of existing forms, see Marchman and Callan (1995), and for form-priming effects in nonword reading, see Kay and Marcel (1981).

overlapping *-ed* forms in an associative network), and it will take further study to discriminate between them.

As regards experimental design, however, these results indicate that repeated-measures designs do not provide the best method for studying nonce inflection. Without a way of neutralizing or controlling for the order effects identified here, it seems clear that obtaining more than one data point per subject in a production task may affect the outcome of experiments. Accordingly in the past tense production experiments described below, only one data point per subject was collected to avoid interference between individual inflections, and all instructions were given in the present or infinitive tense to avoid biasing effects from inflected verbs therein.

#### **4. Does meaning affect inflection?**

Experiment 2 was designed to determine whether semantic similarity could affect the inflection of nonce verbs. A problem that raised its head at the outset of this was simply “what are semantic similarities between words supposed to be?” One thing that cognitive science sorely lacks is any account of what word semantics is (see, e.g., Fodor, 1998). One might try to define semantic similarity as the degree to which the meanings of two words overlap, but this simply transfers the problem to one of saying what the meanings of words are: And the problem with “what is meaning?” is that it may be a question that has no answer (or at least no straightforward answer: see Fodor, 1998; Wittgenstein, 1953). These are not problems that can—or will—be solved here. For the purposes of this experiment, semantic similarity was operationalized contextually: nonces were considered more semantically similar to one existing verb than another existing verb if they occurred in a context in which one verb was more likely to occur than the other (Landauer & Dumais, 1997; see also Miller & Charles, 1991) and if they exhibited more priming for one existing verb than the other. Thus two measures were adopted to determine the semantic similarity of nonces to existing forms based on the contexts in which they appear. First, the contexts that the nonces were presented in were analyzed using a high-dimensional model derived from a large corpus (LSA, Landauer & Dumais, 1997; Landauer, Foltz, & Laham, 1998). LSA calculates a contextual distribution for each word encountered in a corpus by counting the frequency with which it co-occurs with other words. This information is used to define a model locating each word encountered in a high-dimensional space, with distances in this space representing contextual similarities between the words. Thus LSA provided a simple, objective measure of whether these were contexts in which one given verb was more likely to occur than another. Second, the question of whether a context exhibited more priming for one verb than another was further informed

empirically by asking subjects what existing verb the nonce reminded them of (after they had completed the inflection tasks).

## 5. Experiment 2

In this experiment the phonologically similar nonces *sprink* and *frink* were presented in contexts that primed either the phonologically similar regular verbs *blink* or *wink* or the existing phonologically similar irregular verb *drink*. It was hypothesized that if semantic similarity did play a part in the inflection process, then *sprink* or *frink* should be inflected differently depending on whether the semantic context reminded people more of the regular verbs *blink* or *wink* or the irregular verb *drink*.

### 5.1. Participants

Participants were 80 visitors to a shopping mall in Edinburgh, Scotland, and 80 students at the University of Edinburgh. All were native English speakers who participated voluntarily in the study.

### 5.2. Materials

The materials used in this study were cards printed with a paragraph that contained a highlighted nonce verb (*sprink* or *frink*) in a passive context where it was obviously in its infinitive tense (e.g., to *frink*) and then later a blank that required its past tense.

Forty participants read a story in which the nonce verb described the consumption of vodka and fish (see Table 2). This context was designed to prime the existing irregular verb *drink* and thus to promote irregular inflection of the nonce. Another 40 participants read a story in which the nonce described a symptomatic affliction of the eyelid associated with a fictitious disease. This context was designed to prime the existing regulars *blink* and *wink* and thus to promote regular inflection of the nonce.

In addition, 40 participants read a third context describing a hypnotic trance, which was contextually similar to the existing regular verb *meditate* (see Table 2).

In order to control the phonological properties of the nonces, both the initial presentation of the nonce and the blank that was used to elicit the past tense form were embedded in the same sentence substructure in each of the three semantic contexts. Each nonce and blank was preceded by at least two identical words (containing at least three identical syllables) and was succeeded by at least one identical word (containing at least one syllable).

A high-dimensional context model (LSA; Landauer & Dumais, 1997) was used to analyze the passages. This analysis revealed a positive contextual

Table 2

Examples of the “semantic context” passages used in Experiment 2

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 Passage 1—irregular context—primes *drink*

In a traditional spring rite at Moscow University Hospital, the terminally ill **patients all *frink*** 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.

 Passage 2—regular context—primes *blink* and *wink*

In a classical symptom of Howson’s syndrome, **patients all *frink*** in their right eye if they are left handed or left eye if 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.

 Passage 3—phonologically unrelated regular context—primes *meditate*

In a controversial alternative therapy at Moscow University Hospital, the terminally ill **patients all *frink*** 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.

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*Note.* The nonce (in this case, *frink*) is italicized. The text highlighted in bold was used to phonologically control the presentation of the nonce and then later the blank and is identical in either context.

similarity between passage 1 and *drink* (LSA cosine 0.10) but not between the passage and *blink* (−0.03) or *wink* (0.00), whereas LSA analysis of passage 2 indicated positive contextual similarity between the passage and *blink* (LSA cosine 0.24) and *wink* (0.07), but not between passage 2 and *drink* (−0.02). Analysis of the passage that presented the nonces as relating to *meditate* indicated there was positive contextual similarity between it the regular verbs *meditate* (0.13) and *heal* (0.14), but little contextual similarity between this passage and *drink* (−0.04), *blink* (−0.06), or *wink* (−0.00).

### 5.3. Procedure

Participants were given the same instructions as those in Experiment 1 above. After this briefing, participants were given a card containing the example “A single *wucterium* can be very dangerous. When they breed and multiply, a buildup of \_\_\_\_\_ can prove lethal” and verbally informed that they might choose to fill in the blank with *wucteriums* or *wucteria* or anything else, depending on what seemed appropriate to them. These cards were then retrieved by the experimenter and removed from the sight of the participant. Once this was done, the participant was given either a *frink* or a *sprink* card. Participants read the passage on the card and produced a verbal response to the fill-in-the-blank inflection task.

After participants had carried out the inflection task they were asked three further questions. The first two were a check on the passages’ priming

quality: the first asked participants to state what, if any, word the nonce had reminded them of, and the second asked participants to name a word that rhymed with the nonce as quickly as they could. Participants were considered to be primed if they produced the primed-for target verb—and not the non-primed-for target—in response to either or both of these questions.

The last question was intended to see whether participants had discerned any semantic difference between the “meaning” of the nonce in context and the existing verb it was intended to prime. Participants were told to assume that the use of the nonce in the context paragraph was its correct usage, and then the test question was presented (e.g., “*Would you normally associate **sprink** with an illness?*”; “*Would you normally say that you could **frink** a fish?*”). A control group of 20 participants were asked a similar question in relation to the existing verbs that served as targets rather than the nonces in context (e.g., “*Would you normally associate **wink** with an illness?*”; “*Would you normally say that you could **drink** a fish?*”). It was expected that if participants encountering the nonces in context did discern a semantic difference between the nonces and the prime verbs, there would be a difference between their answers to the third follow-up question (which was logically consistent with the way the nonce was used in context) and the control group’s responses to similar questions relating to the existing verbs that were primed for these latter questions were rated to be generally untrue of the existing verbs by participants in a pretest. That is, it was expected that participants would agree that, ordinarily, one might *frink* a fish, but not that one might *drink* a fish. Participants in the *meditate* condition that was expected to prime neither *drink* nor *blink/wink* were asked whether the meaning of the nonce in context reminded them of either *drink* or *blink/wink* (the order of these questions was randomized).

Participants verbalized all their responses, which were transcribed by the experimenter. Only one inflected form per subject was obtained.

#### 5.4. Results

As predicted, semantics had an effect on inflection. When *sprink* and *frink* were semantically similar to *wink* and *blink*, 73% of the participants produced regular forms (e.g., *sprinked*) and 27% produced irregular forms (e.g., *sprank*). When *sprink* and *frink* were semantically similar to *drink*, only 22.5% of the participants produced regular forms, and 77.5% produced irregular forms. Interestingly, when *sprink* and *frink* were semantically similar to *meditate*, 70% of participants produced a regular past tense and 27.5% produced an irregular past tense (3.7% of these participants produced inflected forms of the active past perfect progressive form, adding *-ing/* to the nonce stem, and were not included in these analyses). Overall, 75.3% of the participants who produced a past tense form responded in a prime-consistent manner.

The bias toward producing a form consistent with the past tense of the phonologically similar verb primed (*drink* versus *wink/blink*) was significant in a  $2 \times 2 \chi^2$  analysis,  $\chi^2(1, N = 77) = 19.669, p < .0001$ . Analyses of the individual nonces also showed the consistency bias to be significant: *sprink*,  $\chi^2(1, N = 39) = 9.766, p < .005$ ; *frink*,  $\chi^2(1, N = 38) = 7.204, p < .01$ .<sup>7</sup>

There was no significant difference in nonce inflection between the *blink/wink* and *meditate* conditions; however, comparing the responses of the participants when *sprink* and *frink* were semantically similar to *drink* with those when *sprink* and *frink* were semantically similar to *meditate* did reveal a significant difference:  $\chi^2(1, N = 79) = 19.271, p < .001$ .

Results from the follow-up questions revealed that 85% of participants exhibited priming for one of the three target verbs (*wink*, *blink*, or *drink*). Of these, 88.2% were primed for the target verb appropriate to the context in the passage they had seen, and 11.8% produced the non-primed-for target in response to one of the test questions. Analysis showed that the consistency between the words the nonces reminded participants of and the priming contexts was significant,  $\chi^2(1, N = 80) = 20.460, p < .0001$ . These results confirm that the contexts did succeed in priming the regular (*wink* and *blink*) and irregular (*drink*) phonological near-neighbors of *sprink* and *frink* as intended in the experimental design and as predicted by the LSA analysis.

Of the participants, 92.5% who saw a nonce in a *drink* or *wink/blink* context provided a yes/no answer to the semantic question relating to the nonce in context; the remaining participants gave “don’t know” answers and were excluded from analysis. Of the participants that gave a definite response, 48.6% agreed with the semantic question (e.g., agreed that they would “normally associate *frinking* with an illness”) and 51.4% disagreed (there was no “right” answer to the questions). This compared with the control group, where 97.4% of participants disagreed with a similar question relating to the meaning of a semantically similar verb (e.g., participants disagreed that they would “normally associate *winking* with an illness”). This difference was significant,  $\chi^2(1, N = 113) = 24.781, p < .0001$ .<sup>8</sup> In the third (*meditate*) condition, 91% of participants reported no semantic similarity between the nonces and *drink*, *blink*, or *wink* (9% “didn’t know”). It appears that participants did treat the nonces in context as meaningful words in their own right.

<sup>7</sup> As in Experiment 1, because of low frequencies in some cells, both the values given for the analysis of the individual nonces and the analysis of semantic cues at the end of this section use Yates’ corrected  $\chi^2$ .

