Brain and Language **81,** 545–554 (2002)
doi:10.1006/brln.2001.2546, available online at http://www.idealibrary.com on IDEAL®

Homophonic Forms of Regularly Inflected Verbs Have Their Own Orthographic Representations: A Developmental Perspective on Spelling Errors

Steven Frisson and Dominiek Sandra

University of Antwerp

Published online January 2, 2002

In previous research (Sandra, Frisson, & Daems, 1999) we demonstrated that *experienced* writers of Dutch (18-year-olds) make spelling errors on regularly inflected homophonic verb forms. Intrusion errors, i.e., spelling of the homophonic alternative, occurred more often when the low-frequency homophone had to be written. In the present article we report error data for three groups of *less experienced* spellers, who have not yet fully mastered the rules for verb suffix spelling: 12-year-olds, 13-year-olds, and 14-year-olds. Younger spellers obviously make many more errors than experienced ones. Whereas this is in part due to inadequate rule mastery/application, their error patterns are also clearly influenced by the frequency relationship between the homophonic forms, i.e., the same factor accounting for the errors of experienced spellers. The conclusion of our present and past research is that homophonic forms of regularly inflected verbs have their own orthographic representations in the mental lexicon and that these representations cause interference in writing (spelling errors), whereas they might cause facilitation in reading (a claim made by dual-route models of reading). © 2002 Elsevier Science (USA)

Key Words: spelling; homophones; interference.

INTRODUCTION

In previous research on spelling errors in Dutch (Sandra, Frisson, & Daems, 1999), we have shown that spelling errors to regularly inflected homophonic verbs made by adult spellers do not occur at random. Rather, if a spelling error is made, it is much more likely that it coincides with the most frequent form, irrespective of the morphological complexity of that form (see also Assink, 1985; Largy, Fayol, & Lemaire, 1998). In this article, we report data gathered from different age groups on the same type of homophone spelling error in order to understand its evolution.

The problem under investigation would not be a problem at all if spellers just applied two simple morphosyntactic rules that they have been taught when they were still very young (around 8 years of age) and that have been rehearsed extensively

The order of authorship is arbitrary. This research was supported by a grant of the Flemish government (Special Research Fund of the Antwerp University, Contract 98/3). We thank Nivja de Jong and Andrea Krott for their help with the logit analyses. We are most grateful to the staff and pupils of the different schools for their help and cooperation and to the students who helped us in collecting data.

Address correspondence and reprint requests to Steven Frisson, University of Antwerp–UFSIA, Room D 123, Prinsstraat 13, B-2000 Antwerpen, Belgium. Fax: ++32 3 220 4259. E-mail: steven.frisson@ufsia.ac.be.

0093-934X/02 $35.00
© 2002 Elsevier Science (USA)
All rights reserved.

throughout their formative school years. The rule for the first person singular present tense is to simply take the stem of the verb, the rule for the third person singular present tense is to add a -T at the end of the stem (completely akin to the English rule *add -s* for the same form). Except for the spelling of a few irregular verbs like *is* and *mag* (may), there are no exceptions to this rule. Nevertheless, even highly trained spellers sometimes make errors against these rules, and less trained spellers make more mistakes than one might expect given the simplicity of this rule. Hence, something seems to interfere with its application.

The first observation one can make is that the misapplication is restricted to those verb forms that are homophonic (i.e., forms that have a different spelling but the same pronunciation). Indeed, a form like *werkt* (/wɛrkt/; works), which is the third person singular present tense of the verb *werken* (with the stem *werk,* /wɛrk/), will never be misspelled as *werk.* Alternatively, the form *werk,* the first person singular present tense, will never be spelled as *werkt.* Since in these cases the phonology of both forms differs, and since Dutch spelling is to a high degree phonological, these forms will not be misspelled (even if one does not know the grammatical rules behind them). However, Dutch has a general phonological rule of devoicing voiced consonants at the end of a word, which has the consequence of turning the first and third person singular present tense of verbs with a stem ending in D into homophones. For example, *rijd* (drive) and *rijdt* (drives) are both pronounced as /rɛɪt/, and the spelling errors that are observed for these verbs can include both *ik *rijdt* (I drive) and *hij *rijd* (he drives). The experiments reported here are restricted to these kinds of verbs. We refer to the critical spelling patterns as D versus DT spellings.

