

Form-Oriented Inflectional Errors in Language Processing

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We examine speech errors as a way of understanding fundamental aspects of cognitive processing. Our studies focus on one type of speech error: the failure to add an inflection to a word because the adjacent part of the base word is identical to the inflection. Errors of this type reflect a more general problem with the repetition of actions in cognitive processing. Such errors indicate that language processing is sensitive to the form of the output even as it is generating that output. We demonstrate that form-oriented errors occur in production tasks for past tense *-ed*, present tense *-s*, indefinite *alan*, and three irregular past tense patterns. The data support the following strong principle in language production: if a form resembles the output of an inflectional pattern, there will be a tendency to use it without actually applying that pattern. We also show that when the base word resembles an irregular pattern, the members of the irregular pattern function as a "gang" to impose their shape on the base word, but this does not appear to be the case when the base word resembles a regular pattern. Implications of these effects for models of language and cognitive processing are discussed. © 1986 Academic Press, Inc.

A pervasive aspect of virtually every area of human cognitive/motor performance is the occurrence of error (Norman, 1981). For the past century, many researchers have believed that errors provide us with a particularly well-situated window from which to observe many aspects of mental life. One of the most important distinctions between different types of errors is whether the error is function-oriented or form-oriented. In function-oriented errors, the action that is performed in error is functionally related to the intended action in some fashion. Norman (1981) gives the example of a person who intends to put a toothbrush away in a glass on the counter, but instead performs the functionally related action of putting it in the cabinet under the counter on the opposite side, where the hairbrush is kept. In language production, the speaker might erroneously use a word that is semantically related to the intended word but with reversed polarity, as in *stop* for "start." In form-oriented errors, on

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the other hand, the action that is performed is related in terms of having a formally similar result, in that it utilizes similar actions or involves similar items. Norman gives the example of a person who stopped his/her car and then unbuckled his/her wristwatch rather than unbuckling the seat-belt. A linguistic example of a form-oriented error is the "malapropism," where the speaker erroneously uses a word that is phonologically but not semantically related to the target word, as in *coupons* for "croutons" (Fay & Cutler, 1977). In this paper, we examine another type of form-oriented error that occurs in inflectional processing in language production.

Speakers occasionally make errors related to accessing the correct inflected form of words, producing instead another inflected form of the word or the simple "base" form of the word. We will refer to the latter type of errors as "no-marking errors." A number of studies have explored the production of these errors by children and aphasics, but few studies have looked at the production of no-marking errors by normal adult speakers.

In the area of child language, Berko (1958) was the first to notice that verbs that end in /t/ and /d/, such as *need* and *want*, are more difficult than other regular verbs, such as *talk* and *kiss*, and that these verbs show a greater rate of no-marking errors in the past tense. Berko also discovered that nouns that end in /s/ and /z/ were more prone to no-marking errors in the plural. She attributed the elevated rate of no-marking errors to the phonological similarity of the affixes to the adjacent part of the stem; verbs like *need* already sound like past tense forms (cf. *knee-ed*), and nouns like *rose* already sound like plurals (cf. *rows*). Slobin (1970), Derwing and Baker (1980), MacWhinney (1978, 1983), and Bybee and Slobin (1982) have confirmed such patterns of errors for child speech in both spontaneous speech and experimental tasks. These researchers have all assumed that phonological similarity between the inflection and the adjacent part of the base word makes the word more prone to no-marking errors. Children are somehow being fooled by this similarity into thinking that the inflectional process has been applied to the base form. But it would be a mistake to consider these errors as characteristic of child speech only, since it is now clear that adults make similar errors in both spontaneous (Stemberger, 1981, 1983) and experimental (Bybee & Slobin, 1982) speech situations.

Recently, it has been shown that similar form-oriented phenomena occur as a part of grammatical processes in many languages (Stemberger, 1981; Menn & MacWhinney, 1984). For example, the perfect participle in Swedish involves the addition of /t/ or /d/ to the end of most regular verbs, but nothing is added if the base verb already ends in /t/ or /d/. In other instances, languages avoid adding an affix that resembles the adja-

cent part of the base word by using a different affix, or speakers simply never use that inflected form of the word at all. In general, there appears to be a linguistic constraint that disfavors the addition of an inflection to a similar base form. There is now an impressive array of linguistic evidence demonstrating the pervasiveness of this phenomenon. At this point, however, we know very little about the nature or origin of this phenomenon in cognitive processing.

A moment's reflection suggests that this phenomenon is but one way in which the mind responds to a very general cognitive problem. The problem is, how do we avoid doing something twice when it should be done only once and still do it twice when it should be done twice? Life is full of opportunities of redundancy and the erroneous avoidance of repetition is pervasive. We spell "givenness" as "giveness," "modelling" as "modeling," and "Mossside" (a community near Pittsburgh) as "Mosside." In cursive writing, the repetition of strokes is difficult and often leads to the loss of one of the strokes, so that *mm* may be written *mn* (Hotopf, 1983). This problem is not limited to motoric activity in close temporal contiguity, but is true of actions in general.

What is the explanation of these phenomena? Can we provide a processing account that shows why we avoid the repetition of actions even when such avoidance leads to errors? We believe that such an explanation may be of general interest to students of cognitive processing. If it is true that there is a close interaction between the forms of two units that are being processed at the same time (e.g., a verb and the past tense inflection), we will need to develop a processing model that can accommodate such interaction between the output of two items.