<sup>8</sup> The semantic prime consistency effect noted above was significant both for participants that did not register a semantic difference between the nonces and the targets,  $\chi^2(1, N = 37) = 4.582, p < .05$  and for those that did perceive a semantic difference,  $\chi^2(1, N = 36) = 4.201, p < .05$  (both values are for Yates corrected  $\chi^2$ ).

### 5.5. Discussion

The results obtained were consistent with the hypothesis that semantic similarity could affect the inflection of the past tenses of nonce English verbs when phonological similarity constraints were satisfied. If people encounter a novel verb form that is phonologically close to two different existing verbs but semantically close to only one of them, then they are likely to inflect the nonce verb in the same way as the semantically similar verb. This finding neatly compliments the findings of Bybee and Moder (1983), who discovered that encountering a novel verb form that is phonologically similar to a cluster of phonologically similar irregulars increases the likelihood that the nonce verb form will be inflected irregularly. Once phonological similarity constraints have been met, semantic information also appears to play an influential role in inflection.

## 6. The associative processing of regular past tense inflection: is it productive?

The phonologically different regular control (*meditate*) appears to shed some light on the way in which semantic constraints work. When the nonces were perceived to be semantically dissimilar to the existing irregular, and semantically similar to a phonologically dissimilar regular, they were regularized. This suggests that if no semantic similarity holds between a nonce and an existing irregular, and there is positive semantic similarity between that nonce and an existing regular, then the nonce will be inflected regularly.

A comparison between the results of Experiment 2 and the inflected forms produced for *frink* and *sprink* in the semantically neutral control condition in Experiment 1 confirmed that overall meaning had acted to cause a significant shift toward *regularity* in the nonces in Experiment 2.<sup>9</sup> In the control group in Experiment 1, where participants encountered the nonce in a semantically neutral setting without an immediate prior exposure to another inflected past tense form, 72.5% of participants produced an irregular past tense for *sprink* and *frink* (this figure excludes the data from *cleed* and *spling*). Comparing these figures to those of participants who had encountered *sprink* and *frink* in a context that semantically primed an existing irregular verb produced no significant change in the number of irregular past tense forms produced (76.25% overall). However, these figures do show an increase in the number of *regular* forms produced when an existing

<sup>9</sup> LSA analysis of the neutral text (John likes to \_\_\_\_\_. Yesterday he \_\_\_\_\_), which contained little semantic information that was contextually distinctive, revealed little positive similarity to any of the targets (*blink*, -0.05; *wink*, 0.02; *drink*, 0.03) or any other test verbs (*meditate*, -0.04; *heal*, 0.01; *sleep*, -0.03; *eat*, 0.02; *think*, -0.02; *be* -0.01; *work*, 0.03; *move*, -0.07).

regular verb is semantically primed. Only 27.5% of participants produced regular past tense forms for *frink* and *sprink* in the control condition. However, 73% of participants produced regular and *sprink* forms for the past tenses of *frink* and *sprink* when they encountered them in a context that primed the regulars *blink* and *wink*. This increase was significant: overall,  $\chi^2(1, N = 77) = 15.901$ ,  $p < .0001$ ; *frink*,  $\chi^2(1, N = 38) = 5.743$ ,  $p < .005$ ; *sprink*,  $\chi^2(1, N = 39) = 7.621$ ,  $p < .001$ . Similarly, when participants encountered the nonces in contexts that did not prime *drink*, but did prime the existing, phonologically dissimilar regular *meditate*, there was also a significant increase in regularization compared to the semantically neutral condition; 70% of the forms produced in the *meditate* condition were regular:  $\chi^2(1, N = 79) = 15.50$ ,  $p < .0001$ ; *frink*,  $\chi^2(1, N = 40) = 8.438$ ,  $p < .005$ ; *sprink*,  $\chi^2(1, N = 39) = 4.605$ ,  $p < .05$ .

Thus not only is there a consistent relationship between the past tense forms produced for the nonces and the past tense forms of the phonologically similar verbs that are primed semantically, but it appears that the significant increase is in the number of *regular* forms produced when an existing regular verb is primed. The simplest way of explaining this finding is in terms of a competition in memory between the phonologically similar irregular and regular verbs. When phonological similarities are not augmented by semantic information, the data from Experiment 1 suggest that probabilistically, *sprink* and *frink* are more likely to be inflected irregularly in producing their past tense forms because they will simply match to the most readily available (i.e., most frequent) verb in memory, and this verb will be irregular (Gregg, 1976; Marchman, 1997; Sumby, 1963). *Drink* is a far more common word than either *wink* or *blink* (a comparison between *drink*, and *wink* and *blink* in the 100,000,000-word British National Corpus revealed 1117 instances of *drink*, 29 of *blink*, and 33 of *wink*). However, when the semantic context in which the nonce is presented primes an existing regular, Experiment 2 shows that the nonces tend to be regularized. The simplest explanation for this is that both irregular and regular nonce inflections are being generated productively by analogy in memory. The increased semantic activation of the regular verbs outweighs the attractive force that frequency gives to the irregular match, causing the nonce to be analogically matched to *blink/wink* and its inflected form (*winked/blinked* → *sprinked/frinked*) to be passed to the nonce via an analogous generalization. The regularization effect promoted by the *meditate* context can be explained similarly: increasing the semantic activation of another regular *verb/verbed* match increases the total level of activation in support of applying the *-ed* suffix by analogy (all irregular verbs in English have phonologically similar regular analogs; see Pinker, 1999).

Thus both regular and irregular inflected forms appear to be produced in memory by analogy depending on the degrees of activation of, and the weights assigned to, phonology, semantics, and frequency. Importantly,

there is nothing in these particular results that cannot in principle be accounted for by a single-route model, where one similarity-based process in memory processes both regular and irregular inflection. Further, it seems that dual-route models will have to incorporate regular productivity by analogy in order to capture the effect revealed by this data.

## 7. Semantics and the routes to inflection

How do the results of Experiments 1 and 2 bear on the past tense debate? As noted above, one possible use for semantics in inflection is in the resolution of homophonous verbs. Pinker and Prince (1988) note that phonology alone cannot allow one to distinguish between say *brake* (past: *braked*) and *break* (past: *broke*). When single-route models have used semantics to resolve this problem, they have been criticized by Pinker and colleagues (see Berent, Pinker, & Shimron, 1999; Kim et al., 1991; Kim, Marcus, Pinker, Hollander, & Coppola, 1994; Pinker, 1999; Pinker & Prince, 1988; Prasada & Pinker, 1993). Pinker and colleagues have accepted that semantics *could* allow single-route models to deal with the problem of homophonous verbs (see Berent et al., 1999), but given the hitherto lack of any positive evidence for semantic influences on inflection, and given evidence that semantics may not be an important determinant of homophone inflection (Kim et al., 1991; this evidence will be examined in detail below), they argue that such a move is unwarranted and unjustifiable. Results of Experiment 2 indicate that semantics *can* be used to resolve homophone verbs, suggesting that a single-route model *might* be able to account for past tense inflection.

However, incorporating regular past tense productivity in memory need not necessarily count against the dual-route account as a model, nor need it *necessarily* imply that all of inflection can in principle modeled using a single-route model. If it is the case that all irregular verbs are inflected by analogy in associative memory, while regular verbs can be *either* inflected by analogy *or else* inflected by a rule, and it can still be shown that a rule is necessary to explain some aspects of inflection, then the dual-route model would (and the single-route model would not) be the appropriate model for this process. The question is, is this the case?

### 7.1. Meaning versus grammar in inflection

In order to examine whether rules might still be necessary to account for inflection, we must return to the kind of architectural commitments that come with the inclusion of a rule in a model of inflection. As noted above, the rules in the dual-route account are explicitly symbolic. They take as their input a symbol that is a “verb” or a “noun,” and hence, concomitantly, they require inputs to have been analyzed into their grammatical categories

before they are passed to the rule (see also Hahn & Nakisa, 2000). If speakers and listeners carry out these analyses during language production and comprehension, then clearly they can provide input into rules. Indeed, the demonstrable existence of these analyses would support the dual-route account described above (for instance, rules might offer efficiency benefits over analogies in the cognitive system, leading to time-course effects that are amenable to empirical study; e.g., Ullman, 1999).

Further, Pinker and Prince (1988) (see also Pinker, 1991, 1999, 2001) have argued that the existence of homophonous regular forms for some irregular verbs is evidence for a systematic process of regularization based on abstract grammatical principles. According to Pinker and Prince, verbs that are perceived to originate in nouns will be regularized irrespective of their phonological or semantic properties. Correspondingly, the “grammatical hypothesis” (Kim et al., 1991; Pinker, 1991, 1999, 2001) predicts that only verbs with verb roots (deverbal verbs) can have irregular past tense forms and that verbs with noun roots (denominal verbs) will be regular.

Irregularity is a property listed in the lexical entries of *roots* of words, not the words themselves. A verb derived from a noun has a noun root. Nouns cannot be listed in the mental lexicon as having an irregular past tense form because it makes no sense for a noun to have a past tense form at all. Therefore denominal verbs cannot be listed as irregular, and the regular rule applies by default. (Kim et al., 1991, p. 180)<sup>10</sup>

The “grammatical analysis” claim stands at the heart of the debate between single-route and dual-route accounts of inflection. If correct, the grammatical hypothesis provides a very strong piece of evidence for the dual-route account. Pinker and colleagues (Kim et al., 1991, 1994; Pinker, 1991, 1999, 2001; Pinker & Prince, 1988) claim that evidence that a class of regular verbs are inflected purely on the basis of their grammatical status (i.e., being denominal) is evidence for the existence of mental mechanisms that operate on abstract grammatical categories (i.e., rules) and simultaneously provides evidence that people analyze linguistic input for the kind of grammatical information that the variables in rules require for binding. Further, it is claimed (Kim et al., 1994; Pinker, 1999, 2001) that children’s mastery of the systematic regularization of past tense forms on grammatical grounds *before* they have explicitly learned concepts such as “noun” and “verb” is evidence for an innate sensitivity to grammatical categories in humans.

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<sup>10</sup> Strictly speaking, this claim appears to be incompatible with the notion of irregular productivity: nonce verbs are not listed in the lexicon either.

Further, it follows that if the grammatical analysis hypothesis is correct, then all models of inflection will need to incorporate grammatical information (verbs, nouns, etc.) and representations of the mental mechanisms that process such inputs. That is, all accounts of inflection will have to incorporate a separate route (a rule) for processing these regular forms.

Thus the grammatical analysis hypothesis stands as a crucial, in principle objection to similarity-based single-route accounts and if correct would serve as a strong piece of evidence for the existence of a separate rule-based route. The question of whether people perform these grammatical analyses is clearly a critical element in the past tense debate.