Our previous research with experienced spellers has shown that when a spelling error is made, the incorrect form that is produced is also most likely to be the most frequent form. For example, *rijd* has a token frequency of 6 occurrences per million (CELEX database; Baayen, Piepenbrock, & van Rijn, 1993) while the frequency of *rijdt* is 20 per million. Therefore, as demonstrated by our findings, spellers are more prone to write *ik *rijdt* than *hij *rijd.* When the frequency of the two homophonic forms is reversed, as is the case for the verb *beïnvloeden* (to affect; frequency of *beïnvloed* is 24 and of *beïnvloedt* is 6), the pattern is reversed, with more errors of the type *hij *beïnvloed* than *ik *beïnvloedt.* When the frequencies are comparable, an equivalent number of errors for both forms was observed.

The other finding reported in Sandra et al. (1999) is related to the *accessibility* of the morphosyntactic information. In order to spell the verb correctly, one has to use the information on grammatical person from the subject. We observed a significant increase in spelling errors when the subject and the verb were not adjacent, as can be the case in Dutch subordinate clauses (Subject-Object-Verb or SOV order). For example, many more errors were made for sentences like . . . *dat ik met mijn blitse motor rijd* (. . . that I drive my fancy motorcycle) in comparison to main clauses like *Ik rijd met mijn blitse moto* (I drive . . . ; SVO order). Accessibility did not interact with frequency, i.e., a decrease in accessibility caused an increase in number of errors, but the patterns for both the main clause and the subclause remained comparable.

In order to explain our results, we have to accept that *even highly regular* verb forms are stored in the mental lexicon[1] and that these forms are, to a degree, activated on the basis of their sound pattern. If they receive enough activation, they might become available before the spelling rule has been applied, or alternatively, conflict with the output of that rule such that this form will sometimes be written incorrectly. And when the rule is more difficult to apply in working memory (nonadjacent), as

[1] Or at least the most frequent form. However, since only storage of the most frequent form explains the results in the same way, we pursue this possibility no further.

is the case when the information of the subject is less accessible, this will happen even more often.

In this article, we concentrate on younger, less experienced spellers. Our main goal is to investigate whether frequency already plays a role in the spelling errors that are made by *young spellers* or whether this is restricted to spellers that already have had a lot of exposure to written language. Let us first explore what possible strategies beginning spellers might employ. (a) They might conscientiously follow the few spelling rules they have learned (though their knowledge of the rules might still be underdeveloped), and the frequency of the forms will not play a part in their spelling. In this case, we would not expect many errors (if they know the rules) and no influence of frequency. The first part of this prediction is unlikely given the results of the adult spellers. (b) Because of their impoverished rule knowledge, they might rely on a default strategy and, thus, always spell the same ending. A good candidate would be the D spelling: not only is this the least complex form, it also coincides with the output of the morphophonological ''lengthening'' rule for the spelling of a /t/ at the end of a Dutch word: If a word ends in a /t/ sound, then add a suffix that begins with an /ə/ to the word and examine whether that form has a /t/ or /d/ sound. Write the sound you hear in the lengthened form. For example, *kaart* /ka.rt/ (card) is spelled with T because of *kaarten* /ka.rtan/; but *paard* /pa.rt/ (horse) is written with a D because of *paarden* /pa.rdan/. Comparable rules exist for adjectives and verbs. This lengthening rule is taught well before the rules for the spelling of verb suffixes (on average, age 8 vs age 10 or later). The other candidate is the T spelling since this is the phonetic form. (c) Although young spellers have passive knowledge of the verb forms (i.e., they have encountered them in texts), their active knowledge (i.e., their own production of these forms) might still be very minimal. If the homophone frequency effect is due to active knowledge rather than to reading experience, we would not expect to find such an effect. (d) It might be possible that younger spellers behave like adult spellers and that only the frequency of the individual forms predicts spelling errors.