We must begin by demonstrating in a controlled experimental setting that there is indeed a bias toward the avoidance of the repetition of forms. On the basis of current data (both naturalistic and experimental), it is not possible to exclude the claim that the errors that appear to illustrate the avoidance of repetition are in fact due to other forces. There are at least two possible confounds: difficulty and frequency. First, it is possible that no-marking errors simply involve avoidance of the more "difficult" variant, or allomorph, of the suffix involved. This allomorph would predictably have a higher error rate than less difficult variants (Berko, 1958). Two possible sources of difficulty are lower frequency and phonological complexity (such as requiring an extra syllable). In English, these two measures of difficulty are naturally intertwined, since the more complex syllabic allomorph (e.g., /əd/ as in /ni:dəd/ "needed" and /əz/ as in /rouzəz/ "roses") is less frequent than the nonsyllabic allomorph (e.g., /d/ as in /ni:d/ "knead" and /z/ as in /rouz/ "rows") for most suffixes. The syllabic allomorphs account for only 22.6% of all tokens of past tense *-ed* in Francis and Kucera (1982), and only 9.6% of all tokens of present

tense *-s*. The known English examples of "form-oriented" errors do involve the more difficult syllabic allomorphs of *-ed* and *-s*. Second, it is possible that apparently "form-oriented" errors are due to a confound with the frequency of the inflected form. Stemberger and MacWhinney (1986) have shown that low-frequency inflected forms have a higher rate of no-marking errors. Since previous studies have not controlled for this factor (except Berko, 1958, which used only novel words), it is possible that the no-marking errors detected were confined mostly to low-frequency forms.

In this paper, we explore experimentally the occurrence of no-marking errors in the production of various English inflections. We show that such errors are indeed form-oriented and that they are far more widespread than has been previously suspected. The characteristics of these form-oriented errors help to narrow the possible interpretations of the phenomenon. We make use of an experimental task that causes speakers to make inflectional errors, especially no-marking errors. This task is a variant of one used by Mackay (1976) and Bybee and Slobin (1982), where subjects are given a form of a verb and asked to produce the past tense form as quickly as they can. In Experiment 1, we begin with a replication of previous findings in the literature that verbs that end in /t/ and /d/ are subject to form-oriented errors in the past tense. This ensures that our task can adequately induce form-oriented errors and test whether the frequency of the base form or inflected form alone can account for the occurrence of no-marking errors.

EXPERIMENT 1: LIFT-TYPE PSEUDO-PAST VERBS

Method

Subjects

Subjects were 50 undergraduate students at Carnegie-Mellon University, receiving credit in an introductory psychology course for their participation in the experiment.

Materials

A list of 60 English verbs was constructed. The verbs were divided into three groups.

1. *Pseudo-past regulars*. There were 20 regular verbs ending in /t/ or /d/ (such as *lift* and *yield*), with an average frequency of 39.9 for all forms of the word and 7.3 for the past tense form alone based on Francis and Kucera (1982); since the base forms of these verbs look like past tense forms, they are referred to as "pseudo-past" verbs.

2. *Full regulars*. There were 20 regular verbs ending in other phonemes (such as *bake* and *grab*), with an average frequency of 40.1 for all forms of the word and 12.3 for the past tense form alone; these are referred to as "fully regular" verbs.

3. *Fillers*. There were 20 irregular verbs that served as fillers. All verbs had a single syllable and were between three and five letters long. The full list is given in Appendix 1.

Procedure

The verbs were presented one at a time in the frame "WAS ____ING" in the center of the CRT display screen of an IBM/PC microcomputer. This frame was included to ensure that the subject perceived the presented word as a verb, since related nouns often existed. The subject read the verb silently, then spoke the past tense form of the verb out loud into a microphone connected to a voice key. The instructions emphasized the need to react as quickly as possible. At the onset of the verbal response, the computer removed the verb from the display screen. The next verb was presented 1.5 s later. The subject's verbal responses were recorded on audiotape which was later analyzed for errors.

Each subject was first given 12 practice trials. The 60 experimental verbs were randomized differently for each subject. Each subject's list had 20 blocks composed of 1 irregular verb followed by 2 regular verbs; there were 5 blocks for each of the four possible combinations of fully regular and pseudo-past verbs. The randomization and pairing were designed to factor out any possible confounds due to the order of presentation of the verbs.

Results

The no-marking errors were tabulated and analyzed. They are summarized in Table 1. There were 15 no-marking errors on pseudo-past verbs vs only 2 on fully regular verbs. Pseudo-past verbs showed significantly more errors than fully regular verbs using a two-tailed sign test over subjects (13 +, 2 -, 35 ties; $p < .01$).¹

¹ In this experiment and the other experiments involving past tense, some no-marking errors occurred on the filler trials, which involved irregular verbs. We do not discuss these errors here because we did not control for the frequency of the fillers. We did find that the irregular verbs always showed significantly more no-marking errors than the fully regular verbs. They also showed more errors than the pseudo-past verbs, but this was significant only in Experiment 5. The interested reader is referred to Stemberger & MacWhinney (1986) for an explanation of these phenomena in terms of frequency effects on lexical storage.

TABLE 1
No-Marking Errors on Experiment 1

Pseudo-past		Regular	
Guide	1	Crash	1
Lift	2	Glow	1
Melt	1		
Print	2		
Pound	1		
Shift	1		
Sort	2		
Yield	5		
Total	15	Total	2

Discussion

As predicted, subjects made more no-marking errors on pseudo-past verbs than on fully regular verbs. These results replicate the findings of Bybee and Slobin (1982) for a similar task. By balancing for frequency and length of the base verbs and the inflected forms themselves, we have gone beyond the findings of Bybee and Slobin and have ruled out the possibility that frequency or length might account for the observed differences between the groups.

Next we need to rule out allomorph difficulty as the sole cause of no-marking errors. Experiment 2 addresses this problem by examining verbs and inflections where allomorph difficulty and repetition avoidance are not confounded. The present tense inflection *-s* avoids this confound, since the "difficult" syllabic allomorph of *-s* (*-es*) is used not only after the alveolar fricatives that are identical to the inflection, /s/ and /z/ as in "passes" and "buzzes," but also after the palatal fricatives and affricates: /ʃ/, /ʒ/, /č/, and /j/ as in "lurches" and "judges." Form-oriented errors for *-s* can occur only after /s/ and /z/. In contrast, errors due to allomorph difficulty should occur after the other consonants as well. By comparing the errors on verbs that end in palatal consonants with the errors on verbs that take the nonsyllabic allomorph, we can assess the contribution of allomorph difficulty per se. If allomorph difficulty is the sole determinant of marking omission, then no-marking errors on verbs ending in /s/ and /z/ should be no more frequent than no-marking errors on verbs that end in palatals. Experiment 2 was designed to test this prediction.

