The Effects of Semantic Priming on Novel Verb Inflection

Molly A. McCarthy & Trina C. Kershaw
mmccarthy@umassd.edu, tkershaw@umassd.edu
Department of Psychology, University of Massachusetts Dartmouth, 285 Old Westport Road, North Dartmouth, MA
02747 USA

Abstract

Contemporary theories of language production disagree about the cognitive mechanisms involved in the production of past tense forms of regular and irregular verbs. Two models compete to explain this process: Dual-route and Single-route. The present study tests these models using previously reported methods of production and naturalness rating of the past tense forms of novel verbs. Overall, participants show a preference for regular verb forms, both in production and rating tasks. However, presentation of a novel verb in an irregular semantic context cancels out that preference. Previous findings were not replicated, and inconclusive results show some support for both models.

Keywords: Past tense verb production, semantics, grammar rules

The Past Tense Debate

Over the past 30 years, there has been a large body of work investigating the production of past tense forms of regular versus irregular verbs (e.g. Huang & Pinker, 2010; Marcus et al., 1992; McClelland & Patterson, 2002; Pinker & Ullman, 2002; Prasada & Pinker, 1993; Ramscar, 2002; Ramscar, Dye & Hubner 2012; Rumelhart & McClelland, 1987). Currently, there are two major models competing to explain the process of inflection: dual route models (Marcus, 1992; Pinker & Ullman, 2002; Prasada & Pinker. 1993) and single route models (McClelland & Patterson, 2002; Ramscar, 2002; Ramscar et al., 2012; Rummelhart & McClelland 1987).

Dual Route Models

According to dual route theories, abstract grammatical rules play a central role in language processing. Dual route models propose that past tense verb production is governed primarily by a grammatical rule, which is supplemented by lexical retrieval. The grammatical rule is a suffixation rule that, simply put, tells us whenever a verb is to be put into the past tense we add the /-ed/ suffix. Lexical retrieval comes into play when an irregular past tense form has been previously learned and memorized. In cases such as these, the grammatical rule is overridden and the stored form of the verb is retrieved from the lexicon (Huang & Pinker, 2010; Pinker & Ullman, 2002; Prasada & Pinker, 1993).

Strong support for dual route models can be seen in a series of experiments by Prasada and Pinker (1993). Experiments 1 and 2 demonstrated that participants rated novel verbs with regular endings as seeming "more natural" than novel verbs with irregular past tense forms. In Experiment 3, participants produced the past tense form of a given novel verb within a sentence. Prasada and Pinker observed significantly more suffixed, or regular, past tense forms than non-suffixed, or irregular, forms. They also observed that of those novel verbs conjugated irregularly, those that were closest phonologically to their root verbs were more often conjugated irregularly.

Single Route Models

Single route models aim to eliminate the need for an abstract grammatical rule. According to these models, a connectionist network maps the stems of all verbs and their past tense forms, and makes judgments based on the intensity of the connections as to which form is produced for a given input. The same route is used to map both regular and irregular verbs to their past tense forms-hence, "single-route." As an example, the proposed network of Rumelhart and McClelland (1987) works as a pattern-associator that learns the connections between phonological verb stems and past tense verb forms. These connections are strengthened with repetition. This is a very simplified explanation of a connectionist network, and other factors such as meaning and context also influence the connections between verbs and their past tense forms (McClelland & Patterson, 2002; Ramscar, 2002; Ramscar et al., 2012).

The main criticism of single route production models is that they fail to explain what is commonly referred to as the homophone problem. This problem arises when past tense verb production is only considered in terms of phonology and grammar. There are several sets of real verbs that are homophones, but are not conjugated in the same way. For example: *break/brake,* and *wring/ring*. If a single route model is based on the connections between a phonological stem and its associated past tense form, then the difference between the past tense forms of these homophones cannot be explained.

Ramscar (2002) posited that the explanation of the homophone problem lies in the meaning of verbs. He hypothesized that when given the appropriate semantic context, participants would conjugate a novel verb based on a homophone verb in the desired form. Ramscar's results suggest that rather than being dependent on a abstract grammatical rule, past tense production is based on an inaccessible or untaught system of connections. Semantics is clearly one of the elements used in the

pattern-associator network that links verbs to their past tense forms.