Given this description of possible spelling strategies, we thus address two aspects: the influence of frequency and, indirectly, the development of the knowledge of spelling rules (though the latter was not the immediate focus of our research).

EXPERIMENT

Method

Participants. Three age groups were tested: 209 pupils from the last year primary school (around 12 years of age), 203 pupils from the first year secondary school (13 years old), and 185 pupils from the second year secondary school (14 years old). The time of testing was March–April, well into the second semester.

Items. The same items were used as in the Sandra et al. (1999) study, except that certain difficult words, which were used as distractors for the adult participants, were replaced by easier words. The critical verbs consisted of eight verbs for which the frequency of the D spelling is higher than that of the DT spelling according to the CELEX database, eight verbs for which the frequencies of the D spelling and the DT spelling were comparable, and eight verbs for which the frequency of the DT spelling was higher than that of the D spelling. We are aware that the frequency count of CELEX is based on adult text sources like newspaper articles, books, and so on. However, no Dutch frequency counts are available for written children's text (i.e., written for or by children). Moreover, given the fact that frequency and age of acquisition are highly correlated (cf. Gerhand & Barry, 1999), we consider it plausible that *if* a form is known at a younger age, it will very likely be the most frequent one. Hence, although the absolute frequency values might differ between adult and child language, the relative count will likely to be comparable (our data suggests that this is indeed a reasonable assumption).

In addition to the frequency relation of the verb forms, we also manipulated the accessibility of the morphosyntactic information. The critical verb either appeared right next to the subject (i.e., *adjacent*

TABLE 1
Percentages of Homophonic Intrusion Errors in the Various Conditions for Each Age Group

		Correct spelling			
		Adjacent		Distant	
Age	Frequency Type	D	DT	D	DT
12 years	D > DT	1.01	65.15	10.91	75.00
	D = DT	2.53	58.08	11.82	62.73
	D < DT	4.04	52.02	15.91	49.09
13 years	D > DT	3.00	50.50	18.93	48.54
	D = DT	5.00	43.50	17.48	42.72
	D < DT	9.00	41.00	33.98	32.03
14 years	D > DT	14.66	33.87	14.35	63.06
	D = DT	16.53	43.97	21.62	43.05
	D < DT	19.08	29.41	21.05	36.57
18 years	D > DT	4.46	11.88	23.20	37.63
	D = DT	8.42	8.42	19.30	19.08
	D < DT	7.43	4.46	28.35	19.08

Note. The results for age 18 are taken from Sandra et al. (1999).

conditions) or additional words appeared between the subject and the verb (i.e., *distant* conditions; for the purpose of our experiment, we always used four additional words). The adjacent conditions were main clauses, the distant conditions were subordinate clauses. The subordinate clauses were identical to the main clauses, except for the obvious difference in word order and the part of the sentence preceding the subordination. In order to keep this part semantically neutral we used the sequence ''It is true that. . . .''

A fixed random order was used in the presentation of the items, and lists were counterbalanced so that each participant saw each verb only in one condition (first or third person). However, in order to reduce the testing time with the children, we were obliged to present the main clauses and the subordinate clauses to different groups. Since a large number of children were tested, we do not feel this to be a problem. In any case, this manipulation does not have an effect on the homophone frequency effect we are looking for.

Procedure. The same procedure was used as in Sandra et al. (1999). Sheets of paper were distributed on which complete sentences were written, except for the critical verb and one distractor word. A tape recorder was played on which the complete sentences were recorded, and participants had to fill in the blanks. Enough time was given to fulfill this task, though not so much time that extensive spelling verification could occur. After the last sentence was played, the papers were immediately collected.