We included one further manipulation in this study that is relevant to our discussion below. Of those verbs that end in /s/ and /z/ in Experiment 2, half rhyme with actual present tense forms (as *gaze* rhymes with *plays*) and half do not (as with *buzz* and *cross*). This manipulation thus allows us to see if just the identity of the final consonant (/s/ or /z/) is relevant, or if there are further lexical similarity factors involved in error rates.

EXPERIMENT 2: PSEUDO-PRESENT VERBS

Method

Subjects

Subjects were 60 undergraduate students at Carnegie-Mellon University, who received credit in an introductory psychology course for their participation in the experiment.

Materials

A list of 90 one-syllable English verbs was constructed.

1. *Pseudo-presents*. There were 30 pseudo-present verbs that ended in /s/ or /z/ (such as *toss* and *doze*), with an average frequency of 72.4 for all forms of the word, and 3.3 for the

present tense form alone; these take the syllabic allomorph /əz/. Half of these words rhymed with actual past tense forms and half did not, with the two groups balanced for frequency.

2. *Regulars*. There were 30 fully regular verbs that ended in the palatal fricatives /ʃ/, /ç/, and /j/ (such as *crash*, *watch*, and *judge*), with an average frequency of 59.5 for all forms of the word and 2.4 for the present tense form alone; these also take the syllabic allomorph.

3. *Controls*. There were 30 verbs that ended in other consonants or in a vowel (such as *bark* and *dry*), with an average frequency of 66.2 for all forms of the word and 3.3 for the present tense form alone; these take the nonsyllabic allomorph /s/ or /z/. The full list of stimuli is presented in Appendix 2.

Procedure

The procedure is similar to that in Experiment 1. The verbs were presented in the frame "IS___ING." Subjects were instructed to respond as quickly as possible with the present tense form that would be appropriate in the frame. There were five practice trials to ensure that the subject understood the task properly. The 90 experimental trials were randomized differently for each subject.

Results and Discussion

The no-marking error rates on the three groups of verbs were tabulated and analyzed. These errors are summarized in Table 2. There were 68 errors on the pseudo-present verbs, 18 on verbs ending in palatals, and only one error on other verbs. All differences were significant by a two-tailed sign test over subjects: pseudo-presents vs palatals (28+, 3-, 29 ties; $p < .01$), pseudo-presents vs others (33+, 1-, 26 ties; $p < .01$), and palatals vs others (14+, 1-, 45 ties; $p < .01$). Of the 68 errors on the pseudo-present verbs, 36 (52.9%) were on verbs that rhymed with actual present tense forms, and 32 (47.1%) were on verbs that did not rhyme with actual present tense forms. Rhyming thus had no apparent effect on the error rates.

The higher error rate on verbs that end in palatals than on verbs that take the nonsyllabic allomorph of -s demonstrates that the syllabic allomorph does indeed have a higher error rate than the nonsyllabic allomorph. Our concern about a possible confounding of form-oriented errors with allomorph difficulty on -ed in Experiment 1 was thus justified. However, the higher error rate on the pseudo-present verbs (those ending in /s/ and /z/) than on verbs that end in palatals rules out the possibility that form-oriented errors are due solely to allomorph difficulty, since the same allomorph is involved in both groups of verbs. We may conclude that similarity in form between a base word and an inflectional pattern does indeed cause difficulties for speakers. Moreover, in absolute terms, repetition contributes more to the error rate than does difficulty.

The failure to find an effect of rhyming with actual present tense forms suggests that the effect derives from the nature of the final consonant itself, rather than from some deeper lexical effect. This appears to be true

TABLE 2
No-Marking Errors on Experiment 2

Pseudo-present		Palatals		Others	
Buzz	5	Crash	1	Bend	1
Cause	1	Crouch	1		
Chase	3	Dash	2		
Choose	3	Judge	1		
Close	4	March	1		
Coax	8	Push	1		
Dance	2	Reach	2		
Doze	3	Search	1		
Force	4	Slash	1		
Freeze	1	Splash	4		
Gaze	4	Stretch	2		
Glance	4	Watch	1		
Guess	4				
Hiss	4				
Mix	2				
Pass	2				
Please	2				
Pose	2				
Race	1				
Raise	4				
Squeeze	2				
Toss	3				
Total	68	Total	18	Total	1

of a post hoc analysis of Experiment 1 as well. There were 11 errors on 750 trials involving verbs that rhyme with actual past tense forms, and 4 errors out of 250 trials involving verbs that do not rhyme with actual past tense forms, essentially identical error rates (.015 vs .016). We may conclude that only the identity of the final consonant is a determiner of form-oriented errors for these two regular inflectional patterns, past *-ed* and present *-s*.

It may be that lexical similarity effects only show up strongly for minor irregular patterns. Experiments 3–5 explore this possibility. Here we can return to the past tense and examine another subset of verbs that also avoids the confound between form-oriented errors and allomorph difficulty. Verbs that end in /t/ or /d/, which were used in Experiment 1, are not the only verbs that resemble past tense forms, but simply the subset that resembles regularly inflected past tense forms. Many verbs resemble irregular forms, such as the regular verb *spank* and the irregular forms *drank*, *sank*, and *stank*. Can a regular verb's resemblance to an irregular past tense form lead to a higher rate of no-marking errors? Rumelhart and

McClelland (in press) attribute certain no-marking errors produced by their computer simulation of past tense formation to just such an effect, but they present no evidence that real speakers would show such effects. The past tense forms of pseudo-past verbs, such as *spanked* and *flunked*, involve the nonsyllabic allomorph, so allomorph difficulty cannot lead to an elevated error rate for the pseudo-past verbs. Experiments 3–5 were designed to test this hypothesis. In these experiments, we examine verbs that rhyme with irregular forms. We include all the irregular patterns that allow for a large enough number of pseudo-past verbs to test, excluding irregular patterns that end in /t/ and /d/. In Experiment 3, we examine verbs that end in *-ank* and *-unk*. In Experiment 4, we study verbs containing the vowel /ou/ (ending in /ouk/, /our/, and /ouz/). In Experiment 5, we look at verbs that end in /u:/. The discussion of the results of these three experiments follows the presentation of the results for Experiment 5.