So, do they? In a series of experiments in which participants provided “acceptability ratings” for regular and irregular inflections of words, Kim et al., 1991 (see also Berent et al., 1999; Marcus et al., 1995; Prasada & Pinker, 1993) presented some evidence that they might. Kim et al. found that in rating tasks, the irregular forms of deverbial verbs that were phonologically similar to existing irregular verbs were preferred to regular forms, whereas the regular forms of denominal verbs that were related to existing irregular verbs were preferred to their irregular forms. For example, *sinked* was preferred to *sank* in “*When guests come, I hide the dirty dishes by putting them in boxes or in the empty sink. Bob and Margaret were early, so I quickly boxed the plates and sinkedsank the glasses.*”

However, the study by Kim et al. did not rule out semantic similarity as a possible causal factor. It is simply not possible to present a verb as being either denominal or deverbial while holding semantics constant, and in Kim et al.’s results grammaticality and judgments of semantic distance were highly correlated. In the example above, the use of *sink* in “*sinkedsank the glasses*” is far less consistent with the usual uses of *sink* than the use of *sink* in “*my hopes sinkedsank*” and this factor was reflected in participants ratings. It is therefore possible that semantics, rather than grammatical factors, were responsible for Kim et al.’s results.

### 8. Experiment 3

The materials used in Experiment 2 offer an opportunity to utilize a production task in order to further evaluate the two competing explanations: (1) that homophone inflection is guided by grammatical considerations (if verbs are perceived to be denominal, they will be regularized) versus (2) that homophone inflection is guided by semantic considerations (the less similar a new use of an irregular verb is to its usual use, and the more similar its use to that of a regular verb, the more likely it is that the verb will be regularized). Experiment 3 was designed to examine the hypothesis that grammatical analysis—rather than degrees of semantic similarity—was the important explanatory factor in the inflection of denominal verbs:

[The grammatical analysis hypothesis. . .] is about the psychology of flesh and blood speakers rather than some scholar informed by the best etymologies philology has to offer. People should regularize headless forms only when they *perceive* the words to be headless . . . they should have a sense of when a word is based on another word (for example, that to *fly out* is based on a *fly*). When they do not—when they are oblivious to the noun in a verb-from-a-noun and imagine that it is just a stretched verb root—the theory predicts that they *should* stick with the irregular. (Pinker, 1999, p. 171)

This is the specific formulation of the grammatical hypothesis that was examined in Experiment 3. In Experiment 3 the nonce verbs tested in Experiment 2 were presented as denominals before participants were asked to inflect past tenses for them. The grammatical analysis hypothesis predicts that all denominal verbs should be inflected regularly (provided they are perceived to be denominal). In contrast, the semantic hypothesis predicts that when nonce verbs are presented to participants as denominals in a context that semantically primed an irregular verb cluster, they would be inflected irregularly (despite being denominal).

### 8.1. *Participants*

Participants were 80 visitors to a shopping mall in Edinburgh, Scotland, and 144 students at the University of Edinburgh. All were native English speakers and participated voluntarily in the study.

### 8.2. *Materials*

The materials and task were largely the same as those in Experiment 2, except that this time the nonces (*sprink* and *frink*) were presented first as distinctive novel nouns and then as denominal<sup>11</sup> verbs. To make sure that the nonce verbs presented in this way were actually perceived by subjects to be denominal (a crucial precondition of the prediction made by Pinker and colleagues), we asked a separate group of subjects to rate the verbs as deverbal or denominal (as described below).

The context paragraphs used in Experiment 2 (see Table 2) were modified so as to introduce the nonces as nouns from which the verbs that participants inflected were derived. To the first context in Table 2 (*drink*) the sentence “*A frink is the Muscovite equivalent of the Spanish tapas; it is served in bars, and usually comprises chilled vodka and some salted or pickled fish*” was

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<sup>11</sup> See Clark and Clark (1979) for a review of the possibilities that the “verbing” of nouns permits.

added. This was followed with exactly the same text as is shown in Table 2, passage 1. The sentences “*The frink is the common name for the motor muscle that controls the opening of the eyelid. It is especially prone to neurological interference*” were added to the *blink/wink* context (Table 2, passage 2), and the sentence “*The Frink are a Siberian religious sect that has developed several novel ways of meditating to influence their bodily states*” was added to the meditate context (Table 2, passage 3). Again, in both of these contexts the new material was followed by exactly the same text as was used in Experiment 2 (shown in Table 2).

A control group was given a pared down neutral context taken from Kim et al. (1991): “Last week I borrowed my neighbour’s *frink*. I went and \_\_\_\_\_ several pieces of hard wood with it.”

*Grammatical analysis manipulation check.* To ensure that participants in the main experimental condition would perceive the nonce verbs presented in these materials as denominal (information that is a “necessary and sufficient condition for the regularization effect,” Kim et al., 1991, p. 207) 60 participants were asked to rate their perceptions of whether the verbs appeared to be either denominal or deverbal. Participants were given booklets containing one example of a “deverbal” nonce context, one example of a “denominal” target context, and six other contexts relating to two existing verbs (*give* and *fly*; these verbs and their contexts served as materials in Experiment 5 below). The verbs in these contexts were loosely preclassified as deverbal, denominal, or obscure but probably denominal. The contexts were designed to provide participants with sufficient information to facilitate their making a meaningful denominal/deverbal analysis.

The presentation order of the contexts was randomized and ordered so that each participant saw nonce denominals and nonce deverbals that semantically primed different verbs. Participants were asked to indicate whether, in their judgment, the verb was “being used in a normal ‘verblike’ way or whether it is being used as a verb in relation to a noun. To take a word like ‘drink,’ for example, in (1) ‘John likes to drink beer.’ Then you might decide that ‘drink’ is being used as an ordinary verb. But, in the example. . . (2) ‘It’s always a good idea to relax your guests. Whenever guests arrive at my house, I immediately snack them and drink them. I find that refreshments set them at ease.’ You might decide that ‘drink’ is being derived from the noun ‘drink’ (such that it means something like ‘to serve drinks.’” Participants gave their ratings on a 7-point scale where 1 was definitely a normal “verblike” use and 7 was definitely a “verb from noun” use.

Participants were clearly able to distinguish the grammatical origins of the various verbs in these contexts. This is reflected by the variance in category means for the existing denominal, nonce denominal, and obscure denominals with respect to the existing deverbal and nonce deverbals (a one-way ANOVA confirmed this finding,  $F(4, 227) = 71.61$ ,  $p < .0001$ ). *T* tests between the mean scores for the deverbal (Experiment 2;

mean = 2.31) and denominal (Experiment 3; mean = 5.03) nonce contexts showed that participants had detected significant differences in their grammatical origins  $t(56) = 6.45$ ,  $p < .0001$  (individual nonce contexts;  $nonce \approx drink$ ,  $t(17) = 3.47$ ,  $p < .005$ ;  $nonce \approx wink/blink$ ,  $t(17) = 3.19$ ,  $p < .01$ ;  $nonce \approx meditate$ ,  $t(18) = 3.26$ ,  $p < .005$ ).

These findings indicate that if people fail to use grammatical information (such as the denominal or deverbal status of a nonce) in the inflection task, it will not be due to any failure on their part to perceive the verbs as denominal or deverbal.

### 8.3. Procedure

*Inflection task.* Participants were verbally briefed using the same instructions as used in Experiments 1 and 2 above. Again, after this briefing, participants were given a card containing the example “A single *wucterium* can be very dangerous. When they breed and multiply, a buildup of \_\_\_\_\_ can prove lethal” and verbally informed that they might choose to fill in the blank with *wucteria*, or *wucteriums*, or anything else, depending on which seemed appropriate to them. These cards were then retrieved by the experimenter and removed from the sight of the participant. Once this was done, the participant was given either a *frink* or a *sprink* card, where *sprink* and *frink* were first presented as nouns and later as verbs.

After carrying out the inflection task, the participants in the two semantic priming conditions were asked the same three check questions as those in Experiment 2. The first two were a check on the passages’ priming quality: the last question was intended to see whether participants had discerned any semantic difference between the “meaning” of the denominal nonce in context and the existing verb it was intended to prime.

### 8.4. Results

When the semantic context suggested an irregular verb (*drink*), 72.5% of participants inflected the nonce irregularly (e.g., said *frank* or *sprank*), despite the fact that all the nonces in this experiment were clearly perceived to be denominal and according to the grammatical analysis hypothesis should always be regularized. When the semantic context suggested a regular verb (*wink* or *blink*), 75% of participants inflected the nonce regularly (said *frinked* or *sprinked*). Further, when the semantic context was similar to the regular verb *meditate*, 70% of participants inflected the nonce regularly (said *frinked* or *sprinked*).

Of the participants who encountered the nonce in what Kim et al. described as a “semantically neutral” denominal context, 11.4% did not produce a past tense for the nonce, but instead said *chopped*, *hammered*, and

sliced. Of the 89.7% that did produce a past tense form for the nonce, 87.2% produced a regular form (said *frinked* or *sprinked*).

There were no significant differences in the inflection patterns produced by the “neutral” denominal context and the contexts that primed the regular verbs *wink/blink* and *meditate*, but the results of all three of these contexts did differ from the context that primed the irregular *drink*: the *wink/blink* context compared to the *drink* context,  $\chi^2(1, N = 80) = 18.1$ ,  $p < .0001$ ; the *meditate* context compared to the *drink* context,  $\chi^2(1, N = 79) = 15.5$ ,  $p < .0001$ ; and the “neutral” denominal context compared to the *drink* context,  $\chi^2(1, N = 79) = 28.7$ ,  $p < .0001$ .

As in Experiment 2, the priming manipulation check revealed that the contexts did appear to prime participants for the appropriate verbs; 76.25% of participants exhibited priming for one of the three target verbs (*wink*, *blink*, or *drink*). Of these, 72.5% responded to one of the follow-up questions with the target verb appropriate to the context in the passage they had seen, and 3.5% produced the non-primed-for target in response to one of the test questions. Analysis showed that the consistency between the words the nonces reminded participants of and the priming contexts was significant,  $\chi^2(1, N = 80) = 13.364$ ,  $p < .0001$ ). As in Experiment 2, subjects were able to discern a semantic difference between the nonces and the primed-for verbs (e.g., said that one could *frink* a fish, but one could not *drink* a fish),  $\chi^2(1, N = 118) = 24.531$ ,  $p < .0001$ .<sup>12</sup>

### 8.5. Discussion

This experiment set out to establish whether semantic similarity or grammatical analysis would influence the inflection of novel denominals. The finding that patterns of inflection were consistent with semantic priming—as found in Experiment 2—is consistent with the hypothesis that semantic similarity is an important constraint in determining inflection when phonological constraints have been met (see Fig. 1). The fact that *sprink* and *frink* were inflected irregularly (despite being perceived to be denominal) when they were semantically similar to an existing irregular verb contradicts the prediction of the grammatical analysis hypothesis that these verbs would be inflected regularly because they were perceived to have noun roots.