The Present Experiments

The most common way the dual and single route models are tested involves the use of novel verbs. The two models make different predictions about how individuals will produce the past tense form of a novel verb. Dual route models predict that whenever lexical retrieval fails, speakers will apply the default grammatical rule of adding the regular /-ed/ ending (e.g., *frink/frinked;* Pinker & Ullman, 2002).. Conversely, single route models suggest that, because regular and irregular forms are produced using the same process, failure of retrieval will not necessarily result in production of a regular past tense form. According to single route theories, a novel verb will be inflected according to the real verb it most resembles phonologically because of the strength of the connection between the phonology of the real verb stem it is based on and its past tense form (McClelland & Patterson, 2002). Semantic hints, as shown in Ramscar's work (2002; Ramscar et al., 2012) help individuals to make connections between novel and real verbs.

Although many experiments have been conducted concerning the production of past-tense verb forms, different procedures are generally used. Ramscar's work (2002; Ramscar et al., 2012) often calls for the production of past tense forms of novel verbs, while many of Pinker's experiments (Huang & Pinker, 2010; Prasada & Pinker, 1993) ask participants to rate the naturalness of provided past tense forms of novel verbs. In order to tease apart the difference between the two theories while maintaining comparable experimental methods, three experiments were conducted. In each experiment, participants were provided with the same experimental passages, adapted from Ramscar (2002; see Table 1).

Each passage provided either a regular or irregular semantic context. The passages were three sentences long and contained approximately the same number of words.. The main change between Ramscar's original passages and the passages used in the experiments was that the real verbs in each passage were manipulated to be all regular or irregular forms. For example, in Table 1 the second and third sentences in the regular semantic context were "… cancer patient Ivan Borovich ____ around 35 vodka shots and 50 fish. Doctors believed this practice helped in his treatment." Ramscar's (2002) original passage ended with the sentence "… cancer patient Ivan Borovich ____ around 35 vodka shots and 50 pickled sprats; it is not recorded whether this helped in his treatment." Ramscar's (2002) passage contains regular verbs (record, help), irregular verbs (is), and a gerund (pickled). In the same paper, Ramscar showed that participants' inflection of novel verbs could be affected by just one prior instance of seeing a regular or irregular verb (Experiment 1). Thus, altered passages containing only regular or only irregular forms were created due to the potential influence of other

real verbs. Because regular vs. irregular real verb forms had no effect on the results of any experiment, only the regular form passages are shown in Table 1. In addition, in light of Ramscar's results, participants were asked to perform only one task, either producing the past tense form of a novel verb (*frink*), or rating the naturalness of a given past tense form of a novel verb (*frinked/frank*).

Table 1: Experimental Passages

Regular Semantic Context	In a classical symptom of Howson's syndrome, patients all *frink* in their right eye if they are left hand dominant or left eye if right hand dominant, their eyelids closing rapidly and uncontrollably. In 1996, in extreme discomfort due to his bad eye, Howson's patient Ivan Borovich ___/***frinked/frank*** around 35 times per minute for two days. Doctors discovered this caused severe damage to his left eyelid.
Irregular Semantic Context	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 sardines. In 1996, his favorite vodka glass in hand, cancer patient Ivan Borovich ____/***frinked/frank*** around 35 vodka shots and 50 fish. Doctors believed this practice helped in his treatment.

Note: Participants received one of the **bold** options (a blank space, *frinked*, or *frank*).

Experiment 1

Participants

Participants were 86 University of Massachusetts Dartmouth students from several undergraduate psychology and honors courses. Students were not given any incentives, and no identifying information was attached to their responses.

Materials and Procedure

Students were given one of the passages shown in Table 1 that provided either a regular or irregular semantic context. The different passages were randomly distributed to participants in a classroom setting. A space was provided in the target sentence for participants to provide their past tense form of *frink*. The instructions read: "Please read the following paragraph. After you have read it, fill in the blank with the past tense form of the italicized verb that you believe best completes the sentence." Participants were asked to carefully read the

directions and complete the task. They were given as much time as they needed, but generally completed the task within 5 minutes.