EXPERIMENT 3: SPANK-TYPE PSEUDO-PAST VERBS

Method

Subjects

Subjects were 50 members of the Carnegie–Mellon University subject pool, who received either credit in an introductory psychology course or money for their participation in the experiment.

Materials

A list of 48 one-syllable English verbs was created, divided into three groups.

1. *Pseudo-pasts*. There were 16 pseudo-past verbs that ended in *-ank* or *-unk* (such as *spank* and *flunk*), with an average frequency of 5.2 for all forms of the word and 0.9 for the past tense form alone, based on Francis and Kucera (1982).

2. *Regulars*. There were 16 fully regular verbs that did not rhyme with any past tense forms (such as *chase* and *peek*), with an average frequency of 5.2 for all forms of the word and 1.0 for the past tense form alone.

3. *Fillers*. There were 16 irregular verbs that served as fillers. The full list is given in Appendix 3.

Procedure

The procedure was identical to that of Experiment 1. The stimuli were randomized within groups differently for each subject. Each subject's list contained 16 blocks composed of one irregular ablaut verb, one fully regular verb, and one pseudo-past verb, in that order.

Results

One problem with the chosen verbs was discovered in the course of the experiment. Subjects had difficulty recognizing one of the pseudo-past verbs: *thunk*. This verb had a very high error rate (34%) and a very long

average latency (2.309 s). Many subjects specifically asked about it afterwards. It was decided to eliminate this item from any further analysis, since we were not interested in the inflectional processing of unfamiliar verbs. No other verb had such a high error rate or a deviant latency.

No-marking errors were tabulated and analyzed. These errors are summarized in Table 3. There were 26 errors on the pseudo-past verbs (3.5% error rate) vs only 5 on the fully regular verbs (0.6% error rate). There were significantly more errors on the pseudo-past verbs using a two-tailed sign test over subjects (17+, 1-, 32 ties; $p < .01$). The effects were present for both the *-ank* and *-unk* pseudo-past verbs; there were 12 and 14 errors on these groups, respectively, more than expected by chance ($\chi^2(1) = 10.770$, $p < .001$, and $\chi^2(1) = 17.068$, $p < .001$, respectively).

We could not explicitly manipulate the factor of whether the pseudo-past forms rhymed with actual past tense forms in this task; all the forms rhymed. However, we can examine the issue of rhyming in a post hoc examination of the same subjects' performance on other verbs. Each subject did see 11 other verbs that contained the vowels /æ:/ or /ʌ/ but had different final consonants so that they rhymed with no past tense forms, e.g., *pass* and *bump*. There were only 3 errors on these fully regular forms out of 550 trials, as compared to 26 errors on the pseudo-past verbs out of 750 trials. This difference is significant ($\chi^2(1) = 12.42$, $p < .001$). Rhyming does appear to have a great effect on form-oriented errors involving irregular forms.

It is interesting to note that no-marking errors on verbs like *spank* have never been noticed in error data from spontaneous speech in adult or child language. The reason is probably that pseudo-past verbs like *spank*

TABLE 3
No-Marking Errors on Experiment 3

Pseudo-past		Regular	
Chunk	2	Bribe	1
Clank	3	Fish	1
Clunk	2	Rake	1
Crank	1	Thin	2
Dunk	4		
Flunk	3		
Junk	3		
Rank	2		
Spank	3		
Thank	3		
Total	26	Total	5

are relatively uncommon. There are 3415 tokens of the past tense forms of pseudo-past verbs that end in /t/ or /d/ in Francis and Kucera (1982), but only 14 tokens of the past tense forms of pseudo-past verbs that end in *-ank* or *-unk*. Given the low frequency in general of spontaneous errors in adult speech, it is not surprising that no such errors have yet been reported.

The second set of pseudo-irregular verbs that we studied was the set of verbs like *snore* which resemble irregular past tense forms like *wore*.

EXPERIMENT 4: SNORE-TYPE PSEUDO-PAST VERBS

Method

Subjects

Subjects were 25 undergraduate students at Carnegie-Mellon University, who received credit in an introductory psychology course for participation in the experiment.

Materials and Procedure

A list of 48 one-syllable English verbs was constructed. The procedure was the same as in Experiment 3.

1. *Pseudo-pasts*. There were 16 pseudo-past verbs that contained the vowel /ou/ (such as *snore*, *doze*, and *poke*), each of which rhymed with at least three past tense forms such as *froze*, *wore*, and *spoke*, with an average frequency of 20.2 for all forms of the word and 3.1 for past tense forms alone, based on Francis and Kucera (1982).

2. *Regulars*. There were 16 fully regular verbs (such as *bump* and *mix*), with an average frequency of 20.0 for all forms of the word and 4.9 for the past tense form alone.

3. *Fillers*. There were 16 irregular verbs that served as fillers. The list of verbs is given in Appendix 4.

Results

No marking errors were tabulated and analyzed. These errors are summarized in Table 4. There were 8 errors on the pseudo-past verbs (2.0%

TABLE 4
No-Marking Errors from Experiment 4

Pseudo-past		Regular	
Bore	1		
Croak	1		
Doze	1		
Score	2		
Snore	1		
Store	1		
Stroke	1		
Total	8	Total	0

error rate) vs 0 errors on the fully regular verbs (0.0% error rate). There are significantly more errors on the pseudo-past verbs using a two-tailed sign test over subjects (7+, 0-, 18 ties; $p < .05$).

The final type of pseudo-irregular verbs that we studied was that of verbs like *chew* which resemble irregular past tense forms like *flew*.