Analyses. Logit analyses[2] were performed on the number of errors that were caused by the intrusion of the wrong homophonic form, i.e., when a D ending is incorrectly spelled as DT or a DT ending misspelled as D. In order to be more certain that at least the spelling of the verb was indeed known, we restricted the analyses to those cases where the *entire* verb was spelled correctly or with an intrusion error (age 12: 89.43%; age 13: 93.43%; age 14: 94.68%). Although the (phonetic) T ending was produced occasionally (age 12: 4.31%; age 13: 2.56%; age 14: 1.62%) as well, the vast majority of the answers contained a D or DT ending. This suggests that the children must have been aware of the D ending of the verb stems, which is found by applying the lengthening rule.

Results and Discussion

Table 1 gives an overview of the percentages of homophonic intrusion errors for each condition in each age group. Separate 2 (*Distance:* adjacent vs distant) × 2

[2] We opted for logit analyses rather than chi-square analyses in order to reduce the number of analyses (and thereby reduce the chance of Type I errors) and to verify generalization across items. We thank Harald Baayen for this suggestion.

(*Intrusion Error:* D vs DT) × 3 (*Frequency Relation:* D > DT vs D = DT vs D < DT) analyses were performed on the data for each age group (Table 2). The results from the adult spellers (18 years old) are taken from Sandra et al. (1999).

The strong effect of Intrusion Error for the 12- to 14-year-old spellers indicates that D intrusions are far more common than DT intrusions, demonstrating an overall preference for the D spelling (no overt suffix). This bias decreases over the years, whereas the percentages of DT intrusions *increase* (until the bias for a D spelling has vanished at the age of 18).

The effect of Distance, with more errors for the distant conditions compared to the adjacent conditions, becomes more prominent from the age of 14 years onward.[3] Note that the distance effect indicates that the spellers relied on spelling rules. Indeed, subject–verb distance can have a negative effect on spelling only if the speller intends to use the morphosyntactic information from the subject. As can be derived from Table 1, mastery of the rule behind the DT spelling indeed becomes stronger between ages 12 and 14 years (DT adjacent). In the group of 14-year-olds this knowledge is best developed. Another indicator of this knowledge is the presence of what seem to be overgeneralization errors in the first person adjacent condition (compare D adjacent with the data for the other two age groups). Such errors are typical of a learning process: after a stage in which a particular form was the default form, rules are learned and these rules are sometimes erroneously applied to correct usages of the old default form.

The Intrusion Error by Distance interaction shows that, at least for 12- and 13-year-olds, it is the number of DT intrusions rather than the number of D intrusions that mainly increases in the distant conditions. The increase of DT intrusions in the long distance conditions is a pattern we find throughout all age groups (cf. Sandra et al., 1999). The absence of such a difference for the D intrusions can be explained in a number of ways, though might just be due to the already high error rates for the short distance conditions. The interaction was much smaller for the 14-year-olds and reflected a different pattern than for the two younger age groups: The number of DT intrusions did not increase in the long distance condition, whereas there was an increase in the number of D intrusions. This pattern makes sense if we relate it to the observation that these children had a better mastery of the rule for spelling DT forms correctly. Such rule mastery implies that spellers will not always succeed in applying the rule when they have limited processing resources (as in the distant condition). This is reflected as an increase in D intrusion errors. An increase in DT intrusions could not be found because overgeneralization errors occurred in the adjacent condition.

The effect of Frequency in itself is less interesting since it only shows that the total number of errors in the three frequency categories is different (irrespective of D or DT spelling). More relevant is the Intrusion Error by Frequency interaction, which is significant for all age groups. This indicates that, *at all ages,* the frequencies of the forms exhibit an effect in the predicted direction: Young spellers make more D intrusions when the relative frequency of the D form increases and relatively more DT intrusions when the relative frequency of the DT form increases (even though more D intrusions are observed due to the poor command of the verb suffix rule). In other words, already at the age of 12 does form frequency of the homophonic verbs play a role in spelling.

[3] Although there was an effect for distance as well at the age of 12 years, it is much smaller than that observed for 14- and 18-year-olds.