One notable finding in this experiment was the performance of the “control” group when compared to the control group in Experiment 1. Consistent with the findings of Kim et al. (1991), and as predicted by the grammatical analysis hypothesis, if participants encountered the nonces in a “semantically neutral” context that presented them as denominal verbs, they were significantly more likely to produce regular past tense forms for

<sup>12</sup> Yates’ corrected  $\chi^2$ .

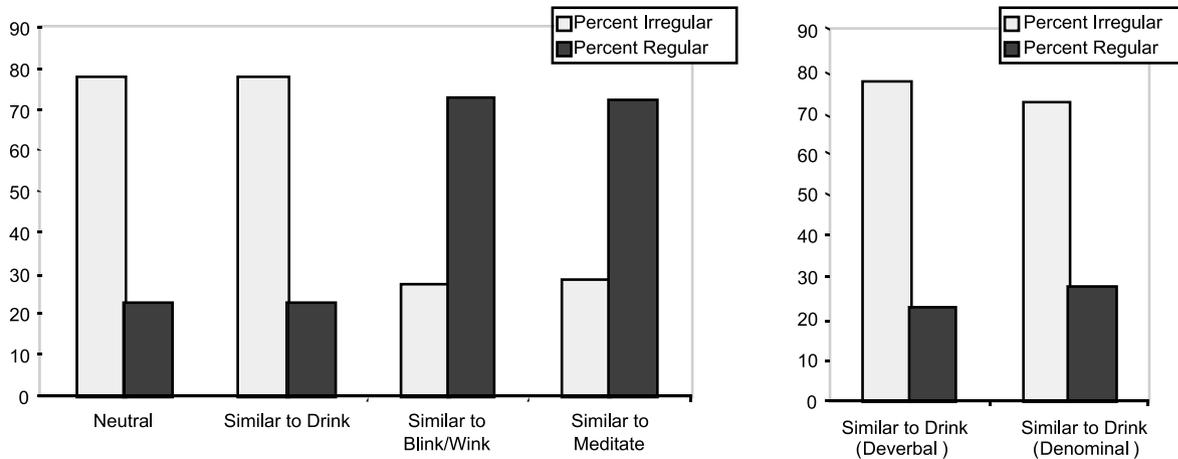


Fig. 1. Summary of the effects of semantics and grammar in Experiments 1–3. The left panel shows the large effect of meaning depending on whether the semantic context in which *sprink* and *frink* appear supports neutral, drink-like, wink/blink-like, and meditate-like meanings. The right panel shows the absence of any effect for the drink-like context regardless of whether the nonces are presented as denominal or deverbal.

them than if they were presented as straightforward (or deverbal) verbs. While this might be due to grammatical factors, the findings from the “irregular prime” condition suggest that this is unlikely. Instead, it seems that this effect may also be semantic. Unlike the “neutral” context in Experiment 1, this context is not one that *drink* (or indeed *blink* or *wink*) could fit easily. Further, while an LSA analysis showed no contextual similarity between the context and either *drink* (LSA cosine  $-0.02$ ), *blink* ( $-0.09$ ), or *wink* ( $-0.05$ ), it did, however, show positive contextual similarities for *slice* (0.06) and *hammer* (0.10) and a strong contextual similarity for *chop* (0.32). These were the forms produced by the participants in this experiment that failed to produce a past tense form of the nonces. It appears that the semantic similarity between this context and those in which regular verbs such as *chop*, *slice*, and *hammer* occur is the most likely cause of this result.

### 8.6. *Some previous evidence for the grammatical analysis hypothesis revisited*

The evidence accrued against grammatical analysis in Experiment 3 conflicts strongly with the findings of Kim et al. (1991), which indicated that participants did use grammatical analysis in determining the past tenses of verbs, and that grammatical analysis is a better predictor of past tense forms than semantics. In their study, which compared homophone verb forms in context, Kim et al. elicited ratings of regularizations of novel senses of irregular verbs and independent ratings of the semantic centrality of the novel sense relative to the original one. Kim et al. then performed regression analyses on the data collected, comparing the predictive power of semantic similarity and grammatical origin (whether a verb was presented as being denominal or a deverbal). These analyses indicated that semantics had no unconfounded effect and that “Word structure was necessary to explain [participants’] preferences; semantic stretching was unnecessary” (Pinker, 1999, p. 170).

Since these findings are clearly incompatible with the findings of Experiment 3, it seems worth revisiting in some detail these earlier studies.

*Measuring grammatical status.* In Kim et al. (1991), judgments of the grammatical status of verbs (whether they were denominal or deverbal) were not collected from impartial observers. Instead, the experimenters relied on their own intuitions for deciding which verbs were denominal and which were deverbal. This practice raises several concerns. First, there is no record of whether the participants in these studies agreed with the experimenters’ classifications. It is possible that some of the verbs that the experimenters classified as deverbal or denominal were not perceived as such by the participants.

Second, it is not always clear what principled analysis motivated Kim et al.’s classification decisions. For example, Kim et al. (1991) classify the verb *to lie* (as in confabulate) as denominal (in their materials: “Sam always

tells lies when he wants people to think he's better than he really is; He *lied* / *lay* to me last night about how good a golfer he is"). Presumably, this is because one can tell a *lie*; a *liar* is someone who tells *lies*, etc. However, Kim et al. simultaneously classify the verb *to drink* as deverbial (presumably, given that *drink* is an irregular, and the grammatical analysis hypothesis suggests that all denominals will be regular, Kim et al. assumed *drink* had to be deverbial). Yet it would appear that *any* reason that one can think of for suggesting that *lie* is denominal applies equally to *drink*: one can drink a *drink*; a *drinker* is someone who imbibes *drinks*, etc. These classification decisions—and the potentially problematic assumptions behind them—are critical to Kim et al.'s analysis of their results. If participants were to judge the most acceptable past tense of *lie* to be *lied* and the most acceptable past tense of *drink* to be *drank* (as one would expect from normal usage, and as indeed they did in Kim et al.'s experiments), then according to the logic of Kim et al.'s experiment, this would count as evidence *for* the grammatical analysis hypothesis in any subsequent analysis. Grammatical analysis would be credited with predicting that *drink* should be irregular, whereas *lie* must be regular, even though as far as one can see, the only reasons that *lie* was judged by Kim et al. to be a denominal verb and *drink* to be a deverbial verb were because the former was a regular and a latter an irregular in the first place.<sup>13</sup>

Thus the logic behind Kim et al.'s experiment runs as follows: a group of verbs that were already known to have a regular past tense were defined as being denominal, and a group of verbs that were known to have an irregular past tense were defined as deverbial. The experiment then tested to see whether regular past tenses for the "denominal" verbs and irregular past tenses for the "deverbial" verbs would be judged most acceptable. On finding that this was the case, Kim et al. concluded that participants must have been using grammatical analysis to determine their inflections. In the light of the considerations raised here, it appears that without an independent measure of the grammatical status of these verbs, this conclusion is not entirely warranted.

*Measuring semantic similarity.* The semantic hypothesis tested by Kim et al. predicted that the semantic *distance* of an otherwise irregular verb form from the core meaning of its verb root would predict its *regularity* (the further the semantic distance, the more likely it is that the verb will be regular). This hypothesis runs counter to both the natural logic of a competition-based model of inflection (where one would expect distance to matter only if there was another possible competitor verb in semantic space) and

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<sup>13</sup> In another example, the verb *right* in "After she finished repairing the boat, she set it *upright*" was classified as denominal by Kim et al., even though it is far from clear that *right* is ever used as a noun with this sense.

the findings of the experiments described so far in this paper, where only nonces that are semantically neutral (Experiment 1) or semantically similar to an existing *irregular* (Experiments 2 and 3) have been inflected irregularly. A more straightforward semantic hypothesis is that the relative irregularity of a verb can be more accurately predicted from its semantic similarity to an existing *irregular* verb (this also obviates the inherent requirement in any semantic regularization prediction that one have semantic similarity measurements relating to all the *regular* verbs a verb form might be semantically similar to and makes the participants' task more straightforward and easily interpretable).

## 9. Experiment 4

Experiment 4 was designed to reexamine the findings of Kim et al. (1991) with respect to the relative value of semantics and grammatical analysis as predictors of past tense acceptability. To briefly restate the logic of the Kim et al. experiments: a series of items were defined as being examples of either deverbal or denominal verbs. These were used in a between-groups design, with one group of participants rating the acceptability of regular and irregular past tenses for each verb in context and another group rating the semantic extendedness of each verb from its core meaning. The data from the acceptability rating task were then fitted to both the semantic data and the grammatical categories formulated by Kim et al. to determine which of the latter two variables best predicted the past tense acceptability data.

In redesigning this study, two important changes were made. First, rather than relying on experimenter intuitions to classify verbs as denominal or deverbal, in Experiment 4 a separate group of participants were asked to rate which verbs *they* perceived to be denominal and which deverbal. Thus the present design improves on Kim et al.'s study in that now measures of both of the key predictor variables (grammatical status and semantic similarity) are obtained from naive impartial observers (the subjects), instead of having one measure determined according to experimenter intuitions.

The second important change from the original study was in the design of the semantic task. For the reasons described above, rather than testing whether semantic distance from an irregular root would predict regularity, Experiment 4 tested whether semantic similarity to an existing irregular would predict irregularity.

With these two measures in place, it was possible to test the two competing hypotheses on a level playing field. The semantic hypothesis was that semantic reminding (the degree to which an activity described by a verb reminds subjects of the activities generally described by an irregular verb) would be a good predictor of the acceptability of irregular past tense forms. In contrast to this, the grammatical analysis hypothesis predicted that

grammatical status (whether a verb is perceived as deverbal or denominal) would be a good predictor of the acceptability of irregular past tense forms (see Kim et al., 1991; Pinker, 1999).

### 9.1. Participants

Participants were 101 undergraduate students at the University of Edinburgh. All were native English speakers and participated voluntarily in the study.

### 9.2. Materials

Two sets of items were used in this study (see Appendices A and B). One set was used for the semantic similarity and grammatical origins judgments and the other set for judgments of past tense acceptability. The items were designed to be brief while still containing enough information to allow participants to make clear judgments about the verbs' semantics and grammatical properties. Because the items used by Kim et al. in their original study contained many idiomatic examples that were culturally specific to American-English speakers, and would be somewhat unintelligible to the British-English speaking participants in this study, the items used in this experiment were appropriately modified versions of those used by Kim et al. (1991).

*Semantics and grammatical analysis ratings materials.* Twenty-four contexts were used to present 12 phonologically similar verb pairs (from Kim et al., 1991) in the infinitive tense (e.g., “Charlie Wilson of United is a real prima donna. He never gets on with the game. Instead, he just shows off. He tries to grandstand all the time, and it really gets on my nerves” was paired with “Margaret Thatcher was always able to withstand any criticisms thrown at her. She just ignored them”). In each context, the target verb was italicized and underlined (see Appendix A for the full set of items).