EXPERIMENT 5: CHEW-TYPE PSEUDO-PAST VERBS

Method

Subjects

Subjects were 50 undergraduate students at Carnegie-Mellon University, who received course credit in an introductory psychology course for their participation in the experiment.

Materials and Procedure

A list of 48 English verbs was constructed. The procedure was the same as in Experiment 3.

1. *Pseudo-pasts*. There were 16 pseudo-past verbs that ended in /u:/ (such as *chew* and *moo*), rhyming with past tense forms such as *grew*, *knew*, and *flew*, with an average frequency of 8.7 for all forms of the word and 0.9 for the past tense form alone.

2. *Regulars*. There were 16 fully regular verbs (such as *mow* and *cure*), with an average frequency of 9.3 for all forms of the work and 1.0 for the past tense form alone.

3. *Fillers*. There were 16 irregular verbs that served as fillers. The list of verbs is given in Appendix 5.

Results

No-marking errors were tabulated and analyzed. These errors are summarized in Table 5. There were seven errors on pseudo-past verbs (0.9% error rate) vs four on fully regular verbs (0.5% error rate). While there were slightly more errors on pseudo-past verbs than on fully regular verbs, this difference was not significant using a two-tailed sign test over subjects (4+, 1-, 45 ties; ns.). We failed to replicate Experiments 3 and 4 with this irregular pattern.

TABLE 5
No-Marking Errors from Experiment 5

Pseudo-past		Regular	
Glue	1	Cure	1
Screw	1	Flay	1
Shoo	1	Prowl	1
Spew	1	Ski	1
Stew	3		
Total	7	Total	4

Discussion of Experiments 3, 4, and 5

We have seen that verbs whose base forms are similar to irregular past tense forms are predisposed toward no-marking errors. Since the nonsyllabic allomorph is involved here, the results cannot be due to allomorph difficulty. These are clearly form-oriented errors. This is true of three irregular patterns: /æ:/, /æ/, and /ou/. However, we failed to demonstrate its existence for the irregular pattern /u:/, though the small differences that were observed were in the predicted direction. Since the stimuli in the three experiments were roughly of the same frequency, we can directly compare the rate of errors in each experiment. This is shown in Fig. 1. Note that the error rate on the fully regular verbs is comparable in all three experiments. It can be seen that the error rate on pseudo-past verbs in the three experiments is greatest in Experiment 3, intermediate in Experiment 4, and least in Experiment 5. Note that the pseudo-past verbs in Experiment 3 have a significantly greater error rate than those in Experiment 5 ($\chi^2(1) = 12.48, p < .001$). Experiment 4, on the other hand, does not significantly differ from either Experiment 3 ($\chi^2(1) = 1.96, ns.$) or Experiment 5 ($\chi^2(1) = 2.73, ns.$). Spank-type pseudo-past verbs thus show a very strong bias toward form-oriented errors. Snore-type pseudo-past verbs show a weaker but still significant bias. Chew-type pseudo-past verbs show such a weak bias toward form-oriented errors that it cannot be reliably detected in this task, at least without running several hundred projects. An adequate account of form-oriented errors must be able to account for these differences in the magnitude of the effect in different subclasses of verbs.

The schema hypothesis of Bybee and Slobin (1982) and Bybee and Moder (1983) cannot by itself account for these facts. These researchers

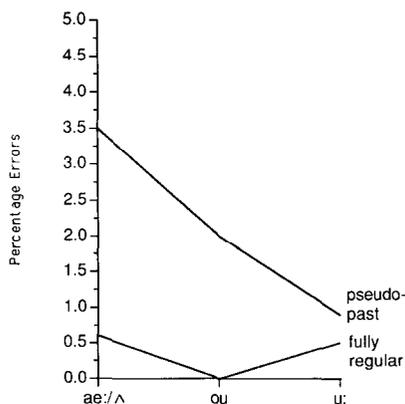


FIG. 1. Percentages form-oriented errors on Experiments 3, 4, and 5.

assume that speakers make use of interpretive schemas such as "some past tense forms end in /t/ or /d/." Form-oriented errors arise in their system when an interpretive schema achieves a match to a pseudo-past verb such as *need*. The schema then allows the verb to be taken as a past tense form and prevents it from undergoing the regular *-ed* rule for past tense. Bybee and Slobin maintain that the existence of form-oriented errors indicates that a schema rather than a rule is being used by the speaker. Bybee and Moder (1983) suggest that the schema is represented in terms of the prototypical inflected form that fits that pattern. They argue that similarity to the prototype increases the rate of no-marking errors, producing form-oriented errors. These researchers present evidence for schemas defining verbs ending in *-ank*, *-unk*, and /u:/ in adult speech. If processing is guided solely or mostly by comparison to a prototype-based schema, then the error rates across the different types of pseudo-past verbs should be comparable, according to the schema account. However, our studies have shown that susceptibility to no-marking errors is not an all-or-none property. Some pseudo-pasts are strongly susceptible to no-marking errors (Experiments 3 and 4); some are weakly susceptible (Experiment 5) and some other explanation of this varying susceptibility must be sought.

The gang effect hypothesis of Rumelhart and McClelland (1982) may be able to account for our data. In a gang effect, several words in the lexicon that are similar in form reinforce the patterns of phonemes or letters that they have in common by giving a certain amount of activation to all the items in the pattern. The strength of the gang (i.e., the degree to which they reinforce the shared pattern) is a function of two things. First, the effect is greater when more phonemes or letters are shared. All other things being equal, a gang with three shared phonemes will have more effect than a gang with two shared phonemes. Similarity of the phonemes involved in terms of position in the word and in terms of contiguity also has an effect. Homogeneous gangs that have the shared phonemes or letters in identical positions with the same items contiguous are stronger gangs. Second, the number of members in the gang has an effect. If two gangs are identical in terms of similarity of phoneme or letter patterns, the stronger gang will be the one that has more words in it.