TABLE 2
Logit Results for 12- to 14- and 18-Year-Old Spellers

Effect	Age			
	12 years	13 years	14 years	18 years
Intrusion Error	$F(1, 84) = 249.02$***	$F(1, 84) = 146.20$***	$F(1, 84) = 35.15$***	—
Distance	$F(1, 84) = 4.48$*	—	$F(1, 84) = 21.76$***	$F(1, 81) = 59.90$***
Frequency	$F(2, 84) = 7.95$***	—	—	$F(2, 81) = 4.24$*
Intrusion Error × Distance	$F(2, 84) = 11.60$**	$F(2, 84) = 16.21$***	$F(2, 84) = 4.22$*	—
Intrusion Error × Frequency	$F(2, 84) = 7.39$**	$F(2, 84) = 5.72$**	$F(2, 84) = 7.27$**	$F(2, 81) = 10.67$***
Distance × Frequency	—	—	—	—
Intrusion Error × Distance × Frequency	—	—	—	—

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

CONCLUSIONS

In the spelling of 12- to 14-year-olds, the most frequent spelling of a homophonic verb form already intrudes itself upon the spelling of the lesser frequent form. This is the case notwithstanding the fact that young spellers show a (very) high number of spelling errors,[4] which sharply decreases over age, and that a strong bias was observed to spell the verbs with a D ending. On the basis of these results, we can exclude possibilities (a) and (c) from the introduction (which predicted no effect of frequency). Possibility (b), which predicted a bias in spelling errors, is partially true (D bias), though frequency is still discernible in the results [possibility (d)]. Hence, the correct interpretation is a combination of (b) and (d).

The observed D bias can be explained by assuming that it is the least complex form. For the spelling of both the D and DT ending, the stem form of the verb needs to be retrieved (or computed). In order to spell the correct D ending of the stem, one has to apply the Dutch morphophonological ''lengthening'' rule (see above). Given the high number of D spellings for the verbs (and the low percentages of T spellings), one can conclude that children know this rule quite well at the age of 12. Having found the correct stem form, the spelling rule needs to be applied. Since the spelling rule for the first person singular is to add a zero morpheme, its form is the same as the stem form. For the DT spelling, one has to add a T at the end of the stem, making the inflected form more complex. The rather high error rates indicate that the third person singular present tense rule is not yet well known. It should be noted here that a search of the CELEX corpus revealed that in less than 10% of the Dutch verbs this choice between a D/DT spelling for a /t/ sound exists. Hence, in over 90% of the cases, children can just ''spell what they hear.'' Since the spelling rules involve determining the syntactic relationship between items and since in most cases phonology will give you the right answer, these descriptively simple rules might in practice be quite abstract for young spellers.

While the D bias becomes weaker over the years, the influence of the DT spelling becomes stronger. This not only reduces the high number of D intrusions when DT has to be spelled, it also increases the number of DT homophone errors when D has to be spelled. Indeed, 14-year-olds, and even 18-year-old spellers, make more errors on a D spelling than 12-year-olds. This suggests that the homophone frequency effect is a memory effect which sometimes ''escapes'' conscious control since the older spellers know the spelling rules better.

The intrusion effect of homophone frequency could be observed at all age levels, despite the strong D bias for the younger spellers. In other words, although the most common spelling error is a D ending for these groups, this bias is significantly reduced when the D ending is not the most frequent spelling of a homophonous verb form. As argued in Sandra et al. (1999), this strongly suggests that *even highly regular* verb forms have their own orthographic representation in the mental lexicon. If one follows the spelling rules, no (homophone) errors would ever be made. However, the word's pronunciation will activate the most frequent spelling of a homophone (or possibly both spellings in order of frequency), and the output of this automatic activation process might intervene with the rule-governed process. For the adult spellers, and the younger spellers who know the rules better, this infringement will be particularly high when the rule-governed process is slowed down, as is the case when the morphosyntactic information necessary to apply the rule correctly is more difficult

[4] Clearly, although the *total* number of errors is around chance level for the youngest group, the D bias and the Frequency by Intrusion Error interaction show that these spellers do not just exhibit chance performance.

to retrieve or has decayed in working memory (distant conditions). Although this Distance effect is less clear for the two youngest age groups, possibly due to the strong D bias, the Intrusion Error by Distance interaction for those two groups already suggests that ease of morphosyntactic information recovery influences their spelling as well.