Results

Fourteen participants were removed from the data set for writing in responses that did not conform to a regular or irregular form of the novel verb *frink* (for example, *consumed, frinks,* and *drank*). The resulting sample was made up of 72 participants.

Overall, participants produced more regular verbs ($n = 49$) than irregular verbs ($n = 24$). To compare frequencies of regular and irregular verb production as a function of semantic context, a chi-square analysis was conducted. This test was significant, $\chi^2 (1, N = 73) = 8.46$, $p = .004$. Examination of the adjusted standardized residuals (ASR) indicated that the locus of this significant result was due to the production of irregular verb forms by participants in the irregular semantic context group (ASR = 1.7). In the regular semantic context group, participants produced more regular past tense verb forms ($n = 32$) than irregular past tense verb forms ($n = 7$). But in the irregular semantic context group, participants produced an equal number of regular and irregular past tense forms (ns = 17). This finding is illustrated in Figure 1.
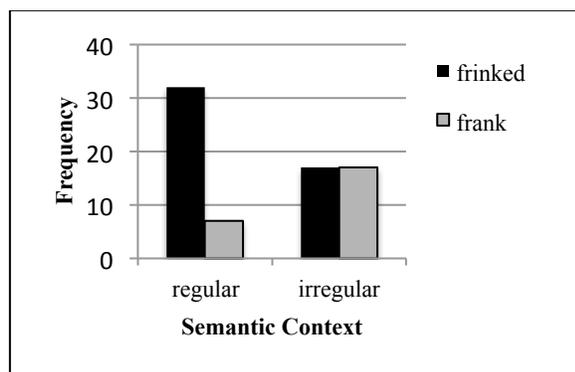

Figure 1: The Effect of Semantic Context on Past Tense Verb Form Production

Discussion

Single- and dual- route models make different predictions of how people will produce the past tense forms of novel verbs. Single route models (cf. Ramscar, 2002, 2012) predict that semantic context will influence verb production. This was only the case in the regular semantic context passages. When the semantic context was irregular, instead of the predicted increase in irregular past tense forms, both forms were equally produced This finding does not replicate Ramscar's (2002, 2012) results. Semantic context has an effect on past tense verb form production, but not to the degree previously found by Ramscar. Dual route models would predict high regular production in both semantic contexts, as participants are simply reacting to an unknown verb by applying the

grammatical rule of adding /-ed/. This prediction was also not entirely supported by these findings. Overall, however, the disproportionately high number of regular verbs that were produced does support the dual route idea that participants default to regular inflection when confronting an unknown verb.

In order to get a more comprehensive understanding of the effects of semantic context on people's perception of novel verbs, a second experiment was conducted in which participants were asked to rate how natural an irregular or regular version of a novel verb sounded instead of producing a past tense form. We wished to evaluate this rating method from Prasada and Pinker (1993) using Ramscar's (2002) passages.

Experiment 2

Participants

Participants were 149 University of Massachusetts Dartmouth students from the same undergraduate psychology and honors courses used in Experiment 1, but students could only participate in one of the experiments.

Materials and Procedure

Each participant was given a single paper containing one of the passages shown in Table 1 with either *frinked* or *frank* in the second sentence. The instructions preceding the passage read: "Please read the following paragraph. After you have read it, you will be asked to rate the naturalness of the italicized word." Below each passage was a scale of 1-7. Participants were asked to circle the number corresponding with their perceived naturalness of the novel verb, 1 being not natural at all, and 7 being completely natural.