Gang effects can influence the pronunciation of nonwords such as *MAVE*. The letter sequence *AVE* can be pronounced as in *have* or as in *cave*. When we examine the lexicon, we find that there is only one word where *AVE* is pronounced as in "have," while there are 14 monosyllabic words where it is pronounced as in "cave." All 14 words like "cave" reinforce that pronunciation by giving it some activation, while only *have* reinforces the alternative pronunciation. The greater size of the "cave" gang leads to the result that subjects are far more likely to pronounce

MAVE as /meiv/ than as /mæ:v/. In essence, gang effects are a particular concretization of the traditional notion of analogy.

The results of Experiments 3–5 above can be nicely explained in terms of gang effects. In Experiment 3, forms like *drank* and *sank* will form a gang and reinforce the phonemes /æ:nk/ at the end of the word when the subject is processing the verb *spank*. The lack of a final /t/ in the members of the gang will lead to the lack of the /t/ in the subject's response, constituting a no-marking error. Similarly in Experiments 4 and 5, irregular verb gangs including verbs such as *wore* and *grew* should cause no-marking errors on pseudo-past verbs such as *snore* and *chew*. Gang effects further predict the differences in the strength of the effect in the different experiments as shown in Fig. 1 above. The size of the gangs in the different experiments is very similar. However, there are striking differences between the experiments in terms of the similarity of the phoneme patterns in the gangs. The members of the gang in Experiment 3 (with verbs ending in *-ank* and *-unk*) share an average of 3.1 contiguous phonemes with the pseudo-past verbs. The members of the gang in Experiment 4 (with /ou/) share an average of 2.1 contiguous phonemes with the pseudo-past verbs. The members of the gang in Experiment 5 (with /u:/) share an average of 1.1 contiguous phonemes with the pseudo-past verbs. Thus the gang of Experiment 3 is a very "tight" gang whereas the gang of Experiment 5 is a fairly "loose" gang. These differences predict the highest error rate in Experiment 3, an intermediate error rate in Experiment 4, and the lowest error rate in Experiment 5. In fact, as can be seen in Fig. 1, the error rate is almost a linear function of the number of shared contiguous phonemes in the different gangs. The increase in the rate of no-marking errors caused by the single shared phoneme in Experiment 5 was so small that it could not be reliably detected. This explanation also predicts that the error rate will be greater on words that share several contiguous consonants with the gangs of irregular forms than on words that share only the vowel. Some post hoc analyses in Experiment 3 above imply that this is the case, since there were far more errors on pseudo-past verbs that rhymed with irregular verbs (with an average of 3.1 shared contiguous phonemes) than any regular verbs that did not rhyme with any irregular forms but had the same vowel (with an average of 1.2 shared contiguous phonemes). The strength of the gangs as a function of the number of shared phonemes is illustrated in Fig. 2, where the strength of the effect is reflected by the number of lines connected to the irregular past tense forms. These data can be viewed as the result of the operation of a gang effect. There are probably other reasonable ways of accounting for the pattern shown in Fig. 1, but we have not yet found a good alternative to the gang effect explanation.

However, the gang effect cannot be the sole source of form-oriented

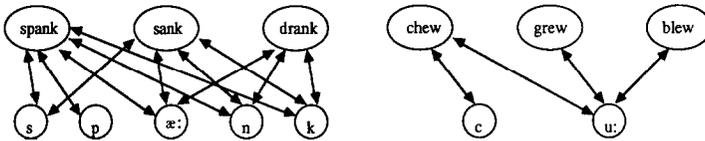


FIG. 2. The gang effect in an irregular past tense pattern with many shared consonants (left) and with few shared consonants (right).

inflectional errors, since the predictions of the gang effect were not borne out in Experiments 1 and 2 above. The gang effect predicts that sharing a number of phonemes with actual inflected forms will increase the rate of no-marking errors, especially if the shared phonemes are contiguous. As we have seen, this prediction seems to be correct for effects on regular verbs from irregular inflectional patterns. However, the prediction appears to be incorrect for effects from regular inflectional patterns. In Experiments 1 and 2, rhyming had no effect on the rate of form-oriented inflectional errors.

There is a clear linguistic difference between regular and irregular inflectional patterns. For regular patterns, speakers of a language can theoretically extract the inflectional pattern as a rule. The speaker need not store each regularly inflected form, but can compute the proper inflected form by rule each time that it is needed. In contrast, the speaker must explicitly memorize which words have irregular forms and the nature of that irregularity (Aronoff, 1976; Stemberger and MacWhinney, 1986). There is no way to produce irregular forms by lexical-item-free rules, and each irregular form must be memorized in some fashion. If all regularly inflected forms were stored in the lexicon, we would have expected to find gang effects due to phonological similarity with known regularly inflected forms. That gang effects were not present suggests that not all regularly inflected forms are stored in the lexicon.

It is possible to devise a test of the degree to which form-oriented errors can be explained solely in terms of an interitem gang effect. To do this, we will look at forms that are not stored in the lexicon and which must be produced by the combination of lexical items. Errors on such forms would indicate that the gang effect is not the sole cause of form-oriented inflectional errors, since a gang effect cannot exist unless forms are stored in the lexicon. Implementation of this test is hampered by the lack of good empirical evidence about what is and what is not stored in the lexicon. However, we have chosen as our test a set of forms that according to almost all current analyses are unlikely to be stored in the lexicon: indefinite forms of noun phrases. The indefinite form of a noun phrase is formed by adding the article (an unstressed clitic) *a* or *an* to the beginning of the phrase if the head noun is a singular count noun, as in *a*

dog and *an apple*; the form *an* is used exclusively before vowels, while *a* is used before consonants (and also can be used before vowels in colloquial speech, as in *a apple*). The indefinite form involves a syntactic rule with two words present, rather than an inflectional rule with just one word present as in Experiments 1–5. Note that adjectives come between the article and the noun, and it is the first phoneme of the adjective that determines the form of the article: *an impossible dog* and *a little apple*. These facts suggest (although they do not prove) that indefinite forms are not stored in the lexicon but are created by the combination of lexical items. Form-oriented errors would reveal themselves in a tendency for words that begin with an unstressed schwa, such as *award* and *accomplice*, to be especially prone to no-marking errors. We would predict form-oriented errors here, since Stemberger (1981) and Menn and MacWhinney (1984) have shown that similar grammatical phenomena in adult language can involve such unstressed clitics in forms that are not likely to be listed in the lexicon. Experiment 6 tests this prediction.