Our off-line findings do not allow us to determine the precise locus of the full-form orthographic representations. They might be output orthographic representations (subserving spelling only) or appear in the input and output orthographic systems. The finding of surface frequency effects in recognition times for regular plurals in Dutch (Baayen, Dijkstra, & Schreuder, 1997) suggests that full-form orthographic representations also appear in the input orthography. Note, however, that full-form orthographic representations will facilitate reading whereas they will cause intrusion errors in spelling.

That regular verb forms are also stored in the mental lexicon goes against the idea of ''optimal coding'' which holds that only exceptions are listed in the lexicon (Chomsky, 1995; see also Bloomfield, 1933). Although this idea seems more elegant from a descriptive point of view since it reduces redundancy in a lexicon, it is not confirmed by our data. However, as pointed out by Pinker and Prince (1991) for the production of past tense forms, the fact that a word is constructed by a productive process does not necessarily preclude it from being listed as well (for additional supporting evidence, see Baayen, Levelt, & Haveman, 1993; Baayen *et al.*, 1997). They argue that the productive rule is *learned* by extracting the underlying generality from the stored forms. On the other hand, the formation of the singular present tense forms in *spelling* is quite different from the construction of past tenses in *speech* since spelling rules are explicitly taught and since the correct spelling is not determined by inherent properties of the verb but by the combination of the morphosyntactic information from the subject with the verb. In other words, if one wants to make a similar argument as Pinker and Prince (1991), one has to allow generalizations involving different words, i.e., orthographic representations of regularly inflected verb forms will be stored and coded for grammatical person and number (e.g., ⟨rijdt⟩ + third person singular). Whereas this is a necessary ingredient in their model, we merely claim that orthographic representations are automatically stored when they are encountered in texts, even for regularly inflected forms, and that their activation is almost reflexive on the basis of their phonological input.

One might argue that the data can equally well be explained without making use of full-form orthographic representations. In principle one could explain the effect within an architecture which only contains (i) lemmas and (ii) affixes that can be combined with those lemmas. In such an architecture each verb suffix has its own representation in the lexicon, which is linked to the entries of many verbs. The strength of each connection is then proportional to the usage frequency of the inflected verb form. Even though such connections would lead to associations between graphemes, just as in the case of the full-form representations we propose, the two accounts differ considerably. In a lemma and suffix model the association involves a morphological operation, whereas in a model with full-form representations the association involves nothing more than graphemes.

The idea of separate suffix representations which are shared by many verbs is based on the assumption that inflectional suffixes belong in a different part of the language system than lemmas. Note that by accepting connections between lemmas and suffixes the two storage systems are not only related by virtue of a computational system but also by virtue of an associationist system. Even though this is a possibility, the presence of such connections would blur the clear-cut distinction between lemmas and suffixes that one would expect in a ''lemma and suffix'' concept of the lexicon.

The above argument is only a cosmetic one, which cannot discredit the lemma and suffix model. Note, however, that this does not mean the model is correct. It only means that the model seems to be able to account for the effects as well, just like full-form representations can. This makes neither account superior over the other. However, there is a type of verb spelling error in Dutch which can more easily be accommodated within the conceptual framework underlying full-form representations than within a lemma and suffix framework. The evidence does not come from experiments but from observational data.