Below the rating section, a second set of instructions was given: "Please indicate which of the following methods you used to rate the verb in the previous paragraph. If you choose 'other,' please write in the method you used." Participants were given similar possibilities to those used by Huang and Pinker (2010, Experiment 1):
a) The apparent meaning of the novel verb.
b) The novel word reminded me of a specific word I already know, so I simply borrowed the past-tense form of the verb. If so, please indicate which verb you had in mind: _____
c) The sound of the novel word made one form seem better than the other.
d) I didn't really think of any particular strategy; one of the past tense forms just seemed better than the other.
e) Other. Please indicate: _____

Results

A 2x2 analysis of variance (ANOVA) was run with semantic context and target verb type as independent variables and naturalness rating as dependent variable. There was no main effect of semantic context, $F (1, 147)$

= 1.43, p = .23, η_p^2 = .01. There was a main effect of target type, F (1, 147) = 4.65, p= .03, η_p^2 = .03, in that participants rated regular targets as more natural (M = 3.64, SD =. 1.72) than irregular targets overall (M = 2.97, SD = 1.61).

There was a significant interaction between semantic context and target type F (1, 147) = 2.89, p = .05, η_p^2 = .02 (see Figure 2). The interaction was such that regular targets were rated as more natural when presented in the regular context (M = 3.99, SD = .27) than irregular targets in the regular context (M = 2.87, SD = .27). When the passage was in the irregular context, there was no significant difference in naturalness ratings of regular (M = 3.13, SD= .27) or irregular targets (M = 3.08, SD = .28).
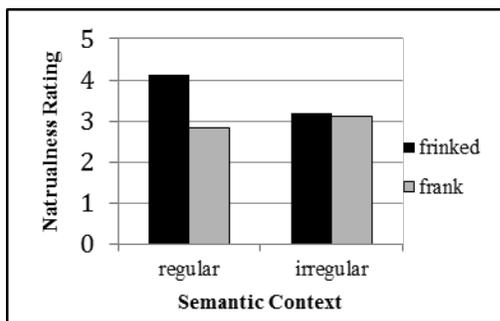

Figure 2: Interaction between Semantic Context and Target Type

Analysis of participants' strategies was based on Huang and Pinker's (2010) analyses of the same question. A multiple regression was performed in order to determine if any strategy in particular could predict a participant's naturalness rating. Each potential response was entered separately, and coded as 1 for yes (indicating the participant chose that response) and 0 for no (indicating the participant did not choose that response). Participants who chose more than one response or gave no response were excluded from this analysis, bringing the sample size to 115.

Options A through E were entered in the first block, and interactions were entered into the second block. Descriptive statistics for participants' responses to the strategy question can be found in Table 2.

The overall model was significant, R^2 = .14, F (4, 110) = 4.32, p = .003. The analysis showed that one strategy was able to predict naturalness rating, Option A (similar meaning), β = .25, p = .01. Participants who chose the known word option rated the novel verbs higher (M = 5.30, SE = .58) than those who did not (M = 3.10, SE = .15). None of the other options were significant predictors of naturalness rating (Option B [known word], β = .20, p = .35; Option C [similar sound], β = .04, p = .86; Option D [no strategy], β = -.02, p = .92; Option E [other], β = -.09, p = .35).

Using this information, the ANOVA was re-run with the additional independent variable of similar meaning strategy. Accounting for strategy use reduced the significance of target type (F [1,122] = .2.53, p = .12, η_p^2 = .02) previously found, as well as the interaction between semantic context and target type (F [1, 122] = 3.56, p = .06, η_p^2= .03). The effect of similar meaning strategy on naturalness rating was significant, F (1,122) = 11.52, p=.001, η_p^2 = .09). Participants who used the similar meaning strategy rated the target verb as more natural than those who did not. There was no interaction between semantic context and target type.

Table 2: Responses to Strategy Question

Strategy	Frequency (%)	
	Exp 2	Exp 3
Similar Meaning	9 (7.83%)	5 (10.64%)
Known Word	40 (34.78%)	23 (48.94%)
Similar Sound	32 (27.83%)	8 (17.02%)
No Strategy	29 (25.22%)	20 (42.55%)
Other	5 (4.35%)	0 (0%)