EXPERIMENT 6: INDEFINITE NOUNS

Method

Subjects

Subjects were 30 undergraduate students at Carnegie–Mellon University, who received course credit in an introductory psychology course for their participation in the experiment.

Materials

A list of 90 English count nouns with two or three syllables was constructed.

1. *Pseudo-indefinites*. There were 30 pseudo-indefinite nouns that began with an unstressed schwa (such as *award* and *announcement*), with an average frequency of 63.5 for all forms of the word, based on Francis and Kucera (1982); the frequency of the indefinite form alone is not available. These take the allomorph *an*.

2. *Initial stressed vowel*. There were 30 nouns that began with a stressed vowel (such as *actor* and *optimist*), with an average frequency of 63.5 for all forms of the word; these also take the allomorph *an*.

3. *Initial unstressed syllable*. There were 30 verbs that began with an unstressed syllable and that started with a consonant (such as *balloon* and *detective*), with an average frequency of 63.6 for all forms of the word; these take the allomorph *a*. Each pseudo-indefinite noun was exactly matched to nouns of the same frequency and same number of syllables in the other two groups. The full list of nouns is presented in Appendix 6.

Procedure

The procedure is similar to that of Experiment 1. Stimuli were presented in the frame “THE_____.” Subjects were instructed to read the noun silently and to respond out loud with the indefinite form as quickly as possible. The experiment began with 5 practice trials, followed by the 90 experimental trials randomized differently for each subject.

Results

The no-marking errors for the three groups of words were tabulated and analyzed. Subjects were very good at this task, making only eight no-marking errors out of 2700 total trials, which are summarized in Table 6. All eight errors occurred on the pseudo-indefinite nouns. This is significantly more than on either of the other groups, using a two-tailed sign test over subjects (6+, 0-, 24 ties; $p < .05$).

Form-oriented errors also occur with the indefinite forms of nouns. The errors here occurred on the low-frequency allomorph of the indefinite article (3727 tokens of *an* vs 23,073 tokens of *a* in Francis & Kucera, 1982), but this alone cannot account for the results, since there are more errors when *an* appears before pseudo-indefinites than when *an* appears before a stressed vowel. These errors are clearly form oriented. Therefore, Experiment 6 demonstrates that form-oriented errors can occur even when lexical items are being combined.

GENERAL DISCUSSION

These studies have shown that when an uninflected base form appears to be inflected already, this appearance leads to no-marking errors. Experiments 1, 2, and 6 show that in some cases these interactions can be between a lexical combination and a pseudo-inflected base form. Experiments 3, 4, and 5 show that in other cases the interaction can be between a "gang," in this case a phonologically defined group of irregularly inflected lexical items, and a pseudo-irregular base form.

These two sets of effects can be accounted for by a model which allows for interaction between forms in an output buffer and items in the lexicon, rather than just between items within the lexicon. Such a model is similar in character to models such as the logogen model (Morton, 1969), cohort theory (Marslen-Wilson & Welsh, 1978), and the interactive activation model (Dell & Reich, 1981; McClelland & Rumelhart, 1981; Stem-

TABLE 6
No-Marking Errors on Experiment 6

Pseudo-indefinites	
Account	1
Achievement	2
Amusement	1
Announcement	2
Arrival	1
Award	1
Total	8

berger, 1985). However, none of these models stipulate an interaction between forms in an output buffer and items or groups of items from the lexicon. This modifies the locus of the gang effect to interactions between the gang in the lexicon and a form that is already specified as a candidate for output. In particular, this is a modification of the proposal of McClelland and Rumelhart. No-marking errors occur when either a gang or a single powerful lexical item (-d, -s, or "a") "finds itself" in the output and decides that no further marking is needed. In all of the experiments there is an inflectional item whose insertion into that output buffer is blocked. This account is an extension of a proposal given by Stemberger (1983) and Menn and MacWhinney (1984) which relates form-oriented inflectional errors to malapropisms, such as in *coupons* for "croutons" or *generics* for "geriatrics." This account holds that malapropisms arise through feedback from the output buffer to nontarget words that are similar to the intended word. These forms once activated are then mistakenly inserted in place of the target word. Importantly, the phonemes shared by the two words involved are taken by the language system as being the same segments; they are accessed directly by both words, while all other phonemes are accessed by only one word. Form-oriented inflectional errors arise in a similar fashion, as shown in Fig. 3. The items *need* and *-ed* have similar phonological outputs: a /d/ at the end of the word. In a form-oriented error, feedback from the final /d/ of *need* on the phonological level misleads *-ed* on the lexical level into believing that it has successfully caused a /d/ to be added at the phonological level, since its output condition that there be a word-final /d/ has been satisfied. The system can settle down into a stable pattern with the final phoneme of the base being equated with that of the inflection and being accessed by both lexical items. Only one phoneme is accessed when two should have been, and a form-oriented error, *need*, results.

No other published explanation of form-oriented errors can account for all the data. The schema hypothesis of Bybee and Slobin (1982) and the prototype hypothesis of Bybee and Moder (1983) are unable to account for all the facts regarding irregular patterns. Since schemas and rules are viewed as mutually exclusive alternatives by these researchers, with form-oriented errors due solely to the use of schemas, they cannot account for the results of Experiment 6, where a rule is clearly involved.

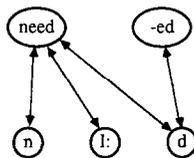


FIG. 3. Phonological feedback leading to a no-marking error on a pseudo-past verb.

Noninteractive models of processing (e.g., Fay & Cutler, 1977; Forster, 1976; Garrett, 1980) have no way of directly generating such errors as part of the process of accessing lexical items and their phonological form. They would be forced to hypothesize postlexical processes that generate form-orientedness in errors as a by-product of correcting errors. Such an account has been suggested for other aspects of production errors (Shattuck-Hufnagel, 1979). It is not clear how such filters can be constrained in a non-ad-hoc fashion. It is not clear how lexical effects such as the number of shared phonemes could be accommodated. No current version of these serial models can properly account for all of the data presented here.