*Past tense acceptability ratings materials.* This set augmented the basic contexts described above by adding sentences containing a second use of the target verb, inflected in either a regular or an irregular past tense form (e.g., “Charlie Wilson of United is a real prima donna. He never gets on with the game. Instead, he just shows off. He tries to grandstand all the time, and it really gets on my nerves. In the game with Rovers on Saturday he got an early goal and *grandstood* [or *grandstanded*] the rest of the match;” see Appendix B for the full set of items).

One important change to the items used in Kim et al.'s study was made. In an effort to ensure that the verbs the experimenters thought were “denominal” might be perceived as such in the past tense rating task, Kim et al. first presented their “denominal” verbs—such as *lie* (confabulate)—as nouns. This was not done for “deverbal” verbs like *drink*. Because in Experiment 4 the grammatical status of the verbs was a matter for empirical

resolution, the items tested here were not preclassified into grammatical categories.<sup>14</sup> Rather, the grammatical analysis condition was used to control for participants' sensitivity to denominal/deverbal verbs in the acceptability ratings task. That is, whether *lie* and *drink* were denominal or deverbal was determined by our participants' perceptions of what the grammatical origins of the verbs were. These perceptions were then used to test whether the grammatical analysis hypothesis predicted past tense acceptability.

### 9.3. Procedure

Three groups of subjects were used to obtain three ratings measures: semantic reminding, grammatical analysis, and acceptability of past tense form.

*Semantic reminding.* The 19 participants in the semantic similarity condition were given booklets containing one example of each the verb pairs in context (e.g., either *fly off* or *fly out*). The group was divided so that each verb in context was seen by half of the participants. Participants were also presented with an example typical use of the irregular form of the homophonic verb (e.g., “Birds fly south in the winter”). Each of the examples had been rated by 12 participants in a pretest for typicality and achieved a mean score of >5.8 on a scale where 1 = not at all typical and 7 = very typical.

Participants were instructed to compare the target verb and the highlighted verb in the example and to rate the extent to which “the activity or action described by the underlined word . . .—taken in the whole context—remind[ed . . . them] of the comparison word” They were asked to “consider all the possible things [you] *usually* associate with this use of the word.” Ratings were given on a 7-point scale where 1 was strong reminding and 7 was no reminding. Participants were given the example (1) “The bells ring out at noon,” and to give an example of the judgments sought, they were told that if they compared this with (2) “The general was forced to ring the city with guns” they “might decide that the activity associated with this ‘ring’ does not remind you of the activities associated with the first ‘ring’ (even though the words sound the same). On the other hand, there might be aspects of the activity/action associated with ‘ring’ in (3) ‘John tends to ring me whenever I’m in the bath’ [that] remind you more of the things that you associate with ‘ring’ in (1). And you might rate the following example differently again: (4) ‘John tends to ring me whenever I’m in the bath. He keeps ringing until I get out and answer the phone.’ In this example, you might rate (2) as 7 (definitely not reminiscent), with

<sup>14</sup> Although in fact, four of the denominals in Kim et al.’s study (e.g., “shed,” meaning to put something in a shed) were first given as nouns, as this was necessary to make the meaning of the subsequent verb comprehensible.

(3) and (4) somewhere in between 7 and 1, depending on how much you associate them with the ‘ring’ in (1).” Participants were told in addition, “In many cases you may not be completely sure, but we’d still like to know what you think.”

*Grammatical analysis.* The 20 participants in the grammatical analysis condition were also given booklets containing one example from each of the verb pairs in context. Again, this comprised half the materials, such that each participant only saw one semantic permutation of each homophonic verb pair, and the participants were again divided so that each verb in context was seen by half of the participants. Participants were asked to indicate whether in their judgment, the verb was “being used in a normal ‘verblike’ way, or whether it is being used as a verb in relation to a noun. To take a word like ‘fly’ for example, in (1) ‘Birds fly south in winter,’ then you might decide that ‘fly’ is being used as an ordinary verb. But, in the example (2) ‘To promote business, the pesticide shop always stands a man in a giant fly costume at the entrance of their shop, to greet customers. This is especially fun for children. Whenever a child enters the shop, the greeter performs ‘the fly.’ One hot day in June, sweating in his fly costume, I saw the greeter fly 40 children in a single afternoon.’ You might decide that ‘fly’ is being derived from the noun ‘fly’ (such that it means something like ‘to do the fly’).” Participants gave their ratings on a 7-point scale where 1 was definitely a normal “verblike” use and 7 was definitely a “verb from noun” use.

*Acceptability of past tense form.* The 50 participants in the acceptability of past tense form condition were divided into four groups. Each group received a booklet containing one semantic permutation of each homophonic verb pair in either a regular or irregular past tense form. The participants were divided so that each verb in context was seen by 50% of the participants, with 25% of these seeing the verb inflected as a regular past tense form and 25% seeing it as an irregular past tense form. The instructions in this task mirrored those in Kim et al. (1991). Participants were told to “to concentrate on how the words ‘sound’ in their context, as you read them, not on how they might be spelled.” Participants were asked to indicate “how likely it is that the form you have seen is the correct one for that context. By ‘correct,’ we mean the one that other native English speakers would naturally and intuitively use (i.e., the form—or sound—that comes most naturally to you).” Participants were also asked to note that correct did not “refer to the kind of ‘proper’ English that gets taught in grammar lessons or style manuals.” Ratings were given on a 7-point scale where 1 was not acceptable and 7 was highly acceptable.

#### 9.4. Results

Participants’ ratings are shown in Table 3. As predicted, there was a significant correlation between semantic reminding and irregular acceptability

Table 3  
Mean rating scores for each item in each condition in Experiment 4

Verb stem	Grammatical analysis	Semantic reminding	Regular acceptability	Irregular acceptability
Steal	1.1	1.7	1.7	6.2
Steel*	4.4	6.7	4.5	2.6
Buy	1.2	1	1.4	6.5
Bye*	4.6	5.7	3.5	3.3
Cast	1.6	2.8	2.1	6.5
Broadcast*	3.3	4	5.3	4.9
Fly off	2.1	4.3	2.1	5.7
Fly out*	5.4	3.3	3.3	4.8
Drink (in gossip)	3.7	3.9	2.1	5.1
Drink* (give drinks)	5.5	3.9	2.5	2.8
Withstand	1.2	3.9	1.2	5.1
Grandstand*	6	6.1	2.5	2.1
Sink (hopes)	2.7	2.2	1.2	6
Sink* (dishes)	4.7	3.7	3.2	3.5
Break	2.8	1.4	2.1	5.2
Brake*	3	5	5.1	3.7
Wake (awaken)	2.2	1.4	2.2	6.8
Wake* (funeral)	4.9	5.1	3.6	2.5
Spit	3.9	2.7	2.5	5.7
Spit* (corn)	5.3	5.7	2.3	4.1
Shed (let go)	3.2	3.2	3	4.8
Shed* (put in)	5.7	5.7	3.5	3.2
Lie (recline)	2.2	3.1	2.5	6.1
Lie* (confabulate)	2.2	6.1	6.8	1.1

*Note.* The scales are *grammatical analysis*: 1, definitely normal “verblike” use, and 7, definitely “verb from noun” use; *semantic reminding*: 1, strong reminding, and 7, no reminding; *past tense acceptability*: 1, not acceptable, and 7, highly acceptable. The “denominals” in Kim et al. (1991) are marked with an asterisk.

( $r = -0.83, p < .0001$ ) and between semantic reminding and regular acceptability ( $r = -0.62, p < .01$ ). There was also a significant correlation between grammatical analysis and irregular acceptability ( $r = .64, p < .001$ ), but no significant correlation between grammatical analysis and regular acceptability ( $r = .24, p > .2$ ). There was also a significant—and important—correlation between semantic reminding and grammatical analysis ( $r = .63, p < .01$ ).

Since semantic reminding and grammatical analysis were correlated, partial correlations were calculated for both predictor variables in relation to the acceptability scores. An analysis of the relationship between semantic reminding and past tense acceptability partialling out the effect of grammatical analysis revealed a significant partial correlation between semantic reminding and both irregular past tense acceptability ( $r = -0.71; p < .0001$ ) and regular past tense acceptability ( $r = .61; p < .005$ ). However,

an examination of the relationship between grammatical analysis and past tense acceptability partialling out the effect of semantic reminding showed no significant partial correlations between grammatical analysis and irregular past tense acceptability ( $r = -0.26$ ;  $p > .2$ ) or grammatical analysis and regular past tense acceptability ( $r = .24$ ;  $p > .25$ ).

Kim et al. (1994) argue that carrying out separate analyses on regular and past tense acceptability ratings (as done here) is invalid because it reflects participants' "reaction to the overall felicity and plausibility of the derived verb meanings, rather than their relative preference for regular or irregular inflected forms" (Kim et al., 1994, p. 210). Accordingly, further partial correlations were calculated between the predictor variables and the signed differences between the mean regular and irregular past tense acceptability rating for each item (the measure used in the analyses reported by Kim et al., 1991). Partialling out the effects of grammar revealed a significant correlation between semantics and past tense acceptability ( $r = .723$ ,  $p < .0001$ ), whereas partialling out the effects of semantics indicated that there was virtually no correlation between grammatical origin and past tense acceptability ( $r = .066$ ,  $p > .75$ ).

It did not appear that the failure of the grammatical analysis ratings to account for the past tense ratings data resulted from any differences in the variance of the two predictor variables. The mean scores for both the grammatical analysis and the semantics rating tasks were roughly similar (3.5 and 3.9), and a  $t$  test revealed no significant differences between the two sets of scores ( $t = 1.01$ ,  $p > .3$ ); the standard deviation (1.57 and 1.65), sample variance (2.44 and 2.73), and kurtosis ( $-1.28$  and  $-1.002$ ) were comparable in each sample. Further, the results of the past tense rating task itself did not differ markedly from those reported by Kim et al. Analysis of the rating scores obtained in this study for the 12 verb pairs showed that the mean score was 3.9 (of 7), the standard deviation in the sample was 1.4, and the range was 1.2–6.8; for the scores in Kim et al. the same figures were mean, 3.2; standard deviation, 1.6; and range 1.3–7.

### 9.5. Discussion

This experiment set out to reexamine earlier findings indicating that people's perceptions of the grammatical origins of verbs predicted past tense inflection better than semantics (Kim et al., 1991). In Kim et al.'s study, the grammatical origins of verbs were assigned according to experimenter intuition. When naive observers judged grammatical origins in Experiment 4, the predictive power of grammatical origin for inflection entirely disappeared. Semantic reminding, on the other hand, emerged as an important predictor of inflection.

A question to consider here is whether the grammatical analysis task was a good measure of the dual-route model's grammatical prediction. In spite

of the examples and instructions presented, it may be that some raters ended up rating the opaqueness of the verb meaning in the items, rather than the grammatical properties of the verbs (this problem is unavoidable: semantics and grammar are inextricably confounded in this respect).