Discussion

As discussed in Experiment 1, previous research (Ramscar 2002, 2012) showed an effect of semantic context on verb production. Experiment 2 was designed to see if semantic context effects can be found using naturalness rating methods (Prasada & Pinker, 1993; Huang & Pinker, 2010). They were not. There was an interaction between semantic context and target type, but it was not what was predicted based on Ramscar's results. Based on his work, regular or irregular semantic context would lead to higher naturalness ratings on regular or irregular verbs, respectively. We found that regular semantic context predicted naturalness ratings. However, irregular context was not a predictor of naturalness ratings of irregular verbs. Based on Ramscar's results, we would expect to see higher naturalness ratings of irregular verbs in the irregular context passages. Instead, as in Experiment 1, for the irregular context passages, regular and irregular targets were rated about the same. This result is also not predicted by dual route models. Based on these models, no matter what the context a regular verb should be rated higher. Obviously, this is not the case.

Some support for dual route models was found in this experiment. First of all, the overwhelmingly higher ratings of regular targets versus irregular targets overall is predicted by dual route models. However, in past research (Prasada & Pinker, 1993) it has been found that naturalness ratings are consistently higher for regular verbs. The effect that the irregular semantic context has on the ratings of regular verbs (i.e., reducing it to match the rating of irregular verbs) does not support these previous results.

The results found for the effect of strategy on naturalness rating were similar to Huang and Pinker's (2010). Their claim that participants' tendency to relate the novel verb to an existing verb is supported by our results.

In order to shed some light on how strategy impacts verb production, a third experiment was conducted using the verb production task from Experiment 1 and the multiple-choice strategy question from Experiment 2.

Experiment 3

Participants

Participants were 50 University of Massachusetts Dartmouth students from several undergraduate psychology courses. None of the students had participated in Experiments 1 or 2.

Materials and Procedure

The same materials from Experiment 1 were used. In addition to the fill-in-the-blank task given in Experiment 1, the participants in this experiment answered the multiple choice strategy question given in Experiment 2.

Results

Three participants were removed from the data set for giving responses that did not qualify as either a regular or irregular form of the novel verb (e.g., consumed). The resulting sample size was 47.

Overall, participants produced more regular verbs ($n = 28$) than irregular verbs ($n = 19$). Participants' choices for the strategy question are in Table 2. Binary logistic regression was used to analyze the data. Logistic regression makes predictions, based on the independent variables, of the likelihood that an event will occur. For the following analyses, we predicted the likelihood that participants would produce an irregular past tense form of the target verb based on type of semantic prime provided and strategy chosen. The initial analysis found that the only significant predictors were semantic context and the known word strategy option. No other strategies had an effect on the likelihood of producing *frank*. The model was then re-run with semantic context entered in the first block and the known word strategy entered into the second block, following the recommendations of Hosmer and Lemeshow (1989).

Table 3: Logistic Regression Model Predicting Past Tense Verb Form Production

Predictor	B	S.E.	Wald χ^2	O.R.	95% C.I.
Block 1					
Semantic Context	-2.17	.86	6.33*	.12	.02-.62
Block 2					
Known	-2.5	.79	8.31*	.08	.02-.45

Word

Note: *$p < .01$, S.E.= standard error, O.R = odds ratio

The first block was statistically significant, $\chi^2(1, N = 47) = 4.93$, $p = .012$. The model classified 66% of the sample. Table 3 shows the regression coefficients, Wald χ^2, and odds ratios for this regression. The odds ratio for semantic context indicated that when presented with the irregular context, participants were 88.5% less likely to produce a regular verb. This finding is illustrated in Figure 3. Block 2, containing the "known word" strategy option, was significant, $\chi^2(1, N = 47) = 11.44$ $p = .004$. The odds ratio indicated that participants who used the "known verb" strategy were 91.7% less likely to produce a regular verb form. This finding is illustrated in Figure 4.
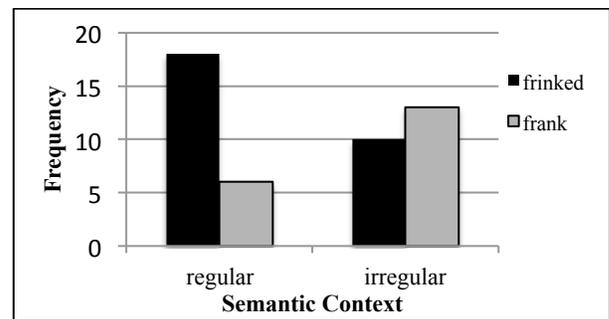
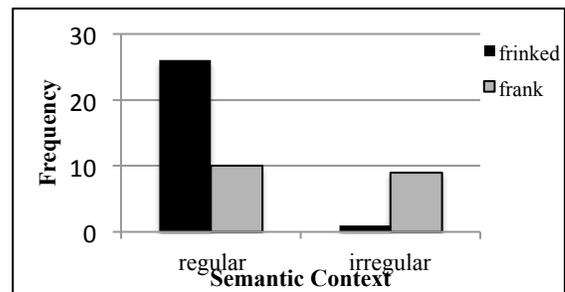Figure 3: The Effect of Semantic Context on Past Tense Verb Form Production