The extra difficulty associated with adding an inflection (or a cliticized independent word such as the articles in English) to a base word that contains the same phonological information is undoubtedly what underlies the cross-linguistic trend for the disfavoring of inflectional processes that add an affix to a phonologically similar base form. Stemberger (1981) and Menn and MacWhinney (1984) have extensively documented this trend. In many languages, including English, it is frequently required that no inflection be added to a word that ends in a similar sequence or an identical inflection. For example, only one *-s* appears at the end of plural possessive *boys'*, even though both the plural *-s* and the possessive *-s* should be present. This grammatical phenomenon looks very similar to the form-oriented errors discussed here. We suggest that form-oriented error tendencies in language production have led historically to grammatical changes, where the phenomenon has been learned as a part of the grammar. This is similar to the way that perceptual confusions can lead to sound changes in a language (Ohala, 1974). Perhaps even more interesting from a cognitive point of view, languages often avoid accidental repetitions of sound sequences between base words and inflections by using a different inflection or by not using a given form at all. This avoidance implies that speakers are (at some level) aware of points of difficulty in their language production, and try to avoid them, much as some young children try to avoid using words that contain sounds that are difficult for them (Ferguson & Farwell, 1975). Such avoidance can apparently become a part of the grammar, so that a given inflected or derived form might even be considered ungrammatical by speakers of the language.

Form-oriented errors and the avoidance of repetition in inflectional processing are a particular instance of a more widespread phenomenon in the cognitive processing of language and other actions. Cognitive systems are apparently designed to minimize incorrect redundancy, to prevent us from doing things twice when we intend to do them only once. Such conservatism is bought only at the cost of an occasional failure to do

something even once, if the context resembles the outcome of the action. In most cases, of course, thinking seriously about doing something important (such as a pilot putting down landing gear) leads to the performance of that action. This type of failure seems to result from a conservative cognitive system that is set up to prevent accidental repetition of actions. If no such mechanism existed, one could imagine a system that would repeat itself incessantly.

The study of form-oriented errors sheds light on the details of the workings of inflectional rules and explains certain cross-linguistic and historical tendencies in grammars. At the same time, these errors reveal how speakers process unintended words that are similar in form to the intended word, and provides support for an interactive activation view of cognitive processing.

APPENDIX 1: STIMULI FOR EXPERIMENT 1

blast	bake	bind
chant	beg	bite
fade	check	bleed
fold	climb	blow
guard	cook	breed
guide	crash	dig
hunt	cry	drink
land	earn	fling
lift	frown	fly
load	glow	grind
melt	grab	hide
paint	hug	ring
pound	knock	shrink
print	park	sink
shift	rip	spin
sort	rock	stick
test	rub	stink
trade	slip	tear
vote	stamp	swim
yield	touch	wind

APPENDIX 2: STIMULI FOR EXPERIMENT 2

buzz	blush	bark
cause	bulge	beg
chase	change	bend
choose	charge	bid
close	clutch	break
coax	crash	breed
cross	crouch	bribe
dance	crush	build
doze	dash	climb
force	fish	cut
freeze	flash	drop
gaze	forge	dry
glance	itch	dump
guess	judge	fib
hiss	launch	gloat
mix	march	howl
ooze	pitch	pet
pass	plunge	point
place	push	read
please	reach	rest
pose	rush	roll
praise	search	shout
press	slash	sleep
race	snatch	spank
raise	splash	spin
sneeze	stretch	spoil
squeeze	teach	stack
tease	touch	sway
toss	wash	trap
trace	watch	yank

APPENDIX 3: STIMULI FOR EXPERIMENT 3

bank	beep	bind
bunk	bribe	bite
chunk	chase	bleed
clank	clip	breed
clunk	cough	cling
crank	crave	dig
dunk	droop	fling
flank	fake	fly
flunk	filch	grind
junk	fish	ring
plunk	jog	sink
rank	peek	sling
spank	rake	spin
thank	sneeze	sting
thunk	thin	stink
yank	yelp	wind

APPENDIX 4: STIMULI FOR EXPERIMENT 4

bore	block	break
choke	boil	choose
croak	bump	draw
doze	churn	drive
joke	crawl	eat
poke	howl	fall
pose	mix	fight
pour	pack	hold
roar	plow	lead
score	prowl	read
smoke	pump	run
snore	shop	shoot
soak	spoil	sing
soar	tap	sit
store	whine	take
stroke	whip	throw

APPENDIX 5: STIMULI FOR EXPERIMENT 5

boo	blare	break
brew	cool	choose
chew	cure	draw
coo	flay	drive
cue	fuel	eat
glue	haul	fall
mew	hoe	fight
moo	mow	hold
screw	plow	lead
shoo	prowl	read
skew	ski	run
spew	splay	shoot
stew	spray	sing
sue	spy	sit
view	stow	take
woo	tow	throw

APPENDIX 6: STIMULI FOR EXPERIMENT 6

accomplice	actor	balloon
account	advocate	beginner
achievement	ancestor	betrayal
adoption	angle	collision
adult	appetite	conclusion
affair	architect	connection
alarm	argument	demand
allowance	article	departure
amount	aspect	description
amusement	atmosphere	detective
announcement	audience	disaster
apartment	avenue	diversion
appearance	average	location
appointment	echo	machine
aroma	embassy	marine
arrangement	empire	mistake
arrival	Englishman	piano
assassin	envelope	potato
assertion	error	procedure
assignment	estimate	producer
assistant	idea	professor

APPENDIX 6—Continued

assumption	image	promotion
attorney	injury	proposal
attraction	instrument	reception
award	interval	refinement
effect	object	repairman
occurrence	octopus	response
official	optimist	restriction
opinion	orchestra	result
opponent	ordinance	solution

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