Even if this were the case, it appears that Experiment 4 would still be a good test of the key prediction that “People should regularize headless forms only when they *perceive* the words to be headless. . . they should have a sense of when a word is based on another word” (Pinker, 1999, p. 171). It is clear that this sense of headlessness itself will be highly correlated with people’s intuitions (their “sense”) regarding the opaqueness or otherwise of meanings, and thus one would expect a strong correlation between ratings of grammatical intuitions and opacity of meaning. What the results obtained here clearly show is that people’s intuitions about similarities of meaning *simpliciter* are far better predictors of the acceptability of past tense forms than their sense for grammatical origins.

That people’s sense for the grammatical origins of the homophone verb pairs studied in this experiment failed to predict their preferred inflected forms is particularly striking because the examples considered here are those put forward *in support* of the grammatical analysis hypothesis (Kim et al., 1991; Pinker, 1991, 1999, 2001). Other examples of homophone pairs appear to further confound the grammatical origins claim. Consider the homophone pair *shoe/shoo*. In this homophone verb pair, what appears to be the denominal verb—*shoe*—has an irregular past tense (i.e., “His large feet were *shod* in trainers”), while *shoo* takes a regular past tense form (i.e., “She *shooed* the children from her lap”).<sup>15</sup> The existence of homophone verb pairs such as this, where the denominal verb is irregular while the deverbal is regular, suggests that the grammatical analysis hypothesis cannot—in principle—provide a solution to the homophone problem.

However, although the results obtained in Experiments 3 and 4 weigh strongly against the grammatical analysis hypothesis, the question of why semantics proved such a good predictor of past tense acceptability in Experiment 4 when it had performed so badly in Kim et al.’s original experiment still remains. There are at least two reasons for this: First, semantics and grammar were highly correlated in Kim et al.’s findings. Here an independent measure of grammar showed it to be a less than accurate predictor of past tense acceptability, which unconfounded much of the predictive power of semantics. Second, the semantic hypothesis tested here was intended to be consistent with both the predictive nature of the data gathered and the logic of semantic attraction among verb inflection in memory. That is, unless one assumes the semantic distances among verbs to be equal and

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<sup>15</sup> These examples are taken from the British National Corpus.

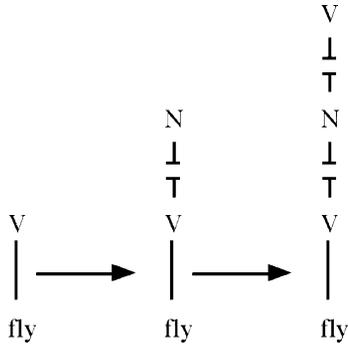
constant (which is unlikely), measures of semantic distances to/from irregular verbs will better predict *irregularity* than *regularity*.<sup>16</sup>

Once these factors are corrected for, it appears that semantics is a good predictor of people’s acceptability ratings of past tense forms.

**10. Why no mere mortal has ever flown out to center field (and why a Briton might)**

The grammatical analysis hypothesis assumes that individuals perform sophisticated etymological analyses each and every time they encounter a verb in context. As an example, Pinker (1999) (see also Kim et al., 1991) ingeniously unravels the grammatical origins of the baseballing verb *to fly out*, which in American English takes the regular past tense form (*flied out*, and hence *flew out* is “wrong”). According to Pinker, the reason “no mere mortal has ever flown out to center field” is because:

in the evolution of baseball argot the plain verb *to fly* was converted to a noun, *a fly*, which was then converted back into the verb *to fly*, meaning ‘to hit a fly that is caught’:



The new verb (top V) is sealed off from the root verb (bottom V) at two layers, the one that converted the verb to a noun, and the one that converted the noun back to a verb. Percolation had to be blocked both times to allow the verb to change categories rather than blindly receiving the category from one layer down. Baseball cognoscenti can hear the *fly ball* in *flying out*, the forms

<sup>16</sup> For example, comparing the irregular verbs *be* and *stink*: while it is easy to come up with numerous synonyms for *to stink* (e.g., *pong*, *reek*, *smell*, *hum*, *whiff*), this is not so easy for *to be*. Individual irregular verbs face semantic competition from differing numbers of regular verbs, and the distances between individual irregulars and their semantic neighbors will vary.

*flew* and *flown* are unable to climb out of the lexical entry for *fly*. The word turns to *-ed* as the last resort and becomes *flied out*. (Pinker, 1999, p. 165)

The results of Experiments 3 and 4 suggest that, resourceful as it is, from a psychological standpoint this analysis may be incorrect. Further, the peculiarities of the *flied out* example present an opportunity to contrast the roles of grammar and memory in determining past tense inflection. Baseball is very much a minority sport in Great Britain, as opposed to in the United States, where it is “the national pastime.” In Britain, televised baseball is a recent phenomenon, shown in the midnight to 6 AM “graveyard” slot, on a little-watched channel, which is viewable in only certain parts of the country. Encounters with baseball terminology are outside the experience of most Britons, who are unlikely to have heard *fly out*, still less its past tense. These conditions present an ideal opportunity for distinguishing accounts of inflection that are memory-based from approaches that claim that inflection is determined by formal grammatical considerations.

## 11. Experiment 5

In this experiment, British participants who were unfamiliar with *fly out* and who were unlikely to have encountered the term were presented with stimuli that made the analysis presented by Pinker (1999) (see above) transparent. Comparing this group of participants (to whom *fly out* was a novel term—effectively a nonce) with an American group of participants who were familiar with—or come from a culture in which they are likely to have been exposed to—*fly out* (and its regular past tense form *flied out*) provided a means of directly testing the hypothesis that regular inflection is processed in memory. If the rules and grammatical analyses hypothesis is right, inflection should be unaffected by memory content. If regular inflection is carried out associatively in memory, a significant difference was expected in the inflections produced by participants who did have the regularly inflected form of *fly out* in memory compared to those who did not.

### 11.1. Participants

The British-English speaking participants in this experiment were 45 students at the University of Edinburgh and 20 visitors to a shopping mall in Edinburgh, Scotland. The American-English speaking participants were 38 students at Stanford University. All the participants were native English speakers who participated voluntarily in the study.

### 11.2. Materials

The materials used in this study (shown in Table 4) consisted of a short paragraph, which summarized the analysis of the development of *flied out* presented in Pinker (1999). *Fly* was first presented as a verb, and it was explained how the noun *a fly* came from it. It was then explained that for a batter, to *fly out* was to hit a fly and get caught. “*Fly out*” was italicized in the same way as nonces had been in Experiments 1–3, and as in those experiments, the first presentation of *fly out* was later followed by two blanks in a context that required its past tense form.

In order to control for the possible objection that the British-English speakers might produce irregular forms for the past tense of *fly out* because they had not previously lexicalized *fly* as a noun, a second set of materials presented a novel denominal *give along*, derived from the mass noun *give* (e.g., “the rope had some give in it”) derived from the verb *give* (see Table 4).

### 11.3. Procedure

The 38 American and 25 British participants in the main experimental condition (*fly out*) responded to a targeted e-mail questionnaire. Participants were given the same instructions as those in previous experiments: they were asked to produce the appropriate form of the highlighted expression and were once again told to “concentrate on how the new form of the novel word “sounds” in the context, not on how it might be spelled.” After they had completed the inflection task, participants were asked to indicate whether they were “familiar with the baseball expression ‘to fly out’ prior to completing this questionnaire.” (The 20 participants from the shopping mall were tested using the card procedure used in Experiments 1–3.)

To control for whether nouns had been previously stored in the lexicon, a control group of 20 British-English speakers were given the second set of materials relating to the novel denominal *give along* using the card-based

Table 4

The passages used to present *fly out* and *gave along* in Experiment 5

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On an analogy with birds flying, in baseball a fly is a ball that is hit high into the air and is easily caught. It follows then that to *fly out*, if you are a batter, is to hit a fly and get caught, as in “In the last innings of the big game against the Syracuse Swifts this year, Jim Crow of the Baltimore Blasters \_\_\_\_\_ just when his team needed a home run from him.”

In box girder bridge building, it is essential that the girders remain rigid at all times, so girders that have any give in them are rejected. When new girders arrive on site, it is customary to *give along* them, testing the girders with an electronic instrument that detects potential weak points. During the building of a new road bridge in New York in 1978, Dwight Smitts \_\_\_\_\_ over 75 miles of girders.

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procedure used in the previous experiments. After the inflection task, these participants were asked two questions. First, to check that they had perceived the relationship between the noun *give* and the novel denominal *give along* they were asked to “state briefly what you think the origins of the phrase *give along* are and what you think it means in this context.” Second, to check that they had previously lexicalized the noun *give*, participants were asked “Have you heard *give* used as a mass noun in this way before (as in ‘there is a lot of give in this rope’)?”

#### 11.4. Results

As predicted, the past tense form of *fly out* was heavily dependent upon culture. Of the British-English speaking participants in the main experimental condition, 91.7% produced the irregular past tense form *flew out* and 6.3% produced the regular *flied out* (4% failed to produce a past tense and were eliminated from these analyses). This compares with the American-English speaking participants, of whom only 33.3% produced irregular past tense forms (*flew out*), whereas 66.7% produced regular *flied out* forms (21% of the Americans either failed to produce a past tense or inflected another stem and were eliminated from these analyses). The consistency effect between linguistic community and inflectional form produced was significant:  $\chi^2(1, N = 54) = 16.454, p < .0001$ .<sup>17</sup>

Comparing the past tense forms of British-English speakers who self-reported having not heard “fly out” (95.6% of the total) to American-English speakers who self-reported having done so (60.5%) showed figures of 95.6% irregular past tense forms (*flew out*) produced by the former group to 71.4% regular forms (*flied out*) produced by the latter:  $\chi^2(1, N = 44) = 18.546, p < .0001$ .

In the lexical (“give”) control group, 95% of participants produced a past tense form of *give along*; 89.4% of these produced the irregular past tense, *gave along*, and 5.3% produced the regular past tense, *gived along*; 5.3% produced a “double” regular past tense, *gived alonged*; 94.7% of participants in this group indicated that *give along* meant to check for *give* in beams or ropes and successfully traced the origin of *give along* to the noun *give*; and 5.3% did not know. Of the participants, 100% acknowledged that they had heard “give” used as a mass noun. An analysis of the difference between the British-English speakers’ production of an irregular past tense for the novel denominal *give along* and the American-English production of a regular past tense for the existing denominal *fly out* was significant,  $\chi^2(1, N = 49) = 12.637, p < .0001$ .

Finally, the British participants’ tendency to inflect *fly out* irregularly did not result from insights into the goals of the experiment (95% of the members

<sup>17</sup> Because of low cell values, this and the following analysis use Yates’ corrected  $\chi^2$ .

Table 5

The deverbial context passage used to present *fly* with a verb root in the grammatical analysis task in Experiment 3

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Last summer John was really bored. One day all he did was lie on his bed all day long watching a fly buzz around his room. The fly buzzed here and there, there and here, and then here and there again. John just watched. He wished he could fly too.