Figure 4: The Effect of Using the *Known Word* Strategy on Past Tense Verb Form Production

Discussion

In terms of the effect of semantic context on past tense production, the results of this experiment are consistent with the results of Experiment 1. When the context of the passage is irregular, participants are 88.5% less likely to produce a regular verb. The analysis of the multiple-choice question shows that when given a verb production task, participants use the same strategy as when rating verb naturalness. In this case, the "known word" strategy (i.e., *The novel word reminded me of a specific word I already know, so I simply borrowed the past-tense form of the verb*) was the only option that had a significant effect on verb production. Participants who used this strategy were 91.7% less likely to produce a regular verb in the

irregular context. What this may mean is that in the irregular context passage, *frink* was reminding the participants of *drink* more than it was reminding them of *blink* in the regular passage. All participants who chose the "known word" strategy responded with "drink" when prompted to indicate which word they were reminded of. This could be the result of the fact the *frink* is phonetically closer to *drink* than it is to *blink.* It could also be the case that the context provided by the passages activated the meaning of the real verb, and participants just borrowed the past tense form from that existing verb as a result.

General Discussion

The results of the experiments discussed in this paper have interesting implications for the state of the past tense debate. First of all, neither experiment was able to replicate the findings of the studies they were derived from. Ramscar (2002, 2010) consistently found that novel verbs presented with an irregular context passage would result in the higher production of irregular verb forms. In contrast, we found that the irregular semantic context did not cause high irregular verb production, but instead resulted in equal production of both regular and irregular verb forms.

The question, then, is what does this equalizing effect seen in the verb production tasks mean? It is possible that by activating the meaning of an existing verb, particularly one so closely related to the form of the novel verb, that the participant is then retrieving the correct past tense form of the verb from the lexicon based on the related existing verb. Evidence for this is seen in the strategy question results. Participants who indicated that the novel verb reminded them of a word they already knew were less likely to produce a regular verb form in the irregular context and rated the provided novel verb as more natural. This, in addition to the overall preference and production rates of regular verbs, lends support to dual route models. When the passage is in the regular semantic context, the grammar rule of adding /-ed/ is automatically applied. It is only when we are triggered to recall an existing irregular verb form similar to the novel verb in meaning and structure that the initial rule is overridden. What is not explained by this are those cases in which participants produced or preferred irregular verbs in the regular context passages.

Another curious finding was the inability to replicate Prasada and Pinker's (1993) and Huang and Pinker's (2010) findings that participants will produce regular verbs no matter the semantic context of the passage, and that they will also consistently rate regular verbs more naturally despite the context. This difference might be explained by our method of only obtaining one response from each participant, suggested by Ramscar (2002). Until now, there have been no studies on naturalness rating of novel verbs using only one response per participant.

While this study did not give definite support for either theory of language production, we did find a clear pattern of results: Irregular semantic context "evens the playing field" for novel verbs. Essential to this topic of study would be some baseline data of how participants conjugate a novel verb with no context at all. By comparing baseline information to previous data and new data using more novel verbs in various contexts, a clearer picture could be formed.

There is still much to be done in determining the processes involved in language production. We do not think it is safe to say one side of the debate has won over the other. Evidence exists to support both sides, and at this point more research is needed.

Acknowledgements

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