In Dutch, spelling errors like *wastte* (washed) and *lachtte* (laughed) are quite common. The correct past tense forms are *waste* and *lachte,* made by adding the past tense suffix *-te* to the stem. Given this morphological structure, the two error forms cannot emerge in a lemma and suffix model, which always produces inflected forms by concatenating stem and suffix. The problem is to explain why an extra *t* appears in between the stem and the suffix. At first sight, our concept of full-form representations cannot explain the errors either, because the spelling pattern which is produced does not exist in the written language and hence cannot be stored as a full form. However, the notion of full-form representations is only one manifestation of a more general concept: The idea that the associative strength between a phonological representation and several orthographic representations determines the spelling response. For the spelling of regular past tense forms this concept is relevant at the sublexical level. The past tense of verbs such as *wassen* is phonologically similar to other past tenses, which all share the phonological sequence starting with the vowel /a/: *braste, paste, plaste, tastte, vastte, waste.* As can be seen, some of these past tenses have a double *t* whereas others have a single *t* (verb forms with a double *t* in their spelling have a stem-final *t*). In other words, a single phonological pattern is associated with two orthographic patterns (*aste* and *astte*), which is a situation of homophony at the sublexical level. Quite plausibly spelling errors emerge as the result of this homophony. Subsequent research on this type of spelling error may be important to resolve the discussion about full-form representations. However, at this moment the principle of associative strength between the phonological and orthographic levels offers a unifying account of homophonic intrusions at the whole word level and homophonic intrusions at the subword level. The notion of full-form orthographic representations follows naturally from this principle.

To summarize, we found evidence for the storage of regular verb forms by spellers as young as 12 years old, even though their knowledge of the spelling rules was far from perfect and they exhibited a D bias in their spelling. As spellers get older, the number of errors drops, the D bias diminishes (indicating a better command of the spelling rules), and, in general, the pattern of errors starts to resemble the pattern found for adult spellers more closely. In addition, as spellers get older, reduced accessibility of the morphosyntactic information also causes an increase in their number of errors. This indicates that they attempt to apply the spelling rule (but are hindered in the long distance conditions), even though they are unable to ignore the influence of stored regular verb forms. In other words, when the rule is harder to apply, more intrusions from the most frequent spelling are found.

In conclusion, the kind of spelling errors that were studied in this article shows, surprisingly, that spellers have a good memory for individual verb forms. As we have noted before, full-form orthographic representations will facilitate performance in the case of reading (i.e., dual route models for the recognition of morphologically complex words), whereas they will lead to interference in the case of spelling (i.e., the representations cause errors, even when the spelling rules are very simple). From a probabilistic perspective, this is less surprising since the most frequent form is evidently also the form that is most likely to be correct, and intrusion errors are high

when the least frequent form needs to be spelled. This also implies that it will be next to impossible to expect even experienced spellers never to make an error of this sort.

REFERENCES

Assink, E. M. H. (1985). Assessing spelling strategies for the orthography of Dutch verbs. *British Journal of Psychology,* **76,** 353–363.

Baayen, H., Levelt, W., & Haveman, A. (1993). *Annual Report of the Max-Planck-Institut für Psycholinguistik, 6.* Nijmegen: Max-Planck-Institut.

Baayen, R. H., Dijkstra, T., & Schreuder, R. (1997). Singulars and plurals in Dutch: Evidence for a parallel dual-route model. *Journal of Memory and Language,* **37,** 94–117.

Baayen, R. H., Piepenbrock, R., & van Rijn, H. (1993). *The CELEX lexical database* (CD-ROM). Philadelphia, PA: Linguistic Data Consortium, Univ. of Pennsylvania.

Bloomfield, L. (1993). *Language.* New York: Holt, Rinehart & Winston.

Chomsky, N. (1995). *The minimalist program.* Cambridge, MA: MIT Press.

Gerhand, S., & Barry, C. (1999). Age of acquisition, word frequency, and the role of phonology in the lexical decision task. *Memory & Cognition,* **27,** 592–602.

Largy, P., Fayol, M., & Lemaire, P. (1998). The homophone effect in written French: The case of verb–noun inflection errors. *Language and Cognitive Processes,* **11,** 217–255.

Pinker, S., & Prince, A. (1991). Regular and irregular morphology and the psychological status of rules of grammar. In L. A. Sutton, C. Johnson, & R. Schields (Eds.), *Proceedings of the Seventeenth Annual Meeting of the Berkeley Linguistics Society* (pp. 230–251). University of California, Berkeley: Berkeley Linguistics Society.

Sandra, D., Frisson, S., & Daems, F. (1999). Why simple verbs can be so difficult to spell: The influence of homophone frequency and distance in Dutch. *Brain and Language,* **68,** 277–283.