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*Note.* See Experiment 5 for further discussion of these data.

of the British public interviewed in the shopping mall produced the irregular *flew out* form) or from their failure to perceive *fly out* as denominal. An analysis of the data for the appropriate items from the grammatical analysis ratings taken in Experiment 3 (where 1 was deverbial, 7 was denominal) showed that participants rated *fly out* (mean, 5.31) to be much more denominal than *fly* (mean, 1.48) and *give along* (mean, 5.01) much more denominal than *give* (mean, 1.28),  $t(56) = 8.922, p < .0001$ , and  $t(56) = 10.23, p < .0001$ , respectively (see Table 5 for the deverbial *fly* stimulus used in this task).

### 11.5. Discussion

The results of Experiment 5 suggest that the important factor in determining the form of the past tense for *fly out* is whether participants have the regular past tense form—*flied out*—in memory or not. Not only did virtually all of the British-English speakers fail to respond to the hypothesized grammatical analysis and produce a regular past tense form, but a sizeable minority of American-English speakers also produced an irregular past tense form. Further, as the control group of British-English speakers who inflected the past tense of *give along* indicates, it is unlikely that the British-English and American-English speakers who produced *flew out* as the past tense of *fly out* did so because they had failed to lexicalize *fly* as a noun. In the control “give” condition, participants who had lexicalized *give* as a mass noun and analyzed *give along* as denominal still inflected the past tense of *give along* irregularly.

The obvious difference between the two groups of participants in this experiment is that the American-English speakers came from a community in which the past tense of *fly out* is generally regularized, and thus they had memorized *flied out*. Those American-English speakers who produced *flied out* did so because they had learned it as *fly out*’s “correct” past tense form.<sup>18</sup> It is unlikely that they were inflecting it as a result of an on-line grammatical analysis.

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<sup>18</sup> Other cross-cultural differences—in plural forms—lead to a slight error in the etymological history of *fly out* in the stimuli used in Experiment 5. While *innings* in that passage was presented as a *pluralia tantum* (its usual form in British English), in American-English, *inning* can take a singular form, e.g., “first inning.” Thanks to Mark Lepper for pointing this out.

## 12. General discussion: One route or two?

Pinker and colleagues (Kim et al., 1991, 1994; Marcus et al., 1995; Pinker, 1991, 1999, 2001; Pinker & Prince, 1988) have claimed that a principled account of the regular past tense *requires* an abstract rule, which binds to abstract variables like “noun” and “verb” because:

Focusing on a single rule of grammar [regular inflection], we find evidence for a system that is modular, independent of real-world meaning, non-associative (unaffected by frequency and similarity), sensitive to abstract formal abstractions (for example, root versus derived, noun versus verb), more sophisticated than the kinds of “rules” that are explicitly taught, developing on a schedule not timed by environmental input, organized by principles that could not have been learned, possibly with a distinct neural substrate and genetic basis. (Pinker, 1991, p. 534; see also Pinker, 1999, 2001)

None of these claims are supported by the results obtained here.

### 12.1. *Is the regular past tense modular independent of real-world meaning and nonassociative (unaffected by frequency and similarity)?*

The results of these experiments suggest that regular inflection *is* affected by real-world meanings, similarity, and frequency. In Experiments 2 and 3, manipulating the semantic similarities between nonces and phonologically similar regular verbs significantly influenced the number of *regular* past tense forms participants produced for the nonces. When *frinking* had to do with consuming vodka and fish (priming *drink*) participants irregularized it to “*frank frunk*,” but when *frinking* was a disease of the eyelid (priming *wink/blink*), they regularized it to “*frinked*.” This finding was further supported by the results of Experiment 4, which indicated that it is real-world meaning that determines the inflectional patterns of differently inflected homophone verbs in English (e.g., meaning determines whether the past tense of *lie* is *lied* or *lay*). Finally, Experiment 5 provided a vivid illustration of how frequency can determine regular past tense forms: in the same linguistic context, Americans, for whom the past tense of *fly* has been regularized through a convention of dialect (i.e., for individuals, frequency of exposure) were far more likely to produce a regular past tense for *fly* than Britons, whose dialect lacked this convention.

### 12.2. *Is the regular past tense sensitive to abstract formal abstractions (for example, root versus derived, noun versus verb)?*

The results of Experiments 3–5 indicate that the regular past tense is *not* sensitive to abstract formal abstractions, and the regularization of denominal

verbs is not as systematic as has been claimed (for example, the regularizing of *fly out* was far from systematic even for Americans). Further, the results of Experiments 2 and 3 suggest that regular inflections can be formed by analogy, and Experiment 4 indicates that meaning is the key determinant of inflected form in cases where phonological information is not sufficient. No abstract grammatical formalisms are necessary to explain these results (see, e.g., Daugherty & Seidenberg, 1994; Hahn & Nakisa, 2000; MacWhinney & Leinbach, 1991; Plunkett & Marchman, 1993; Rumelhart & McClelland, 1986; Westermann, 1998, 2000a, 2000b). That there is some “systematic” regularity across denominal verbs is unsurprising: denominalizing a noun related to a verb will invariably involve a change of meaning, and given the distribution of phonological properties and meanings among regular and irregular verbs in English, this may often (but as *fly out* and *give along* show, not always) lead to regularization.

*12.3. Does the evidence suggest a regular past tense system that develops on a schedule not timed by environmental input, organized by principles that could not have been learned, possibly with a distinct neural substrate and genetic basis?*

Though the data gathered here do not directly address these claims, these findings have strong implications for them. The finding here that the mastery of different past tense forms is intimately bound up with the mastery of the meanings of words suggests that insofar as meanings are organized by principles that are learned, and insofar as meaning acquisition is timed by environmental input, then mastery of the past tense is a matter of learning. No innate capabilities specific to inflectional morphology are needed to explain these results. Moreover, insofar as adult verb inflection of homophone verbs does not reveal any specific sensitivity to grammatical information, there seems no reason to suppose that children’s verb inflection is sensitive to grammatical information either (see Kim et al., 1994).

*12.4. Whither the rule?*

Because the regular past tense appeared to be “independent of real-world meaning, nonassociative. . . [and] sensitive to abstract formal abstractions,” Pinker and colleagues have argued (Pinker & Prince, 1988; Pinker, 1991, 1999, 2001) that regular inflection cannot—in principle—be modeled by a single-route. The results presented here indicate that these claims about regular inflection do not stand up to empirical scrutiny. One cannot conclude from this, of course, that a symbolic past tense rule *does not exist* (any more than one can conclude from examining any number of white swans that black swans *do not exist*). However, it appears from these results that both

regular and irregular past tense inflection *can* be modeled using a uniform mechanism considering factors such as phonological and semantic similarity and frequency. This evidence undermines both the claim that a rule is necessary to model past tense inflection and the concomitant *in principle* claim that single-route models cannot account for inflection.<sup>19</sup>

Further, these findings also undermine the claim that grammatical sensitivity and rules are innate. Proponents of the dual-route model (Kim et al., 1994; Pinker, 1999) have argued that because children master homophone verb forms prior to acquiring concepts like “noun” and “verb,” and because abstract grammatical information is necessary to the mastery of homophone verb forms, it follows that children must be innately sensitive to abstract grammatical information. Since the present findings suggest that meaning determines the inflection of homophone verbs, children’s mastery of these verbs can no longer be used to argue for their innate sensitivity to abstract grammatical distinctions or, by extension, to rules. This poses a new challenge to any model that relies on abstract grammatical information and rules: unless innate grammatical sensitivity can be demonstrated in some other way, rule-based accounts will need to explain how the abstract grammatical distinctions they rely on are learned in the first place.

On the evidence currently available, Occam’s razor (the scientific principle that all things considered, the simplest explanation that fits the facts is to be preferred) appears to count against the inclusion of the second route—the abstract rule—in an account of inflectional behavior. A single-route account of inflection,<sup>20</sup> with forms being processed by matching and analogous generalization in memory, appears to be both more economical explanatorily and to better fit the available data.

## Acknowledgments

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<sup>19</sup> Other aspects of the modeling of inflectional morphology remain open to debate, such as patterns of acquisition and particular frequency effects. However, these aspects relate more to matters of fitting models to data than principle; as such, they are best resolved by the fitting of fully specified models to empirical data (see Ellis & Schmidt, 1999; Hahn & Nakisa, 2000).

<sup>20</sup> These models are far from homogeneous in nature (e.g., Bybee, 1988, 1995; Daugherty & Seidenberg, 1994; Hahn & Nakisa, 2000; Joanisse & Seidenberg, 1999; Köpke, 1993; MacWhinney & Leinbach, 1991; Plunkett & Marchman, 1993; Rumelhart & McClelland, 1986; Seidenberg & McClelland, 1989; Westermann, 1998, 2000a, 2000b).

Wasow, and Gert Westermann for helpful discussions and Tracy Alloway, Severine Hubert, William O'Connor, Webb Phillips, Andrew Wishart, and Davie Yoon for their help in data gathering. Thanks also to British Airways and the Boeing Company for inspiration. Correspondence concerning this article should be addressed to Michael Ramscar at the School of Cognitive Science, University of Edinburgh, 2 Buccleuch Place, Edinburgh EH8 9LW, UK. Electronic mail may be sent to michael@dai.ed.ac.uk.

## **Appendix A. Materials used in the semantic reminding and grammatical analysis tasks in Experiment 4. The verbs classified as denominal by Kim et al. (1991) are presented first in each pair**

### *A.1. Fly*

Wade Boggs has a bad habit of hitting fly balls and getting caught. Last season, he hit just 3 home runs, but 45 fly balls. In yesterday's game, I saw him fly out four times. I swear he cost us the game.

Tim has a terrible temper. No-one knows when next he will fly off the handle. Whenever I see that certain look on his face, I know to steer clear.

Typical use: Birds fly south in winter.

### *A.2. Steal/Steel*

Brian had to steel himself before going to see the headmaster. He knew he was in big trouble.

John has been known to steal on occasion. Although he swears he is not a habitual villain, I'm beginning to have my doubts.

Typical use: It is wrong to steal from others.

### *A.3. Stand*

Charlie Wilson of United is a real prima donna. He never gets on with the game. Instead, he just shows off. He tries to grandstand all the time, and it really gets on my nerves.

Margaret Thatcher was always able to withstand any criticisms thrown at her. She just ignored it.

Typical use: The soldiers were told to stand at ease.

### *A.4. Spit*

When he barbecues, Colin always roasts a pig on a spit. He also tends to spit corn cobs as well. Colin loves barbecuing.

Whenever his wife has a good idea, Brown just spits on it. Last time I saw them, I had to listen to him spit on several really good ideas. She is such a creative woman, and I do not know why she puts up with it.

Typical use: I hate seeing sports stars spit on TV.

### A.5. *Lie*

If you ask Sam about his holiday, he will probably just lie to you. He is such a fabricator. The cure for cancer will lie beyond the abilities of scientists for some time to come. We just do not know enough about how it develops just now.

Typical use: When I sleep I lie down.

### A.6. *Break/Brake*

When Jim saw the child in the road, he had to brake suddenly. He was glad he was in a new car.

John has to introduce new employees to the company. This week he had to break in several newcomers.

Typical use: If you drop that vase it will break.

### A.7. *Shed*

Whenever it rains, Farmer Brown always puts his tractor in his shed. He also tends to shed the tractor when it is windy as well. Otherwise the engine tends to get clogged with dust.

The poor farmer had to let go of most of his possession to pay off his debts. Although he tried to hold on to some things, it got harder and harder to make ends meet. In the end he even had to shed his tractor to raise cash.

Typical use: A snake can shed its skin.

### A.8. *Drink*

It is always a good idea to relax your guests. Whenever guests arrive at my house, I immediately snack them and drink them. I find that refreshments set them at ease.

It is always a good idea to relax your guests by paying lots of attention to them. Whenever guests arrive at my house, I get them chatting and I drink in their news. I find that it sets them at ease.

Typical use: I like to drink plenty of water.

### A.9. *Cast*

John Smythe is a popular television presenter. His fame means that he is called on to broad-cast several programmes a week.

I think that witch cast a spell on Norman. He has not been at all well since she cursed him.

Typical use: Who shall cast the first stone?

### A.10. *Buy/Bye*

One team will automatically go through the first round of the cup this year. Clive is a big Rovers fan. Because of their big injury list, he hopes they will be lucky enough to bye into the second round, and get a Saturday off in the process.

Tom likes to buy books. If he got the chance, he would buy more books than he could ever hope to read in a life-time.

Typical use: There are some things money cannot buy.

### A.11. Wake

Biggins hotel specialises in receptions after funerals. It is very popular, and on some days they have to wake several funeral parties in the same afternoon.

When the heavy metal band Motorblood played the Roxy, they were so loud I could have sworn they would wake the dead.

Typical use: I always wake at 6 am.

### A.12. Sink

When guests come, I hide the dirty dishes by putting them in boxes or in the empty sink. Bob and Margaret were early last night, so I had to sink all my dirty dishes in a hurry.

When guests come, if they arrive with slides my hopes for a lively evening really sink. When I saw Bob and Margaret carrying six boxes, I felt my hopes sink instantly.

Typical use: He saw the Titanic sink.

## Appendix B. Materials used in the past tense acceptability rating task in Experiment 4. The verbs classified as denominal by Kim et al. (1991) are presented first in each pair

### B.1. Fly

Wade Boggs has a bad habit of hitting fly balls and getting caught. Last season, he hit just 3 home runs, but 45 fly balls. In Saturday's game, I saw him fly out four times. I swear he cost us the game.

When he flew out again yesterday, I could have cried.

Wade Boggs has a bad habit of hitting fly balls and getting caught. Last season, he hit just 3 home runs, but 45 fly balls. In Saturday's game, I saw him fly out four times. I swear he cost us the game.

When he flied out again yesterday, I could have cried.

Tim has a terrible temper. No-one knows when next he will fly off the handle. Whenever I see that certain look on his face, I know to steer clear.

All I did yesterday was walk on his lawn, and he immediately flew off the handle at me.

Tim has a terrible temper. No-one knows when next he will fly off the handle. Whenever I see that certain look on his face, I know to steer clear.

All I did yesterday was walk on his lawn, and he immediately flied off the handle at me.

### B.2. Steal/Steel

Brian had to steel himself before going to see the headmaster. He knew he was in big trouble.

Although he stole himself, he still cried when he was caned.

Brian had to steel himself before going to see the headmaster. He knew he was in big trouble.

Although he steeled himself, he still cried when he was caned.

John has been known to steal on occasion. Although he swears he is not a habitual villain, I am beginning to have my doubts.

I know he stole a car on Saturday.

John has been known to steal on occasion. Although he swears he is not a habitual villain, I am beginning to have my doubts.

I know he *stealed* a car on Saturday.

### B.3. *Stand*

Charlie Wilson of United is a real prima donna. He never gets on with the game. Instead, he just shows off. He tries to grandstand all the time, and it really gets on my nerves.

In the game with Rovers on Saturday he got an early goal and *grandstood* the rest of the match.

Charlie Wilson of United is a real prima donna. He never gets on with the game. Instead, he just shows off. He tries to grandstand all the time, and it really gets on my nerves.

In the game with Rovers on Saturday he got an early goal and *grandstanded* the rest of the match.

Margaret Thatcher was always able to withstand any criticisms thrown at her. She just ignored them.

She withstood a lot as leader.

Margaret Thatcher was always able to withstand any criticisms thrown at her. She just ignored them.

She *withstanded* a lot as leader.

### B.4. *Spit*

When he barbecues, Colin always roasts a pig on a spit. He also tends to spit corn cobs as well. Colin loves barbecuing.

At his barbecue at the weekend he spat a whole wild boar on a special long spit. It was delicious.

When he barbecues, Colin always roasts a pig on a spit. He also tends to spit corn cobs as well. Colin loves barbecuing.

At his barbecue at the weekend he *spitted* a whole wild boar on a special long spit. It was delicious.

Whenever his wife has a good idea, Brown just spits on it. Last time I saw them, I had to listen to him spit on several really good ideas. She is such a creative woman, and I do not know why she puts up with it. If he spat on my ideas like that, I would leave him.

Whenever his wife has a good idea, Brown just spits on it. Last time I saw them, I had to listen to him spit on several really good ideas. She is such a creative woman, and I do not know why she puts up with it. If he *spitted* on my ideas like that, I would leave him.

### B.5. *Lie*

If you ask Sam about his holiday, he will probably just lie to you. He is such a fabricator.

He lay to me about his holidays last time I asked him. He said he went to India, but I later heard that he was in Inverness!

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He lied to me about his holidays last time I asked him. He said he went to India, but I later heard that he was in Inverness!

The cure for cancer will lie beyond the abilities of scientists for some time to come. We just do not know enough about how it develops just now. Many things that once lay out of reach have now been achieved, so I am optimistic a cure will be found one day.

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### B.6. *Break/Brake*

When Jim saw the child in the road, he had to brake suddenly. He was glad he was in a new car. When he broke like that in his old car, it took an age to stop.

When Jim saw the child in the road, he had to brake suddenly. He was glad he was in a new car. When he braked like that in his old car, it took an age to stop.

John has to introduce new employees to the company. This week he had to break in several newcomers. After he broke them in, he took them for beers.

John has to introduce new employees to the company. This week he had to break in several newcomers. After he braked them in, he took them for beers.

### B.7. *Shed*

Whenever it rains, Farmer Brown always puts his tractor in his shed. He also tends to shed the tractor when it is windy as well. Otherwise the engine tends to get clogged with dust. Last night when it rained, Brown shed the tractor and went to the pub.

Whenever it rains, Farmer Brown always puts his tractor in his shed. He also tends to shed the tractor when it is windy as well. Otherwise the engine tends to get clogged with dust. Last night when it rained, Brown shedded the tractor and went to the pub.

The poor farmer had to let go of most of his possession to pay off his debts. Although he tried to hold on to some things, it got harder and harder to make ends meet. In the end he even had to shed his tractor to raise cash.

After he shed his tractor, he had to give up farming and become a bus conductor.

The poor farmer had to let go of most of his possession to pay off his debts. Although he tried to hold on to some things, it got harder and harder to make ends meet. In the end he even had to shed his tractor to raise cash.

After he shedded his tractor, he had to give up farming and become a bus conductor.

### B.8. *Drink*

It is always a good idea to relax your guests. Whenever guests arrive at my house, I immediately snack them and drink them. I find that refreshments set them at ease. I drank and snacked Julia as soon as she arrived at my party.

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It is always a good idea to relax your guests by paying lots of attention to them. Whenever guests arrive at my house, I get them chatting and I drink in their news. I find that it sets them at ease.

When Bill arrived on Sunday, I drank in everything he had to say, even though he is a bore. A host has to try you know.

It is always a good idea to relax your guests by paying lots of attention to them. Whenever guests arrive at my house, I get them chatting and I drink in their news. I find that it sets them at ease.

When Bill arrived on Sunday, I drinked in everything he had to say, even though he is a bore. A host has to try you know.

### B.9. Buy/Bye

One team will automatically go through the first round of the cup this year. Clive is a big Rovers fan. Because of their big injury list, he hopes they will be lucky enough to bye into the second round, and get a Saturday off in the process.

Rovers last bought into the second round of the cup in 1976, and they then went on to win it.

One team will automatically go through the first round of the cup this year. Clive is a big Rovers fan. Because of their big injury list, he hopes they will be lucky enough to bye into the second round, and get a Saturday off in the process.

Rovers last *byed* into the second round of the cup in 1976, and they then went on to win it.

Tom likes to buy books. If he got the chance, he would buy more books than he could ever hope to read in a life-time. He bought “War and Peace” over 5 years ago, but it is still unread.

Tom likes to buy books. If he got the chance, he would buy more books than he could ever hope to read in a life-time. He *buyed* “War and Peace” over 5 years ago, but it is still unread.

### B.10. Cast

John Smythe is a popular television presenter. His fame means that he is called on to broadcast several programmes a week. Last week he broadcast seven different programmes.

John Smythe is a popular television presenter. His fame means that he is called on to broadcast several programmes a week. Last week he broadcasted seven different programmes.

I think that Witch cast a spell on Norman. He has not been at all well since she cursed him. Last year the Witch cast a spell on Bert, and he has been sick ever since.

I think that Witch cast a spell on Norman. He has not been at all well since she cursed him. Last year the Witch *casted* a spell on Bert, and he has been sick ever since.

### B.11. Wake

Biggins hotel specialises in receptions after funerals. It is very popular, and on some days they have to wake several funeral parties in the same afternoon. Last Tuesday they woke eleven funerals in one day.

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When the heavy metal band Motorblood played the Roxy, they were so loud I could have sworn they would wake the dead. They certainly wake a few of the local citizens!

When the heavy metal band Motorblood played the Roxy, they were so loud I could have sworn they would wake the dead. They certainly waked a few of the local citizens!

### B.12. Sink

When guests come, I hide the dirty dishes by putting them in boxes or in the empty sink. Bob and Margaret were early last night, so I had to sink all my dirty dishes in a hurry. After I sank the dishes, I made some coffee and we chatted. I soon regained my composure.

When guests come, I hide the dirty dishes by putting them in boxes or in the empty sink. Bob and Margaret were early last night, so I had to sink all my dirty dishes in a hurry. After I *sinked* the dishes, I made some coffee and we chatted. I soon regained my composure.

When guests come, if they arrive with slides my hopes for a lively evening really sink. When I saw Bob and Margaret carrying six boxes of slides my hopes sank instantly.

When guests come, if they arrive with slides my hopes for a lively evening really sink. When I saw Bob and Margaret carrying six boxes of slides my hopes *sinked* instantly.

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